PANAVISION TRAINING PROGRAM

Phantom HD Ops & Workflows

How does this camera work?

The Phantom HD Digital hi-speed camera is based around its hi-performance 2048 x 2048 *(2k x 2k)* CCD chip. The physical size of the chip is comparable to a Super 35mm film gate horizontally, but it is also quite a bit taller, or higher that a Super 35mm film gate.

It is square shape where a film gate is usually rectangular in shape.

This has its distinct advantages particularly in SFX driven productions, whereby the director can *"pan & scan"* the printable area to suit their requirements.

Unlike the Panavision Genesis or Sony hi-end single chip cameras that use an RGB striped CCD, the Phantom HD camera records its images using what is known as a *"Bayer Filter"* which will require a *"de-bayering"* process as a part of the post-production workflow.

This is neither a good thing nor a bad thing, it is just a design philosophy of the manufacturer, but the data/footage from the camera does require this additional procedure.

The camera can shoot up to 1500fps at 720p, which is the same resolution as the popular Panasonic *"VariCam"* DVCPRO-HD camera format. Or, at up to 1000fps at full HD resolution of 1920 x 1080 which has become the de facto World standard for HD resolution.

So, the camera can shoot from 1fps all the way to 1500fps is single frame increments depending on the resolution the production requires.

Our Phantom HD Camera's have an internal memory cache of 16Gb. This memory cache will hold one shot at 1000fps for 4.4 seconds, which then gets transferred to the camera's on-board ***"CineMag".***

Now, that may not sound like a long shot, but that equates to 4400 frames, or 176 seconds *(2 min's, 54 sec's)* when played back at HD sync speed of 25fps.

The transfer of the data/footage from the internal memory cache only takes a few seconds, as soon as you've completed that task, you can set-up to shoot again, all in no time at all, as opposed to the old hi-speed 16mm/35mm film cameras, which can take forever to reload mags.

And remember that the hi-speed film cameras can be notoriously temperamental, plus the undeniable fact that a 1000ft roll of 35mm film can cost more than $1,000.00 per roll.

What is a "CineMag"?

A "***CineMag"*** is unique to the Phantom HD: it is just a big solid-state memory bank that docks to the top of the camera body, not unlike a film magazine. When shooting at less than 450fps, you can save the data/footage directly into the ***CineMag*** *(by-passing the camera's internal memory),* so you can shoot very long takes.

Above 450fps, you can shoot in the usual way into the camera memory cache and then copy the footage across from camera's memory to ***CineMag*** in a matter of seconds.

Look at it another way:

If you shot high speed on a Photosonics film camera, a typical take using 1000ft magazine of 35mm film could cost up to $3,000.00 in stock and telecine alone, before you've even put it through steady-gate to sort out the film weave, *(the images recorded on digital formats are steady as a rock).*
A high-speed video shoot day with Panavision's Phantom HD system can yield 50 or more takes - *imagine how much that would cost if shot on film!*

What must I fully understand before I use the Phantom HD camera?

Like all hi-end production digital cameras, they need to be fully understood before you start production. This digital camera, again, like most, is menu driven and we strongly advise the DP to familiarize themselves with the many options within the menu tree.

Digital cameras with complex menu's are easy to get wrong - the Phantom HD camera is no different and it does have some of its own idiosyncrasies that need to be considered and catered for to avoid poor results.

For instance, there can be issues in using HMI or other discharge type of lighting over a certain wattage. Evidently the best results have been by using tungsten lamps of 5k or higher. We discuss this in a bit more detail further down in this paper. Another example is that the camera needs to be black balanced periodically, knowing when and how to do this is crucial.

You must also consider the post-production workflow, if you manage to fill both 512Gb ***CineMags*** and you really need only about 10% of the data on these ***CineMags*** as the other 90% is largely made up of bad takes, then sending these full ***CineMags*** for post processing and transcoding will take many hours and cost much more than the production would've anticipated.

