HIGH-DEFINITION: THE EVOLUTION OF VIDEO CONFERENCING

Technology Brief

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This white paper defines high-definition (HD) and how it relates to the video conferencing industry today. HD video conferencing standards, requirements, resolutions and formats are discussed, as well as the benefits of HD video conferencing in key industries today such as telemedicine, government and distance learning. Readers of this HD video conferencing brief will be well-informed and will be able to clearly determine when and how to implement HD video conferencing in their organization.

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TABLE OF CONTENTS

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WHAT IS HIGH-DEFINITION VIDEO?

We are all familiar with standard-definition (SD) analog television. It is the television (TV) we have known and watched for decades. NTSC TV (used in North America and a few other parts of the world) displays pictures consisting of 525 lines of resolution at 30 frames per second. PAL TV (used in the rest of the world) displays 625 lines of resolution at 24 frames per second. Still pictures are first drawn on all the odd numbered resolution lines; after that, the same picture information is drawn from the even numbered lines. Given there are two frames painted on the monitor, this is referred to as 50/60 fields per second. This odd/even drawing pattern is called *interlacing*, which was developed to conserve transmission bandwidth (the data rate capacity of a given network connection). This resolution is referred to as 480i, and it provides 240 unique lines of picture information. The bandwidth required for SD at home is 45-90 Mbps.

For small video monitors (less than 27 inches), standard-definition television looks reasonably sharp and smooth. However, as screens increase beyond 27 inches, it is easy to see degradation in picture quality with the 480i format. Jagged lines, blurry outlines, washed-out colors, visual noise, and choppy movements may be noticed.

The *progressive scan* format is an alternative to interlacing that improves picture quality on larger screens. Progressive scanning combines 480 unique lines of picture information into one picture frame and corrects picture quality automatically. Progressive scanning reduces jagged pictures and smoothes movement on larger monitors. For standard-definition television, this resolution is known as 480p.

True high-definition video displays picture resolutions of 1080i or 720p. Resolutions other than these are not truly high-definition.

Of the many formats available, the following six are considered true high-definition formats.

Format	Frames per second	Aspect Ratio
720p	24	16:9
720p	30	16:9
720p	60	16:9
1080i	30	16:9
1080p	24	16:9
1080p	30	16:9

The high-definition formats provide more visual information than any standard-definition format. If the screen resolutions are converted to pixels, it is easy to see that the high-definition formats can provide at a minimum up to four times more visual information than the 480i format. The following table gives the screen resolution in pixels for the common formats and aspect ratios.

Format	Pixels (16:9 ratio)	Pixels (4:3 ratio)
1080p	2,073,600 (1920 X 1080)	1,576,800 (1460 X 1080)
1080i	1,036,800 (1920 X 540)	788,400 (1460 X 540)
720p	921,600 (1280 X 720)	691,200 (960 X 720)
480p	412,800 (860 X 480)	307,200 (640 X 480)
480i	206,400 (860 X 240)	153,600 (640 X 240)

To understand this visually, think of the television screen as a computer monitor. Imagine what would happen to the quality of a 640 X 240 (480i equivalent) low-resolution digital picture if stretched across a 42-inch screen. The image would be distorted due to not enough picture information being available to provide a high quality view of the low-resolution picture. The increased pixel count inherent in the high-definition formats provides better picture quality and makes viewing images on larger screens clearer and easier to watch. In video conferencing, this enhances the overall viewing experience and eliminates meeting fatigue. Colors are also more vibrant and realistic, and movements are sharp and smooth.

What Are the Standards for High-Definition Video Conferencing?

Before high-definition encoding/decoding, video conferencing data was encoded based on the *Common Interchange Format* (CIF). Video standards, known as H.261 and H.263, were developed by the International Telecommunications Union – Telecommunication Standardization Sector (ITU-T). With the H.261 standard, only the QCIF and CIF formats were defined. The *Quarter CIF* (QCIF) format was applied for conferences at only the lowest data rates (64 Kbps and below) and is rarely used today. Once the H.263 standard was released, more formats (4CIF and 16CIF) were introduced with "full resolution" being defined as 16CIF. Due to the computational and bandwidth limits at the time these standards were adopted, the common resolution used for full motion video conferencing continued to be CIF to 4CIF. The following table shows corresponding format resolutions for the H.261 and H.263 standards for NTSC (North American) and PAL (European) video signals. The resolutions listed below represent 4:3 aspect ratios.

Format	Frames Per Second	Resolution - NTSC	Resolution - PAL
QCIF	30	176 X 120	176 X 144
CIF	30	352 X 240	352 X 288
4CIF	30	708 X 480	708 X 576
16CIF	30	1408 X 960	1408 X 1152

The ITU-T has recently adopted new standards for video compression, the process through which a complete video file is reduced in size so it can be transmitted more economically over a smaller network connection (lower data rate / bandwidth). For high-definition video conferencing, the ITU-T now recommends the H.264 video standard which provides superior quality at relatively low data transfer rates. H.264 is now a mandatory standard for HD-DVD (high-definition DVD), as well as for broadcast, cable, video conferencing, and consumer electronics products. The following table shows the SD and HD resolutions introduced in the H.264 standard.

