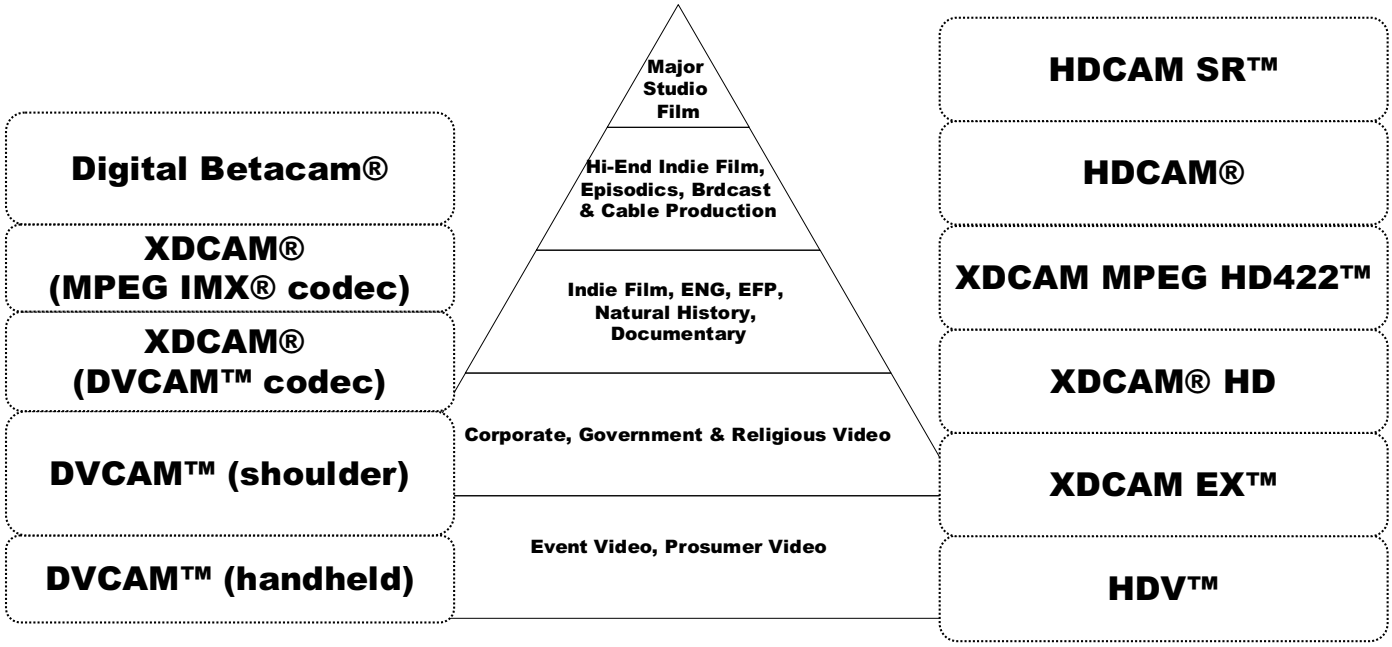
SONY

The Inside Guide to HD Formats

Freedom of Choice

If every HD production had the same needs, one HD production format could satisfy them all. In fact, there is a familiar pyramid of professional applications, from Hollywood studios to high school sports. Each layer in the pyramid has distinct performance, work style, workflow, budgetary, media and archival requirements. In response to this broad *range of customer needs*, Sony has created a *range of HD solutions*.



Just as in standard definition, Sony delivers a range of high definition solutions to meet customer requests and match customer requirements.

Sony's range of HD production solutions mirrors the breadth of products that Sony created in the SD world. Sony now offers a choice of HD bitrates, from an awesome 880 Mbps to an affordable 25 Mbps. There's a choice of media, including tape, optical disc, hard disk and flash media. And there's a choice of production solutions from a cine-style camera with a single, Super 35mm image sensor to shoulder-mount cameras with 2/3-inch type image sensors to compact cameras with 1/4-inch type sensors.

Now Sony invites you on a tour of how and why those systems came to be.

High Definition. It's in our DNA.

1985 **High Definition Video System.** Sony's first HD recorder was the HDV-1000, which captured analog signals onto 1-inch tape. It was based on the BVH-2000 Series Type C recorders.

1985 **HDC-100 Camera** used 1-inch electrostatic deflection tubes.

1988 **HDC-300 Camera** used 1-inch Saticon™ pickup tubes.

1989 **World's first digital HD recorder.** The HDD-1000 uncompressed digital HD recorder and HDDP-1000 processor weighed 367 pounds (167 kg), consumed 1750 Watts and cost roughly $350,000.

1990 **HD videocassette recorder.** The HDV-10 UNIHI recorder used half-inch tape, was a "lightweight" 110 pounds (50 kg) and a "compact" seven rack units.

1992 **World's first CCD HD camera.** The HDC-500 used the world's first high definition CCDs, with 2 million pixels and HAD technology.

1997 **World's first HD camcorder.** The HDW-700A HDCAM® camcorder was 97% smaller, 96% lighter, and 98% less power hungry than Sony's previous digital HD recording system.

2000 **World's first 24P HD camcorder.** High definition at the same 24-frames-per-second rate as 35mm film: the HDW-F900 CineAlta™ camcorder.

2003 **4:4:4 RGB HD recording.** For high-end bluescreen/greenscreen compositing, digital intermediate and telecine transfer, Sony created the HDCAM SR™ system.

2004 **Digital Super 35mm camera system.** The result of joint development between Panavision and Sony, the Panavision Genesis™ camera is quickly adopted for major motion pictures.

2005 **HDV™ 1080i recording.** With affordable HD based on the ubiquitous 25 Mbps DV infrastructure, Sony's HVR-Z1U became an instant classic.