Consequently, through the correct use of the ***Data Wrangling/Loading Station***, it is possible to discard the out-takes and save the production a lot of time and expense.

The post-production workflow choices

With the Phantom HD camera, there are two possible post-production workflows: RAW digital or HD video.

Most people are familiar with the video workflow:

- *Record into camera memory at high speed*
- *"Play" the recorded images over the HD-SDI output to the VTR*
- *Record to a HD video tape recorder (VTR) or disk recorder*
- *Import the recorded "HD video" into an NLE Apple, Avid suite*

In the video workflow, the bayer color interpolation, gamma settings, color matrix and other image adjustments are *"baked into"* the video that becomes your master during post-production.

For a RAW digital workflow, the images stored in the CineMags are downloaded to a hard-disk drive. These are RAW images that do not have any image adjustments made - no de-bayering has been performed, they are linear representations of the sensor data - completely *"uncorrected".*

These raw images *(called a "CineFile" in Phantom speak)* can have all these manipulations performed in transcoding and/or editing - keeping the RAW images as the ultimate *"digital negative".*

This gives you the maximum flexibility to choose your de-bayering algorithm, assign gamma, color grade/correct, and compress the images in post-production while never doing anything destructive to the original images.

If you plan to use the RAW digital workflow, here are some things to consider:

- *Is your post-production house familiar with a digital RAW workflow? Are they prepared to deal with Phantom CineFiles? If not, we have installed a complete transfer/dubbing suite at Panavision that can assist you with this process. We can transfer to any tape format or hard-drive at much better rates than any post facility, discounts apply when the material was acquired with Panavision Phantom HD cameras*

- *You will need plenty of disk space. Typical RAW files can be as large as camera memory (up to 16Gb of high speed memory, and up to 512Gb of CineMag memory.) And, when you eventually save de-bayered versions of these files (DPX/QT/TIFF instead of RAW), they may take up to 3 x the disk space of the original RAW files*

- *There are lots of variants to the RAW digital workflow, this is just one version, so be sure to explore them and choose the one that works for you. We can help to advise you on the best workflow for your budget*

If your workflow is using the HD-SDI video path then you must remember that the pictures will have an unusual slight green cast due to no de-bayering process being performed, but this can be colour graded out.

This workflow path probably works out to be more economical in the long run, but it must be understood that this method is a compromise over the traditional RAW data option, but, it does work.

What is Transcoding?

As described above, the Phantom HD camera makes its own proprietary type of files called “CineFiles”. These CineFiles must be transcoded or translated to another type of commonly used high quality file format/codec for editing platforms from Apple, Avid etc to read, understand and manipulate. To do this translation we need to use the proprietary Phantom software.

These translated/transcoded file formats/codecs can be DPX, TIFF, QT, or any of the many others. It really depends on the project and what level of quality is expected. The higher the quality demanded, the larger the files will be…

As a rough guide, a shot at 1000fps for 4.4 seconds will use 16Gb of memory in the CineFile codec. When we translate/transcode these CineFiles into an uncompressed DPX file format/codec, each frame is 8.5Mb, therefore the entire 4.4 second shot will require 37.4Gb of storage.

So, as you can see, we’ve more than doubled the storage demand for this process – from 16Gb of CineFiles to 37.4Gb of DPX files. Consequently, you can see the need to have at least a basic understanding of this process to allow for possible storage problems in your post-production path.

There are many other file format/codecs that are more than acceptable to use, DPX files are often used as a point of reference as a common file format/codec for digital intermediate and visual effects work and it is an ANSI/SMPTE standard.

Once the files have been transcoded into the format you want, the remainder of the post workflow is just the same as working with tape or scanned film footage.

Andrew Timlin

April ‘09

Some Phantom FAQ's

What is the resolution of the camera?