Format	Frames per second	Resolution (16:9)	SD/HD
1080p	24,30	1920 X 1080	HD
720p	24,30,60	1280 X 720	HD
480p	24,30,60	860 X 480	SD

The H.264 profile is an ideal fit for video conferencing. Although it requires more processing power than the previous H.26x algorithms, most video conferencing systems produced in 2004 and beyond include H.264. It provides good video transfer and low-latency encoding and decoding that result in smoother, more natural video flow. In fact, H.264 is twice as efficient as H.263, resulting in twice the video quality at any given line rate. In addition, some enhanced H.264 profiles include error concealment algorithms for interactive video that adjust video handling automatically to operate smoothly and provide a higher quality experience even within an overtaxed, unstable or error-prone network.

The H.264 encoding standard provides greater flexibility and a common ground for interoperability across manufacturers. Unlike the H.263 standard which allowed a wide range of possible variations, the H.264 standard encompasses far fewer compression techniques. This should make integration of video conferencing equipment from multiple vendors more realistic without a significant loss in video quality.

How Does HD Video Conferencing Compare to HD Television?

High-definition television is a one-way broadcast. Television networks transmit (broadcast) video in one direction. High-definition video conferencing is a two-way, interactive process that transmits audio and video data in real-time, back and forth across a network. To achieve high-definition video conferencing, all endpoints in the conference must be high-definition enabled.

High-definition television broadcasts achieve consistent signal quality, whereas video conferencing quality can be compromised due to the large amounts of data transmitted over the network. Processing delays, known as *latency*, can occur due to the encoding/decoding process and the time it takes to transmit large blocks of data over the network. Excessive latency increases the chances of people talking over each other and increases the likelihood that video may not stay in synch with the audio. While higher latency is typically most noticeable from an audio perspective, poor audio can severely reduce the overall quality of the entire video conferencing experience.

What Are the Requirements for High-Definition Video Conferencing?

High-definition video conferencing requires that all endpoints be HD-compatible in order for any of the video conference participants to take advantage of the high-definition video experience. In addition to having endpoints with high-definition data compression, an important consideration in achieving top-quality video conferencing is network bandwidth. A data transfer rate of 1 Mbps is the minimum requirement for high-definition interactive video conferencing. For optimal results, data transfer rates at or above 2 Mbps are recommended to allow incremental bandwidth for premium audio and additional content sharing devices such as PC input, DVD's or high-resolution document cameras. Quality of Service (QoS) for the network is a must to ensure consistent performance for the duration of video conferencing calls.

To capture high-resolution images, a camera that supports true high-definition (minimum 720p) in the 16:9 format is required. Ideally, the camera should come from the same manufacturer as the video conferencing endpoint. This will ensure that the camera and endpoint have been optimized for providing the best end-to-end high-definition video conferencing experience.

High-definition video monitors (LCD, Plasma, or DLP) must also support a minimum of 720p horizontal lines of resolution. Additionally, the monitors should offer connectors that enable optimal high-definition

signals, such as DVI-I (Digital Visual Interface) or component YPrPb. DVI cables longer than 5 meters could cause degraded or unpredictable video display. Purchasing high-definition monitors and endpoints with flexibility and correct connectivity eliminates this concern.

Correct monitor selection will also require matching the size of the room and the average distance participants will sit from the monitor. For large conference rooms where participants sit 10 to 15 feet from the monitor, a monitor that is at least 50 inches is recommended. The following table matches screen sizes and typical viewing distances.

Screen Size 16:9	Viewing distance
30 in.	6.25 ft.
34 in.	7.0 ft.
42 in.	8.75 ft.
50 in.	10.4 ft.
57 in.	11.9 ft.
60 in.	12.5 ft.
65 in.	13.5 ft.

For high-definition multipoint video conferencing, where more than two parties plan to participate from different sites (endpoints), a high-definition Multipoint Control Unit (MCU) is required for bridging all of the calls together. Of course, the MCU must also support true high-definition (minimum 720p) and a sustained 30 frames per second, to deliver the same quality experience provided in point-to-point calls. Purchasing an MCU from the same manufacturer as the video conferencing endpoints is highly recommended to ensure optimal end-to-end performance. Finally, the MCU should be standard-based (H.264) for interoperability and scalable to allow as many connections as required for multipoint calls.

What Are the Benefits of High-Definition Video Conferencing?

There are numerous benefits from high-definition video conferencing. First, clear, crisp picture quality and synchronized audio with minimal latency helps to maintain focus and provide an effective, high-quality video conferencing experience. For example, projecting images in the 16:9 aspect ratio offers a wider presentation angle that enables more meeting participants to be on camera and fully engaged in the meeting at hand.

Second, enabling the transmission of high-resolution content such as blueprints, flowcharts, maps, or photographs with superior clarity benefits knowledge workers that rely on critical communications. For example, high-definition video conferencing allows doctors in distant locations to meet and review X-Rays, MRI images, ultrasound results or ECG printouts with enough detail to make informed decisions. Sharing PowerPoint slides, Flash presentations, software demonstrations and other training events are far more impactful, enjoyable and memorable when the material content can be seen or read on-screen without causing eye fatigue. Clear images combined with the smooth motion also make sign language easy to follow for hearing-impaired conference participants.

In conclusion, high-definition technology broadens the quality and range of information communicated through video conferencing to create a valuable communication tool for business, distance learning, telemedicine, community, government, and charitable activities.