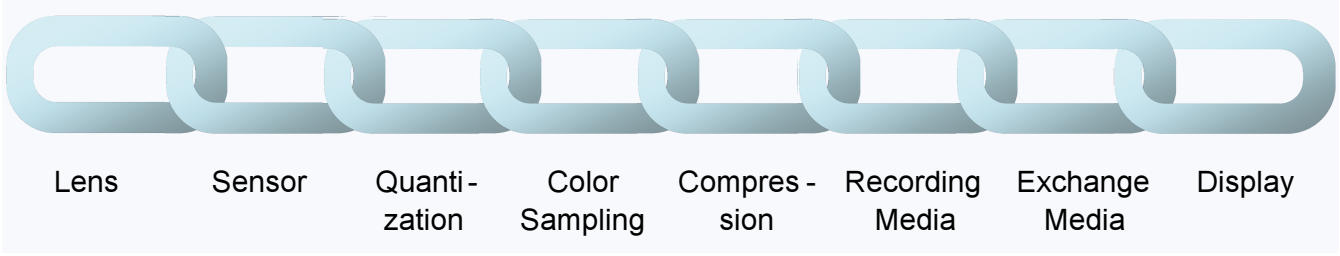
2006 **XDCAM® HD recording.** For mainstream ENG and EFP, Sony created the XDCAM HD Professional Disc™ system and the PDW-F350 and PDW-F330 camcorders.

2007 **World's first handheld 1920 x 1080 camcorder.** The PMW-EX1 is also the world's first to feature XDCAM EX™ recording and SxS Pro™ flash media.

2008 **XDCAM MPEG HD422™ recording.** An extension of the XDCAM HD optical disc solution, the PDW-700 camcorder provides full 1920 x 1080 recording, robust 4:2:2 color and long loads on Sony's dual-layer Professional Disc media.

Every Link in the Chain Matters

Sony's HD formats each offer distinct advantages for specific work styles and applications. To appreciate the differences, it's important to remember that in every HD format, reproduction is a chain.



The chain is "only as strong as its weakest link." And ideally the entire chain should be tailored to the specific recorded bit rate.

Not only is a chain only as strong as its weakest link, but it also makes no sense to give one link of the chain super quality when the other links can't take advantage. Even if you could fit a Mack Truck engine into a Honda Civic, it wouldn't make the driving experience any better—and could make it worse.

Simply stated, all the links in the chain are contingent on the recorded bit rate. One secret behind Sony's success in professional video is our ability to *balance all the links,* finding the sweet spot for a given bit rate. We understand the lenses, image sensors, sampling and compression necessary to feed the format. And of course, we have the ability to build many of these links in-house. To understand HD formats, it pays to examine each link in the chain. When we do, we'll see how the links connect to form a successful HD format.

Link 1: Lens

Because lenses are so vital to telling a story in pictures, Sony works in close collaboration with lens manufacturers. Whenever a new Sony camera arrives, it is either mated to an appropriate lens or compatible with a set of appropriate interchangeable lenses. When you think of HD lenses, think of these considerations:

- **Focus is even more important.** Because HD formats have so much higher resolution than SD, focus is more critical. This also means even tiny imperfections that might be acceptable in the SD world become offensive in HD. Sony has responded with high-resolution viewfinders, focus assist, color peaking and, in our small-format camcorders, Auto Focus.
- **Lens size and cost scale to the image sensor.** Big image sensors require big, expensive lenses. Small image sensors can use inexpensive lenses.

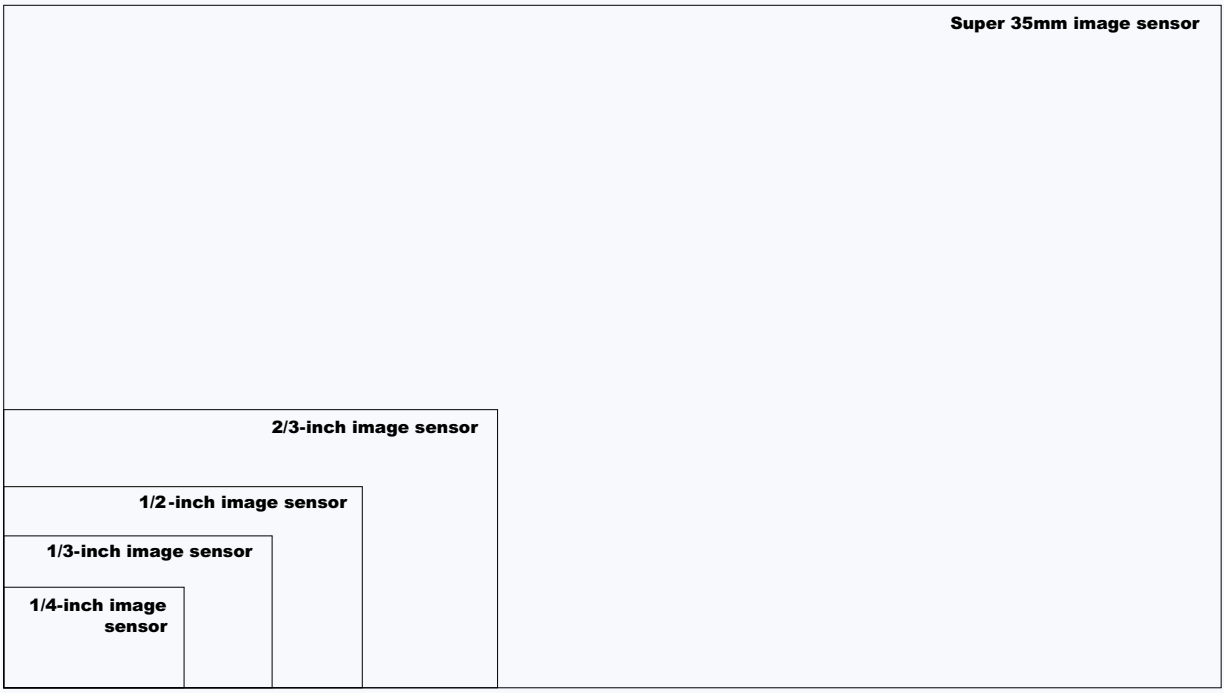
- But lens *performance* doesn't scale. Thanks to the laws of physics, you can't simply shrink a big lens down for a smaller image format and expect the same resolution. In addition, when using smaller sensors, diffraction can cause a loss of resolution as the iris aperture is stopped down.
- Depth of focus doesn't scale. Lenses for small image sensors tend to have huge depth of focus. That can be great for event videographers and run-and-gun documentarians. Everything tends to be sharp. But movie makers depend on selective focus, the ability to focus on the actress and blur the background. Selective focus also plays a familiar role in storytelling, as when a rack focus move first puts the focus on a beautiful woman in the foreground, and then shifts the focus to reveal a mysterious stranger in the background who is watching her. These depth of focus effects are much easier to achieve with a large sensor.