The sensor is native 2k, 2048 x 2048 *(a big square).* The record resolution is selectable for the given application, which also gives expanded options on record time and frame rates. The camera uses a single CMOS sensor, and our Phantom's use a 35mm film format PV lens mount. Common resolution choices are 1920 x 1080 *(aka 1080p, same as the Sony F900)* and 1280 x 720 *(720p, same as the Panasonic VariCam).* Other resolutions are also available for Digital Cinema use, for example 2048 x 1112 *(1.85 aspect ratio).*

How fast can it shoot?

Frame rates are dependent on the choice of resolution. Only the vertical pixel count effects the maximum frame rate, so 2048 x 720 and 1280 x 720 will have the same frame rate options. Exposing the entire chip, the Phantom HD is capable of 527fps. At the more common 1080p, top speed is just over 1000fps. At 720p, top speed is about 1500fps. The camera can shoot at slower speeds as well, down to one frame per second.

How light sensitive is the camera?

The Phantom HD is rated at approximately 320 ISO with a dynamic range of exposure in excess of ten stops. No other high-speed Digital Cinema camera can offer similar performance.

How long can it shoot?

Currently, our Phantoms are equipped with 16G of internal RAM. Runtime is determined by resolution, as a given resolution will yield a given number of frames that will fill this memory. So, in 1080p the memory can hold 4438 frames, which translates to 4.44 seconds when shooting at 1000fps.

Played back at 25p this translates to 177 seconds of material. At 720p, the memory can hold 6658 frames. At 25p playback, this runs for 266 seconds.

A convenient calculator for this is located on the Vision Research website at:

http://www.visionresearch.com/index.cfm?sector=tools&page=timecalc

If you are looking for the highest image quality, be sure to select 16G of memory 14-bits of bit-depth. *(In some cases, when longer run times are desired and more important than*

ultimate image quality, 12 bits can be selected at the expense of very slight image degradation.)

The Phantom is limited by its internal RAM recording capabilities, but it is also now able to record to 512G capacity CineMags, which are interchangeable flash-based memory magazines that clip to the top of the camera and can record up to 80 minutes of Uncompressed RAW *(in 1080p).* There is a separate CineStation for downloading the files from a second CineMag while continuing to shoot with the camera.

What do I do with the material once it is captured on the camera?

Captured material can leave the camera in two ways. The camera has an HD-SDI port *(single wire, 4:2:2),* which can be used to feed directly to an HD deck in a variety of formats. Using the laptop computer controller some basic color correction can be performed on the image output over the HD-SDI.

Downloading in this manner is in real-time, so a full file of 1080p material *(4428 frames)* played at 25p would take 177 seconds. This is not the recommended output method of the Phantom HD, but is an excellent way to monitor the image onset and to deliver a signal in a live event "instant-replay" environment.

The second way to output material is by data transfer. The camera captures in Uncompressed RAW, which is considerably more information than any video format can handle. This is excellent for complicated post-grading and effect work and offers the richest material for Digital Cinema production.

To copy this material, the files are downloaded from the camera's internal RAM through the laptop computer controller to a hard drive. Currently all our rental laptops use FireWire800 drives.

Downloading Uncompressed RAW is not a real-time operation, and it takes about 15 minutes to transfer the entire memory buffer from the camera.

How can I shorten download time during my shoot?

There are a few procedural ways to keep the downtime on set as minimal as possible. First and foremast is to realize that the entire length of a shot does not need to be transferred.

Most extreme slow motion shots are used to capture events of a limited duration, such as a water drop or ball bounce.

For these events, 1000fps footage would have perhaps 30 seconds of useful material. Using the laptop controller, IN and OUT points can be selected *(they can also be selected for the HD-SDI output).*

Often it is the nature of this type of shooting that the required reset time on set, due to the nature of the subject, is longer than the download time of the Phantom system.

What do I do with the Uncompressed RAW files?

There is a third-party application that will play the CINE file natively within a QuickTime wrapper, but typically the RAW files are converted to .tiff or .dpx stacks. Panavision can also perform these file conversions or convert files to various HD and SD video formats for a fee at our transfer suite.

What is included in a typical Panavision Phantom rental package?

The Phantom HD base rental package includes:

* *Phantom HD camera with 35mm PV or PL mount and 16G internal RAM*
* *Laptop computer controller*
* *Color viewfinder or small HD LCD onboard monitor*
* *Riser plate to marry to standard 15mm sliding base plate*
* *AC power supplies & batteries if required*
* *Various appropriate cables*

The package does not include lenses or a hard drive. Other accessories such as matte-box, tripod and monitor are available a la carte.

Panavision's policy is that a trained Phantom technician accompanies the Phantom camera on all jobs. There are a growing number of technicians that have experience with the Phantom. Panavision will hold periodic Phantom Training program Seminars at our Sydney office and if you're interested in learning more about this skill, please contact Andrew Collier or John Virtue for more details.

Sensor Cleaning

The sensor on the Phantom HD is a very expensive item. We do not recommend cleaning it without special tools and training. If any dust should land on the surface of the sensor, then it can be blown off using a hand-squeezing bulb syringe. Never use compressed air, lens cleaning fluid or lens cleaning cloths on a sensor.

Lighting for High-Speed

Lighting issues are not specific for the Phantom cameras but for high frame rate photography in general. Even with the great sensitivity of modern cameras, be prepared to use a considerable amount of light. Beyond illumination, the largest issue in high-speed lighting is flicker.

Tungsten lights actually have a flicker rate. When powered by alternating current (AC) electricity, the power cycles 50 or 60 times per second *(depending on the country and its power system).* During the down cycle the tungsten lamp filament can dim slightly, causing flicker.

The amount of dimming is related to the type of bulb, wattage and physical size of filament. In general, we have found that lamps larger than 2000 watts use tungsten filaments so large that they do not have time to cool and dim before the power cycles

back up. Therefore, we recommend using 2K or greater tungsten light fixtures when shooting above 100fps.

Be aware that a nine-light/mini-brute is NOT a large light but is actually an array of smaller light and as such can flicker.
Some additional recommendations are to use DC power for tungsten lights, which eliminates flicker entirely. HMI and fluorescent lights are generally fine for speeds under 100fps as long as they use electronic ballasts. Magnetic ballasts should not be used. HMI lights can suffer from “arc wander,” whereby a plasmatic “hot spot” can move about within the bulb, causing an amorphous shifting movement in the light output. LED lights are subject to the electronic circuits driving them and are subject to a vast array of refresh rates.

Finally, the shutter angle on the Phantom can affect flicker as well, as a greater shutter angle allows for a longer response time from the light. When shooting extremely high frame rates, it may no longer be necessary to retain a 180-degree shutter to capture the motion generally preferred for a filmic look. A 360-degree shutter allows both more light sensitivity and reduced flicker possibilities.

This article originates from the AbelCine website and has been edited for local relevance.

Q & A With AbelCine's Mitch Gross

Director of Photography Mitch Gross has been working in the New York film industry for the past fifteen years. He recently completed principal photography of his twenty-first feature film*, "Get Famous".*

His credits include dozens of short subjects, documentaries, commercials and music videos, as well as two television series. His work has been screened and won awards at festivals including Sundance, Berlin, Cannes, Edinburgh and New York. Since May 2006, he has been the Technical Director of Rentals at Abel Cine Tech's New York office.

What prompted the decision to work with Vision Research (VRI) and Phantom cameras?

At Abel, we really like being on the cutting edge. We know how to take revolutionary products that appeal to our industry and help the manufacturers bring them to market and realize their full potential. That's part of Abel's history with products like the Aaton A-Minima, Panasonic VariCam, and MOVIEtube.

The Phantom HD and 65 fit this vision very well.

As time goes on, the production world is moving towards uncompressed RAW and IT-based imaging. The Phantom cameras embody all of this. It's a line of cameras initially perceived by the industry as a niche product… strictly as high-speed digital cameras. But as the Phantom HD and 65 cameras evolve and memory options expand, they'll be able to be utilized in more and more situations.