- Lens functions differ dramatically.
  - Digital cinema requires a full manual lens with direct, mechanical linkages for zoom and focus, aperture in T-stops, and easy accommodation for follow focus controls. In addition, cinematographers are less tolerant of lens imperfections like breathing and ramping that might be acceptable in other applications.
  - ENG and low-cost production requires a full manual lens with aperture in F-stops and flexible zoom with extreme wide angle as well as rear lens control capability. Also important: ruggedness for run-and-gun shooting and low flare for uncontrolled exterior day lighting.
  - Compared to shoulder-mount shooting, handheld is a different animal. Because HD focus is more critical, and more difficult to achieve in the viewfinder, auto focus is much more desirable. And because compact, lightweight handheld camcorders are less stable than shooting on tripods or shoulder mount, image stabilization is also an attractive option.

Clearly, the lens is more than something to hang off the front of a camera. It's the key to image making. And it sets the table for everything that follows.

Link 2: Sensor

Every image sensor must strike a balance between pixel *count* and pixel *quality*. Pixel count comes from putting as many pixels as you can onto a sensor. It gives you resolution. Other things being equal, pixel quality comes from making each pixel as large as possible.



Relative sizes of image sensor types. Other things being equal, bigger sensors mean higher image quality.

Of course, "other things" are not always "equal." In fact, Sony has continually discovered new ways to improve pixel quality without sacrificing resolution. Sony has improved the light-capturing features of the image sensors themselves. Advancements like Hyper HAD, Power HAD™ and Power HAD EX image sensors have achieved ever *higher* sensitivity with ever *smaller* pixels!

Sony's success in high definition cameras results in part from our ability to see the big picture. We can match the image sensor pixel count to the capabilities of the recording format, the resolution of the lens, the sensor size and the specific performance characteristics of the sensor itself.

- **HDCAM SR™ recorders** are sometimes used with cameras like the Sony F35, which features a single Sony Super 35mm sensor with 12.4 million subpixels and an RGB stripe color filter array yielding 1920 x 1080 resolution. Other cameras like the Sony F23 use three Sony 2/3-inch CCDs with 1920 x 1080 pixels.
- **HDCAM® and XDCAM MPEG HD422™ solutions** use Sony 2/3-inch CCDs with full 1920 x 1080 pixels.
- **Sony's XDCAM HD and XDCAM EX™ camcorders** use smaller, 1/2-inch image sensors. In the case of the XDCAM EX PMW-EX1 camcorder, the three CMOS image sensors have 1920 x 1080 pixels to match the 1920 x 1080 recording. In the case of XDCAM HD camcorders, the three CCD sensors have 1440 x 1080 pixels to match the 1440 x 1080 recording.
- **Sony's HDV 1080i camcorders** generally use 1/3-inch image sensors. The HVR-Z1U uses three CCDs with 960 x 1080 pixels. A half-pixel horizontal shift effectively increases luminance (Y channel) resolution by about 20%.

The HVR-S270U and HVR-Z7U both use three 1/3-inch ClearVid™ CMOS sensors with a diamond pattern and 1 million pixels. The Enhanced Image Processor uses an interpolation technique to generate 1920 x 1080 pixels. The HVR-V1U uses three 1/4-inch ClearVid CMOS sensors.

Link 3: Quantization

Each photosite on the image sensor turns incoming light into an electric charge. The image sensor then converts the charge into an analog voltage. To be useful in the digital world, the voltage needs to be turned into a binary number. This is quantization.

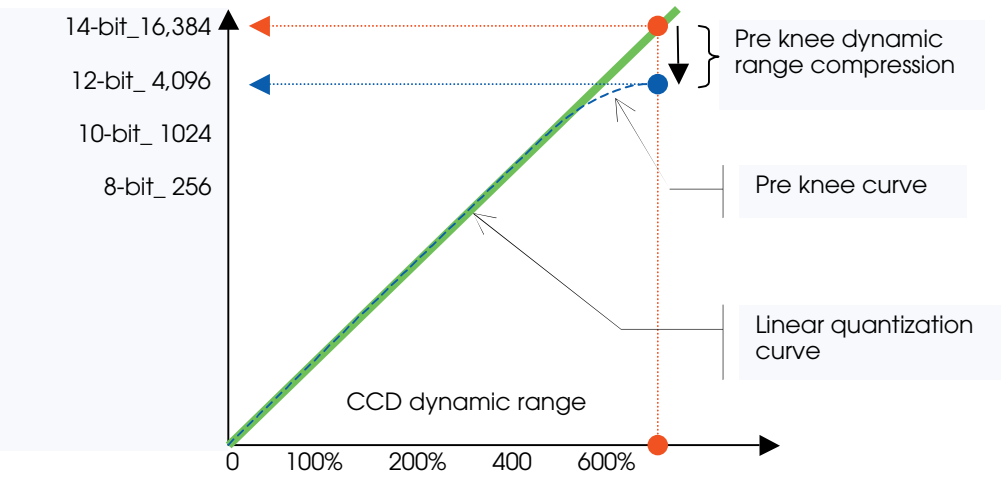
A major challenge to quantization is that today's best CCDs have tremendous dynamic range, which film photographers call "exposure latitude." The CCD in Sony's F35 digital cinema camera can sense meaningful detail up to 800% of nominal peak white. An exterior daytime wedding scene, for example, will retain the texture of the lace pattern in the bride's white gown without losing the difference between the black wool and the black silk in the groom's tuxedo.

PCM quantization assigns a fixed number of bits to every sample. Each additional bit of quantization adds roughly 6 dB of dynamic range and doubles the number of distinct tonal values available. For example, quantization at 12 bits yields 4,096 distinct values, while 14 bit quantization produces 16,384 values.

Quantizing typically occurs in two distinct stages. In the initial analog-to-digital (A/D) conversion, a high level of quantization is used prior to the camera's signal processing. This high quantization (12 or 14 bit) enables the camera to conduct signal processes such as White Balance, Gamma Correction, Skin Tone Detail and Knee at very high precision. In the broadcast environment, cameras use Knee and Gamma to fit the signal within the 100 IRE limitation of video. In the digital cinema environment, features like Sony's Hypergamma and S-LOG encoding help accomplish this task. In effect, the camera pre-conditions the signal with high numerical precision for recording at practical quantization levels and data rates.

Unfortunately, 12- or 14-bit quantization is too high to carry forward into recording and does not conform to current broadcast and distribution standards. In addition, high bit rates can impose a crushing burden on equipment size, cost and power consumption. For all these reasons, recording systems use three strategies for bit rate reduction: judicious choices in quantizing, sampling and compression.

Prior to recording, signals are requantized with fewer bits per sample. In most cases, HD signals are recorded at 8-bit quantization. However, the HDCAM SR system records with the superior dynamic range of 10-bit quantization.



High performance CCDs can still capture meaningful detail far beyond the 100% nominal peak white. In the broadcast environment, pre-knee and gamma keep the peak brightness values within a recording format's quantization range.

Link 4: Color Sampling

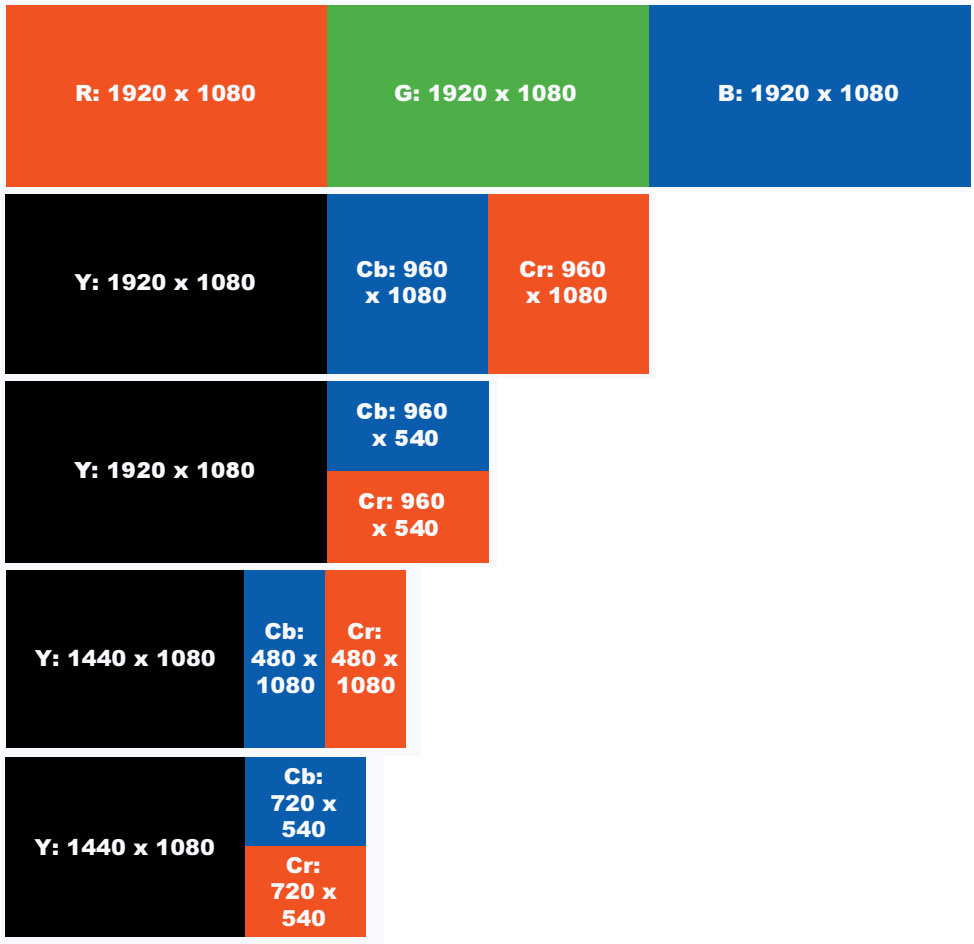
Pixels from the image sensor are quantized for processing by the camera DSP. But not every quantized sample is necessarily recorded to tape or disc. In fact, only one of our formats, the HDCAM SR system in RGB HQ mode, actually records a sample for every active pixel on the Red, Green and Blue CCDs. Since the human eye has a relatively limited ability to resolve color, it usually makes sense to record channels for chrominance (Y), blue color difference (Cb) and red color difference (Cr) with relatively fewer samples on the Cb and Cr channels than on the Y channel.

Color sampling structures are conventionally referred to the number 4 as in 4:4:4, 4:2:2, 4:2:0, 4:1:1 and other sampling structures. In the days of standard definition, this nomenclature served the industry quite well as the "4" was an absolute. But today, the "4" has become a relative term. It could refer to a sampling structure of 720 x 480 or 1920 x 1080 or possibly 1280 x 720 or even 1440 x 1080. Unfortunately, without a clear understanding of what the "4" means in each case, ambiguities and misunderstandings abound.

To eliminate these ambiguities, this discussion will dig beneath the "4:4:4" nomenclature to show the underlying color sampling of Sony HD formats. As the following chart demonstrates, the high-end formats store more color information.

In their efforts to push the recorded bitrate substantially below the 140 Mbps of HDCAM recording, some manufacturers have abandoned the 1920 x 1080 high definition raster and sacrificed both the number of scanning lines and the numbers of samples per line. Sometimes but not always, this smaller raster size is offset by a higher frame rate. In other cases, for example when all formats are operating at 24P, smaller is just plain smaller.