Can you describe your relationship with Vision Research so far and the role that Abel plays?

It's a real collaborative effort. A very simple example of this is a recent software improvement that Vision Research has implemented.

Phantom HD, by definition, is a 2k x 2k camera, 2048 x 2048. Usually, clients won't use all the real estate that this imager offers, instead they'll most often require a resolution and aspect of 1920 x 1080. In fact, the user can select the size they require upon camera setup.

So what happens with that unused image area? Vision Research simply blacked out that extra portion of the imager. Coming from a film background, we quickly realized how useful it would be for the DP to actually see that out-of-image area.

On a film set, operators are used to seeing outside of the image area, so that they can detect a c-stand on the edge of the frame, or a boom pole dipping into frame.

When we explained this to Vision Research engineers, it took them less than a day to implement a modification that showed the image area in full color, while the area outside the 1920 x 1080 frame was in black and white. A perfect solution that might never have occurred to them without Abel's input. This early example helped us realized that the two companies could work well together.

How have the cameras evolved?

Vision Research's history is more of a scientific, industrial use. They're used to building remote cameras to go into extreme situations; on top of a tower or deep into a well or cave with nobody next to the camera for long periods of time. Because of this, all camera controls have been via a software and computer interface. As the Phantom HD and Phantom 65 models evolve, more and more of the controls for the camera are now being incorporated directly into the camera body.

How will Abel support the Phantom?

We've been renting the Phantom since January. The demand has been extremely high. I have a selection in rental now, and I can make additional cameras available as Vision Research delivers. We also offer post-production solutions. The Phantom uses a file-based proprietary system that isn't something everyone knows how to deal with, or else they aren't comfortable with it, or they don't have the hardware.

How does Phantom compare to existing HD and film cameras?

There is currently nothing on the market that is PL mount-equipped and has the resolution and speed capabilities of the Phantom HD and Phantom 65 digital cameras. People can use their 35mm lenses and get the depth of field and optical characteristics they're used to. These Phantoms have 11 stops of dynamic range with 14-bit color depth and render a very filmic type of image.

We are finding new solutions with our users' input, feeding it back to Vision Research and improving constantly. Software is evolving with our input, and we're designing various accessories.

How is the camera typically equipped?

16 GB of onboard storage is the standard way the camera goes out for rental, and soon this can be upgraded to 32 GB. When we get to CineMags, you won't need that much onboard memory any longer. The CineMags will be available in 256 GB and 512 GB of memory sizes. At the popular 1920 x 1080 resolution you'll be able to shoot nearly an hour and half of material on a single 512 GB CineMag.

You can download your material on the CineStation while continuing to shoot on another CineMag. This makes the on-set workflow very similar to the film model with which crews are familiar.

What's the post-production workflow for Phantom?

You can either have a video or IT-based workflow. There's limited memory storage, but for what the camera is used for, this hasn't been too much of an issue so far. For people who need an immediate result or have footage where post-manipulation is limited, they can take HD-SDI from the camera straight out to a deck like a Sony HDCAM-SR SRW-1 or Panasonic DVCPRO HD 1400. They can apply gamma and basic color correction to the HD-SDI feed and get a very attractive image. The camera can feed that connection in a variety of forms like 1080i, 60p, 25p, 24p & 30p.

The video workflow is used a lot for sports, where they need something right away. We have clients doing live events, where they want playback on-set for demonstration purposes. We've also done live-to-tape programs for live audiences. The clients wanted to demonstrate something in slow motion right away. The video-based workflow is an ideal solution for these projects.

The other post-workflow is IT-based, in which you download clips in file format right out of the camera. You can take an entire clip or a portion of that clip by selecting start and end points. For example, at 1920 x 1080 with 16 GB of internal RAM at 14-bit of color depth, you can shoot a burst at 1000 frames per second for 4.44 seconds of capture time. That gives you 4,438 frames. The playback time of that clip at would be 177 seconds at 25p.