Formats	Samples per Frame (% re 4:4:4)	Recorded H x V Samples, by Channel
HDCAM SR RGB HQ (4:4:4)	6,220,800 (100%)	R: 1920 x 1080 / G: 1920 x 1080 / B: 1920 x 1080
HDCAM SR 4:2:2 and XDCAM MPEG HD422	4,147,200 (66.67%)	Y: 1920 x 1080 / Cb: 960 x 1080 / Cr: 960 x 1080
XDCAM EX HQ Mode	3,110,400 (50.00%)	Y: 1920 x 1080 / Cb: 960 x 540 / Cr: 960 x 540
HDCAM	2,592,000 (41.67%)	Y: 1440 x 1080 / Cb: 480 x 1080 / Cr: 480 x 1080
XDCAM HD, XDCAM EX SP mode and HDV 1080i	2,332,800 (37.50%)	Y: 1440 x 1080 / Cb: 720 x 540 / Cr: 720 x 540



The sampling structures of Sony HD formats. The second column shows the total recorded samples on all three channels and that number as a percent of the 6,220,800 samples recorded in the HDCAM SR RGB HQ format. In the third column, each rectangle represents a recorded channel. The width and height of each rectangle is proportional to the number of horizontal and vertical samples recorded on that channel. Bigger rectangles mean more samples.

Link 5: Compression

At this point, we've already had two stages of bit rate reduction. In quantizing, we went from the camera's 12- or 14-bit signals to 10- or 8-bit signals for recording. In sampling, we went from the camera's native pixel count, often 1920 x 1080, to what is often a smaller sampling structure for recording. But we *still* have too much data for typical, on-camera long-form program recording. That's where video compression comes in.

To appreciate the bit rate reduction required for the video signal, consider the arithmetic of recording a 10-bit 4:4:4 HD signal at 29.97 frames per second:

1920 pixels H x 1080 pixels V = 2,073,600 pixels per frame.

Times 3 channels = 6,220,800 samples per frame.

Times 10 bits per sample = 62.2 Megabits per frame.

Times 29.97 frames/second = 1,864 Megabits/second

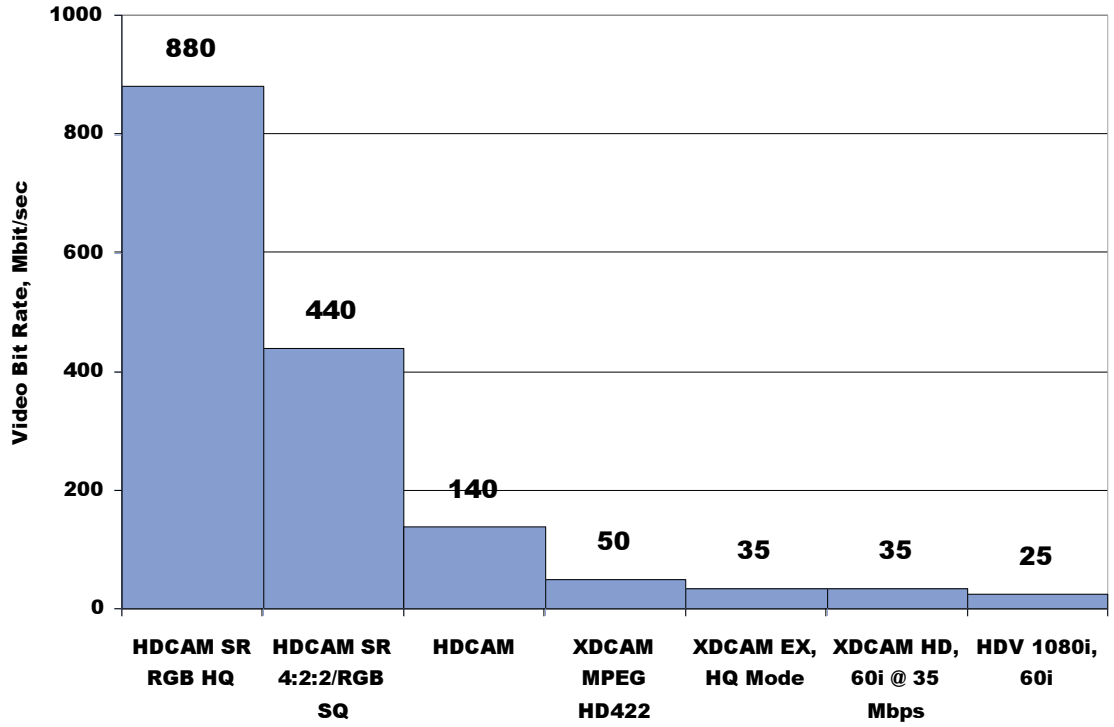
= 233 MegaBytes/second

= 13.98 GigaBytes/minute

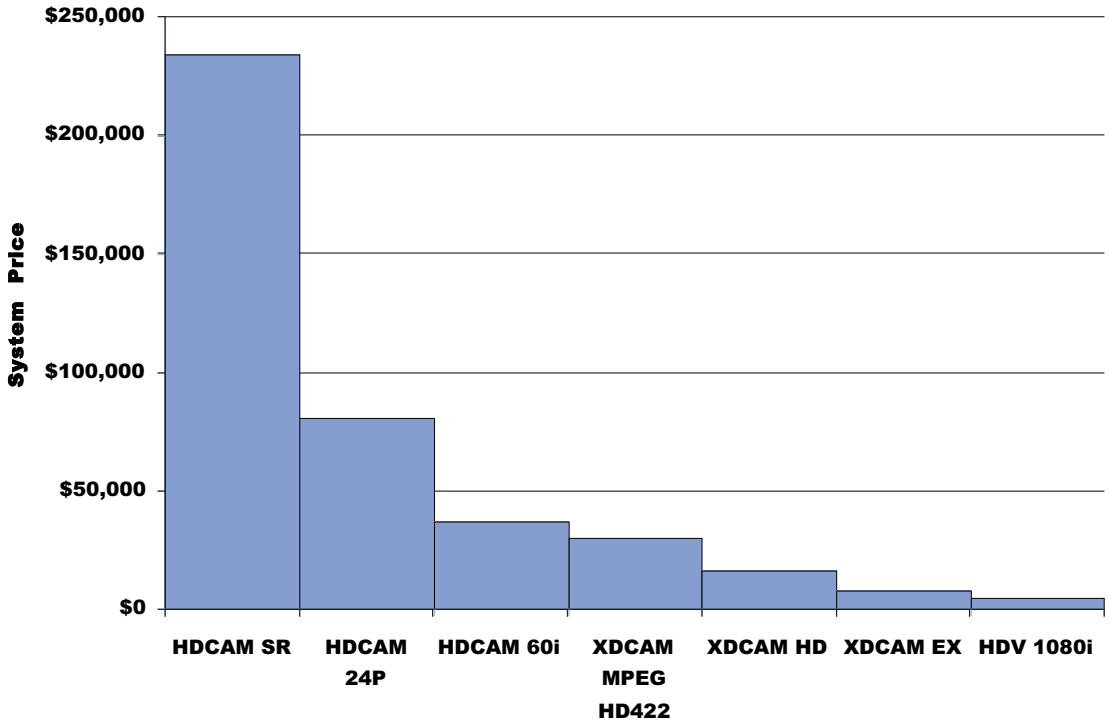
= 839.0 GigaBytes/hour

In 1994, as they contemplated the development of the HDCAM system, Sony technologists recognized that such high bitrates would impose crushing penalties in equipment size, weight, power consumption and cost. HDCAM recording made high definition practical by lowering the recorded bitrate to 140 Megabits per second.

The cost penalties of high bitrates still apply today. A glance at Sony's range of HD recording systems reveals dramatically different bitrates. And these bitrates are in almost lockstep proportion to system prices.

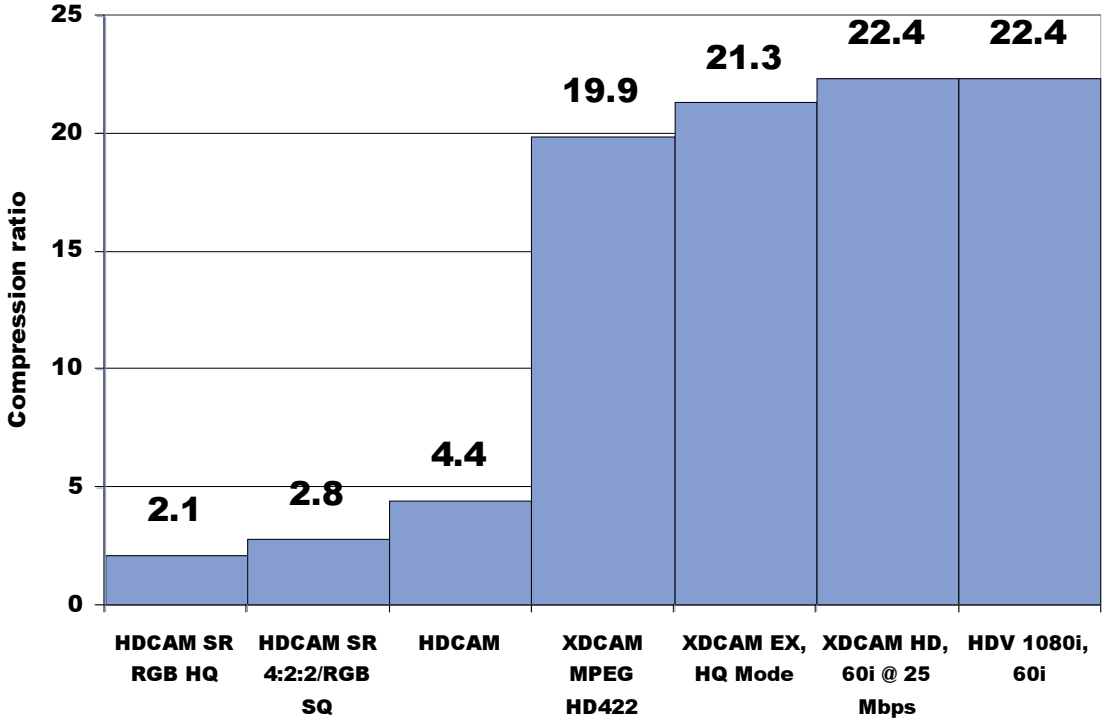


Recorded video bitrates. HDCAM SR HQ mode recording captures more than 30 times as much information as HDV 1080i recording.



System prices for an HD shoot and capture system. Note how closely this chart resembles the recorded video bitrate chart above. This is not a coincidence.

This wide range in recorded video bitrates is also mirrored by a wide range in compression ratios. With its massive bitrate, the HDCAM SR system is lightly compressed, while the affordable HDV and XDCAM HD systems require correspondingly higher compression ratios.



Compression ratios of HD formats. The intra-frame approach works well for the mildly compressed HDCAM SR and HDCAM formats at left. The higher compression ratios on the right take advantage of the inter-frame efficiency of MPEG Long GOP encoding.

Just as a single *format* cannot meet the expectations of all customers, a single *compression scheme* cannot support compression ratios as diverse as 2:1 and 22:1. That's why Sony, a charter member of the Moving Pictures Experts Group (MPEG) and a world leader in video compression technology, chose a range of compression systems.

- HDCAM SR recording uses MPEG-4 Studio Profile. Unlike MPEG-4 low bitrate compression, the MPEG-4 Studio Profile was created for top-quality systems operating at bitrates up to 2 gigabits per second and beyond. The system uses intra-field compression for interlaced signals and intra-frame compression for progressive signals. The system also demands extraordinary processing power. HDCAM SR recorders devote no fewer than *32 million* transistors to the codec chipset.
- HDCAM recording uses proprietary compression. As with other DCT based codecs, it takes advantage of redundancy within a video frame—each pixel of blue sky is almost exactly like the pixel next to it. The HDCAM codec is optimized for recording both interlaced and progressive HD signals.