Rarely does anyone need the full 3 minutes of run time on a single high-speed shot. 4.44 seconds of capture is a very long time when you're talking about a strawberry dropping into cream, a lightning strike or a light bulb shattering. This is something that happens within a second or two. So you can select in and out points of the shot you want to use, then do a transfer.

If you transferred the entire file, you're talking as much as 15-20 minutes of download time. If you select 30 seconds of the shot, it's maybe 3-4 minutes. You can also compartmentalize the memory on the camera, partition it into a number of takes and select the in & outs you like. This way you can shoot a number of takes before needing to pause for downloading. And with a CineMag on the camera, the download is a matter of seconds, so the time becomes inconsequential.

How is footage accessed with the IT-based workflow?

The Phantom uses a proprietary file format. The transfer program itself is very straightforward. Currently, the most common solution is to export the material as a stack of .tiff or .dpx files, which can be read by numerous post programs. We're working on other solutions such as a QuickTime wrapper.

And while the software is Windows based, we've controlled the camera and run the transfer software using Macs running Bootcamp. We are also working with Vision Research to develop new software and ways for their file format to be directly read by plugins to other manufacturers' software.

What projects have used high-speed photography through Phantom?

We've worked with Errol Morris on a commercial shot by Robert Richardson. We've also did some Sony PS3 spots. We've done a lot of effects house work including a recent test of fire elements for the third Pirates of the Caribbean movie. The feature Iron Man is looking to do some tests with the Phantom 65. We're also working with National Geographic and NFL films. Major productions are already using this camera.

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A Glossary of Some Digital Terminologies

Raid - RAID *(redundant array of independent disks; originally redundant array of inexpensive disks)* is a way of storing the same data in different places *(thus, redundantly)* on multiple hard disks.

By placing data on multiple disks, I/O *(input/output)* operations can overlap in a balanced way, improving performance. Since multiple disks increase the mean time between failures *(MTBF),* storing data redundantly also increases fault tolerance.

Bit - *(short for binary digit)* is the smallest unit of data in a computer. A bit has a single binary value, either 0 or 1. Although computers usually provide instructions that can test and manipulate bits, they generally are designed to store data and execute instructions in bit multiples called bytes.

In computer systems, there are eight bits in a byte.

1 Byte = 8 bits
1 Kilobyte = 1024 Bytes = 8192 bits
1 Megabyte = 1024 Kilobytes = 1048576 Bytes = 8388608 bits
1 Gigabyte = 1024 Megabytes = 1048576 Kilobytes = 8388608 Bytes = 67108864 bits

LTO - short for Linear Tape Open, a technology that was developed jointly by HP, IBM and Certance *(Seagate)* to provide a clear and viable choice in an increasingly complex array of tape storage options. LTO technology is an *"open format"* technology, which means that users will have multiple sources of product and media, and the open nature of LTO technology also provides a means of enabling compatibility between different vendors' offerings.

Resolution - The display resolution of a digital television or computer display typically refers to the number of distinct pixels in each dimension that can be displayed. It can be an ambiguous term especially as the displayed resolution is controlled by all different factors in cathode ray tube *(CRT)* and flat panel or projection displays using fixed picture-element *(pixel)* arrays.

Raster - The horizontal lines *(scan lines)* displayed on a TV or computer monitor. This is the origin of the term *"raster graphics,"* which is the major category that all bitmapped images and video frames fall into *(GIF, JPEG, MPEG, etc.)*

Color Space - A three-dimensional coordinate system, where coordinates in that system represent colors.

Video Compression - reducing the quantity of data used to represent video images.

Codec – A device or program that is capable of encoding and/or decoding a digital data stream or signal.

Rec. 601 or BT.601 or its former name, CCIR 601 - Is a standard published by the CCIR (*now ITU-R)* for encoding interlaced analogue video signals in digital form. It includes methods of encoding 525 line 60 Hz and 625-line 50 Hz signals, both with 720 luminance samples and 360 chrominance samples per line.