- **Other Sony systems use MPEG-2 Long GOP compression.** Already ubiquitous in DVDs, HDTV broadcasting and Blu-ray Disc™ packaged media, MPEG-2 brings unique benefits to professional HD production. Thanks to the added power of interframe processing, the MPEG-2 codec is supremely *efficient*, providing exquisite picture quality at modest bitrates. MPEG-2 is also broadly *compatible* with the most popular nonlinear editors and other systems from 33 third-party suppliers. Compared to some recently-proposed codecs, MPEG-2 is *mature*, which means that the full benefits are realized by present-day production systems. Finally, MPEG-2 is *practical*. Conventional PCs can perform MPEG-2 processing at faster than real time.
    - **XDCAM MPEG HD422.** 422 Profile at High Level; 50 Mbps
    - **XDCAM EX HQ Mode.** Main Profile at High Level; 35 Mbps
    - **XDCAM EX SP Mode.** Main Profile at High Level (1440); 25 Mbps
    - **XDCAM HD.** Main Profile at High Level (1440); 35, 25 or 18 Mbps
    - **HDV 1080i.** Main Profile at High Level (1440); 25 Mbps

Link 6: Recording Media

Sony hardware and media are co-developed. For example, the laser optical blocks of Sony XDCAM gear are tailored to the optical properties of Sony Professional Disc media. This close alliance between recording hardware development and recording media development has enabled Sony to offer a full range of HD media, including tape, optical disc, the HVR-DR60 external hard disk unit for HDV 1080i recording as well as SxS Pro™ and CompactFlash® memory. Each recording method has relative strengths and weaknesses in terms of cost, random access, speed of ingest into nonlinear editing systems, and suitability for program exchange and archiving.

Format	HDCAM SR	HDCAM	XDCAM MPEG HD422	XDCAM HD	XDCAM EX	HDV 1080i	HDV 1080i
Media Type	Tape	Tape	Optical	Optical	Flash Memory	Tape	Flash memory**
Representative Media	BCT-40SR	BCT-40HD	PFD-50DLA	PFD-23A	SBP-16	PHDVM63DM	NCFD16GP
Media Cost per minute*	$1.49 @ SQ, 24P***	$0.70 @ 24P***	$0.62	$0.28 @ 25 Mbps	$17.50 @ HQ mode	$0.25	$5.09
Program exchange	●●●	●●●	●●●	●●●	-	●●●	-
Archiving	●●●	●●●	●●●	●●●	-	●●●	-
Speed of NLE Ingest	●●	●	●●	●●	●●●	●	●●
Instant Random Access	-	-	●●	●●	●●●	-	●●●

●●● Excellent ● Good ●● Very Good - Not Applicable

* Based on the average retail selling prices of Sony recording media as of March, 2008.
** CompactFlash memory recording on selected models only.
*** Tape costs per minute vary by recording length, decreasing as length increases.

Link 7: Exchange Media

At the end of a day's shoot, can you simply give the producer the original camera master? After Hollywood production studios complete a TV episode, how do they deliver it to the broadcast networks? These are cases where exchange media becomes a vital part of the workflow. In the first case, affordable, removable camcorder media can keep the workflow simple and direct. In the second case, Hollywood studios, broadcasters and cable networks are increasingly turning to HDCAM SR 4:2:2 tapes. No matter what the origination format, HDCAM SR exchange media protects the picture from visible concatenation errors and transfer losses.

Link 8: Display

Your audience will ultimately watch your finished production on a display. If that display is a 40-foot movie theater screen, any picture flaws and artifacts will be visible for all to see. HDCAM SR and HDCAM acquisition is widely accepted for motion pictures. If the intended display is a 40-inch widescreen television, both XDCAM HD and HDV 1080i will deliver a subjectively pleasing picture.

Home television itself represents a moving target. Modern TV screens look like giants compared to their predecessors from the 1950s and 60s. And the triumph of HD is triggering a mass migration to ever larger TV screens. This trend is likely to continue. At CES 2008, manufacturers were showing prototype flat-screen TVs over 100 inches, diagonal.

The resolution of HD televisions is also evolving. In the early years of HD, industry analysts complained about the absence of home televisions that could actually display a full 1920 x 1080 picture. Now 1920 x 1080 televisions, marketed as "1080p," are available at mainstream screen sizes and price levels. The current crop of 1080p televisions includes LCD flat panels, rear projection televisions and even a few plasma panels. The list of models and brands of 1080p television continues to grow. And CES 2008 saw the unveiling of prototype home televisions with 4K resolution, roughly four times the pixels of 1080p television.

These two trends—bigger screens and full 1080p resolution—will continue to fuel the demand for high definition content of exceptional quality.

Choosing an HD Format

The bits, pixels and compression ratios of production tools are only part—and not the most important part—of telling stories with moving pictures. More depends on the vision, talent and resourcefulness of the artists who use these tools. Sony learned long ago that there are no absolute rules about when to use which equipment. For example, we never recommended the DVCAM™ format for theatrical release movies. But when three famous Hollywood directors made movies with the DVCAM format, we were delighted. And when movies are shot on Sony HDV camcorders, we are also happy. Of course, if anyone does ask our advice, we have definite recommendations about which formats are best suited to which applications on the pyramid.

Format	HDCAM SR 4:4:4	HDCAM SR, 4:2:2	HDCAM	XDCAM MPEG HD422	XDCAM HD	XDCAM EX	HDV 1080i
Digital Intermediate	••••	•••	••	–	–	–	–
3D Productions	••••	••••	••	–	–	–	–
TV program exchange	••••	••••	••	–	–	–	–
Mastering	••••	••••	••	•••	•	–	–
Major Studio Film	••••	••••	•••	•••	••	–	–
Nat'l TV Commercials	••••	••••	•••	•••	••	–	–
High-end Indie Film	••••	••••	•••	•••	••	–	–
Scripted Episodic TV	•••	••••	•••	•••	••	–	–
Cable Production	••	••••	•••	•••	•••	••	–
Indie Film	••	•••	••••	••••	•••	••	••
Documentary	–	•••	••••	••••	•••	••	••
Natural History	–	•••	••••	••••	•••	•••	••
Local TV Commercials	–	–	••••	••••	•••	•••	••
Corporate Video	–	–	••••	••••	•••	•••	••
Religious Video	–	–	••••	••••	•••	•••	••
Government Video	–	–	••••	••••	•••	•••	••
News (ENG)	–	–	–	••••	••••	•••	••
Reality TV	–	–	–	••••	••••	••••	•••
Event Video	–	–	–	–	•••	••••	•••
Wedding Video	–	–	–	–	•••	••••	•••
Unobtrusive Recording	–	–	–	–	–	••••	••••
Crash Cam	–	–	–	–	–	••••	••••
Personal Video	–	–	–	–	–	••	••••

••••	Best
•••	Very Good
••	Good
•	Adequate
–	Not Recommended

Formats and Representative Cameras

Format	HDCAM SR format, 4:4:4 mode*	HDCAM SR format, 4:2:2 mode*	HDCAM format*	XDCAM MPEG HD422 format*
Representative camera	F23**	F23**	HDW-F900R	PDW-700
Typical Lens	Cine style with T-stops, follow focus, fully manual	Cine style with T-stops, follow focus, fully manual	Cine style with T-stops or ENG style with f-stops, fully manual	Interchangeable with f-stops, fully manual
Image Sensors	Three CCDs, 2/3-inch	Three CCDs, 2/3-inch	Three CCDs, 2/3-inch	Three CCDs, 2/3-inch
Sensor Resolution	1920 x 1080	1920 x 1080	1920 x 1080	1920 x 1080
Recorded samples, Y Channel	Red: 1920 x 1080	1920 x 1080	1440 x 1080	1920 x 1080
Recorded samples, Cb Channel	Green: 1920 x 1080	960 x 1080	480 x 1080	960 x 1080
Recorded samples, Cr Channel	Blue: 1920 x 1080	960 x 1080	480 x 1080	960 x 1080
Video quantization	10-bit	10-bit	8-bit	8-bit
Video bitrate after compression	SQ: 440 Mbits/sec. HQ: 880 Mbits/sec.***	SQ: 440 Mbits/sec. X2: 880 Mbits/sec.***	140 Mbits/sec.	50 Mbits/sec.
Compression Type	MPEG-4 Studio Profile, intra-frame / Intra-field	MPEG-4 Studio Profile, intra-frame / Intra-field	Proprietary	MPEG-2 422 Profile at High Level, Inter-frame Long-GOP
Compression Ratio	SQ: 4.2:1 HQ: 2.1:1***	2.8:1	4.44:1	20:1
Frame Rates				
1080/59.94P	Yes	Yes	-	-
1080/50P	Yes	Yes	-	-
1080/29.97P	Yes	Yes	Yes	Yes
1080/25P	Yes	Yes	Yes	Yes
1080/24P	Yes	Yes	Yes	-
1080/23.98P	Yes	Yes	Yes	-
1080/59.94i	Yes	Yes	Yes	Yes
1080/50i	Yes	Yes	Yes	Yes
720/59.94P	-	Yes	-	Yes
720/50P	-	Yes	-	Yes
Audio channels	12 channels	12 channels	4 channels	8 ch. (format) 4 ch. (camcorder)
Audio Coding	PCM	PCM	PCM	PCM
Audio quantization	24 bits	24 bits	20 bits	24 bits
Audio Sampling Rate	48 kHz	48 kHz	48 kHz	48 kHz
Recording Media	1/2-inch fine-grain MP tape	1/2-inch fine-grain MP tape	1/2-inch MP tape	Professional Disc 12 cm blue laser disc

* Features vary by model. Not every camera or camcorder in each format has the features shown here.
** The HDCAM SR portable recorder also docks to the F35 and Genesis™ cameras.
*** Restrictions apply.

Format	XDCAM HD format*	XDCAM EX format, HQ mode*	XDCAM EX format, SP mode*	HDV 1080i format*
Representative camera	PDW-F355	PMW-EX1	PMW-EX1	HVR-Z7U
Typical Lens	Interchangeable with f-stops, fully manual with auto focus option	Fixed lens with full manual focus, zoom, iris; auto options, image stabilization	Fixed lens with full manual focus, zoom, iris; auto options, image stabilization	Interchangeable lens with full manual focus, zoom, iris; auto options, image stabilization
Image Sensors	Three CCDs, 1/2-inch	Three Exmor™ CMOS, 1/2-inch	Three Exmor™ CMOS, 1/2-inch	Three ClearVid CMOS, 1/3-inch
Sensor Resolution	1440 x 1080	1920 x 1080	1920 x 1080	960 x 1080 diamond pattern
Recorded samples, Y Channel	1440 x 1080	1920 x 1080	1440 x 1080	1440 x 1080
Recorded samples, Cb Channel	720 x 540	960 x 540	720 x 540	720 x 540
Recorded samples, Cr Channel	720 x 540	960 x 540	720 x 540	720 x 540
Video quantization	8-bit	8-bit	8-bit	8-bit
Video bitrate after compression	35, 25 or 18 Mbits/sec.	35 Mbits/sec.	25 Mbits/sec.	25 Mbits/sec.
Compression Type	MPEG-2 Main Profile at High Level (1440), Inter-frame Long-GOP	MPEG-2 Main Profile at High Level, Inter-frame Long-GOP	MPEG-2 Main Profile at High Level (1440), Inter-frame Long-GOP	MPEG-2 Main Profile at High Level (1440), Inter-frame Long-GOP
Compression Ratio	16:1 @ 35 Mbps 22:1 @ 25 Mbps 31:1 @ 18 Mbps	21:1 @ 35 Mbps	22:1 @ 25 Mbps	22:1
Frame Rates				
1080/59.94P	-	-	-	-
1080/50P	-	-	-	-
1080/29.97P	Yes	Yes	-	Yes
1080/25P	Yes	Yes	-	-
1080/24P	-	-	-	-
1080/23.98P	Yes	Yes	59.94i with 2-3 pull-down	Yes
1080/59.94i	Yes	Yes	Yes	Yes
1080/50i	Yes	Yes	Yes	-
720/59.94P	-	Yes	-	-
720/50P	-	Yes	-	-
Audio channels	4 channels	2 channels	2 channels	4 ch. (format) 2 ch. (camcorder)
Audio Coding	PCM	PCM	PCM	MPEG-1 Audio Layer II
Audio quantization	16 bits	16 bits	16 bits	16 bits
Audio Sampling Rate	48 kHz	48 kHz	48 kHz	48 kHz
Recording Media	Professional Disc 12 cm blue laser disc	SxS Pro flash memory	SxS Pro flash memory	1/4-inch ME tape or CompactFlash memory

* Features vary by model. Not every camera or camcorder in each format has the features shown here.

SONY

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