The color encoding system is known as YUV 4:2:2, that being the ratio of Y:Cb:Cr samples *(luminance data:blue chroma data:red chroma data).*

Rec. 709 or BT.709 - standardizes the format of High-definition television.

MPEG-2 – Is a standard that combines lossy video compression and lossy audio compression *(audio data compression)* methods which permit storage and transmission of movies using currently available storage media and transmission bandwidth.

MPEG-4 - Is a collection of methods defining compression of audio and visual *(AV)* digital data.

Uses of MPEG-4 include compression of AV data for web *(streaming media)* and CD distribution, voice *(telephone, videophone)* and broadcast television applications.

MPEG-4 absorbs many of the features of MPEG-1 and MPEG-2 and other related standards, adding new features such as *(extended)* VRML support for 3D rendering, object-oriented composite files *(including audio, video and VRML objects),* support for externally-specified Digital Rights Management and various types of interactivity. AAC *(Advanced Audio Codec)* was standardized as an adjunct to MPEG-2 before MPEG-4 was issued.

Encoding - process of transforming information from one format into another

Transcoding – Is the direct digital-to-digital conversion from one *(usually lossy)* codec to another. The main purpose is to allow media in one format to be played back on a player that does not support that format; the main problem is that it degrades quality by introducing further compression artifacts.

The aspect ratio of an image is its width divided by its height - Two common video aspect ratios are 4:3 *(1.33:1),* universal for standard-definition video formats, and 16:9 *(1.78:1),* universal to high-definition television

Digital Bandwidth – Is the capacity for a given system to transfer data over a connection. It is measured as a bit rate expressed in bits/s or multiples of it *(kb/s Mb/s etc.).*

Chroma Sub-sampling – Is the practice of encoding images by implementing less resolution for chroma information than for luma information. It is used in many video encoding schemes in both analog and digital and also in JPEG encoding

Gamma – The name of a nonlinear operation used to code and decode luminance values in video or still image systems.

ATSC Standards - Digital television format that will have replaced the analog NTSC television system by February 17, 2009 in the United States. It was developed by the Advanced Television Systems Committee.

Pixel - *(picture element)* is the smallest piece of information in an image. Pixels are normally arranged in a regular 2-dimensional grid, and are often represented using squares or rectangles.

Serial Digital Interface (SDI) – This refers to a family of video interfaces standardized by SMPTE. These standards are used for transmission of uncompressed, unencrypted digital video signals *(optionally including embedded audio and time code.)*

A related standard, known as high-definition serial digital interface *(HD-SDI)* provides a nominal data rate of 1.485 Gbit/s.

Letterboxed Image/Letterbox - Practice of transferring widescreen film to video formats while preserving the film's original aspect ratio. On video displays with a 4:3 aspect ratio, the resulting videographic image has mattes *(black bars)* above and below it. LTBX is the identifying acronym for films and images so formatted.

Pillar Boxed Image/Pillar Box - black bars *(mattes or masking)* are placed on the sides of the image. It becomes necessary when film or video that was not originally designed for widescreen is shown on a widescreen display, or a narrower widescreen image is displayed within a wider aspect ratio, such as a 1.85:1 image in a 2.35:1 frame.

PsF - Progressive segmented Frame is a High Definition mastering video format designed to acquire, store, modify and distribute progressive content using interlaced equipment and media.

Progressive or non-interlaced scanning is a method for displaying, storing or transmitting moving images in which all the lines of each frame are drawn in sequence. This is in contrast to the interlacing used in traditional television systems where only the odd lines, then the even lines of each frame *(each image now called a field)* are drawn alternatively.

NTSC - *(National Television System Committee)* is the analog television system used in the United States, Canada, Japan, Mexico, the Philippines, South Korea, Taiwan, and some other countries. Vertical resolution of NTSC is 525 lines

PAL - Phase Alternating Line, is the analog television system used in broadcast television in large parts of the world. Vertical resolution of PAL is 625 lines.

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