

HD Videoconferencing

***Three Leading Contenders
Face Off***

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About Wainhouse Research

Wainhouse Research (WR) is an independent market research firm that focuses on critical issues in the Unified Communications and rich media conferencing fields. The company conducts multi-client as well as custom research studies for industry vendors and consults with end users on key implementation issues. The firm also publishes a news bulletin, white papers and market statistics, and delivers public and private seminars as well as presentations at industry meetings.

Areas of concentration for Wainhouse Research include:

- Unified Communication products, applications, services, and vendors
- Audio, video, and web conferencing products, applications, services, and vendors
- Streaming products, applications, services, and vendors
- Instant Messaging and Presence server products, services, and vendors
- Conferencing infrastructure products including media servers, gateways, bridges, and broadband access devices

Wainhouse Research analysts have been quoted in the Wall Street Journal, New York Times, Washington Post, Boston Globe, Philadelphia Inquirer, Fortune, Business Week, PC Magazine, the Economist, and other leading publications

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Wainhouse Research has been asked to clarify the way this project was organized and supported by the vendors.

WR invited five manufacturers of HD videoconferencing equipment to participate in a head-to-head evaluation by providing Wainhouse Research with loaner equipment and with financial support. Tandberg, Aethra and Sony declined to take part. LifeSize and Polycom chose to participate and agreed to pay for the study and provide loaner equipment.

WR unilaterally decided to include Tandberg (but not Aethra or Sony) nevertheless because of that company's important position in the videoconferencing marketplace. WR notified both LifeSize and Polycom of that decision before beginning the testing. Tandberg was not informed of the decision to include its codecs in the study and was not aware of the study or its results until after the report was made public.

The Tandberg equipment used in the evaluation was borrowed from a Tandberg reseller without Tandberg's knowledge. The two 6000 MXP codecs borrowed from the 3rd party were running V6.0 of the software, a version that was current at the time of the original testing (August 13-17). By the time the final tests were completed and the report was released, however, Tandberg had released V6.1. Based on the release notes for V6.1, WR believed that the updated software would not affect the results of our testing. We acknowledged and documented within the report that the Tandberg codecs we used were limited by software license to support 1.5 Mbps of bandwidth and did not have the highest bandwidth options installed.

As paying participants, LifeSize and Polycom provided codecs with the latest software and options. One of these two companies also provided bug fixes during the testing. The Polycom software used, V2.0, was announced the same day the report was released, but was not generally available for shipping until November 3.

As paying participants, LifeSize and Polycom were given the opportunity to review the results and correct technical errors before the report was made public. Tandberg was not given this opportunity. Based upon these and the other factors recited above, Tandberg has notified WR that Tandberg believes the study to be deeply flawed and of little value.

Independently, LifeSize Communications has expressed very strong disagreement with both the results of our study as well as the methodology (detailed extensively in the agreed-upon statement of work and in the final report) used by Wainhouse Research.

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Chapter 1: Summary

High definition (often referred to as 720p) videoconferencing products started shipping in December 2005 when LifeSize began delivery of its first product, LifeSize Room. By the end of that year, market leaders Tandberg and Polycom had also announced HD capabilities, and Sony started actively demonstrating the PCS-G90, an HD-only video system targeting the broadcast industry.

With high definition (HD) videoconferencing systems, the improvement in video quality over standard definition (SD) videoconferencing can be quite dramatic since HD carries more than 9x the pixel count of standard CIF videoconferencing images. The HD videoconferencing systems in the market today offer a wide range of price and functionality. To separate fact from fiction, Wainhouse Research put three leading HD video systems (LifeSize Room, Polycom HDX 9002, and Tandberg 6000 MXP) through a series of subjective, side-by-side comparisons and tests. Key areas of focus included:

- Differences (if discernable) in image quality and sound fidelity
- Interoperability between HD and SD systems from different vendors
- Capabilities, feature-set, and usability of each solution

As a part of this evaluation, WR made scores of test calls, across our internal IP local area network (LAN) and over the Masergy MPLS network, between the three HD systems and various SD systems.

WR would like to express our appreciation for the cooperation of the following companies: Aethra, Emblaze-VCON, Huawei, LifeSize, Masergy, Polycom, Radvision, and Sony.

Top-Level Findings

- 1) Although the three HD video systems evaluated perform very differently in many ways, they all provide what we'd call an acceptable business quality HD resolution videoconferencing experience.
- 2) In addition, for all three HD systems tested we were pleased with the support for encryption and H.239, the performance of the internal MCUs, and interoperability with SD systems.
- 3) The Polycom HDX 9002 system, the most expensive of the three models tested, excelled for its video quality, audio quality, and multimedia performance. The system's embedded MCU was also a notable strength. We recommend the Polycom HDX 9002 to anyone concerned with all-out AV performance and robust I/O connections.
- 4) The LifeSize Room system shined for its low price, strong support for intermediate resolutions, and exceptional multipoint capabilities. The LifeSize Room system, with its included speakerphone and embedded multipoint, is a solid performer and an exceptional value proposition for anyone moving to HD videoconferencing. The camera and user interface, however, are in need of improvement.
- 5) The Tandberg 6000 MXP performed consistently, but the use of static macro blocks impacted interoperability and incoming video quality under high motion conditions. In addition, the Tandberg's embedded MCU was the only one evaluated that did NOT support HD resolution in continuous presence mode. The Tandberg HD product line is best suited for all-Tandberg deployments.
- 6) After completing hundreds of HD to HD test calls, WR makes the following sharpness vs. motion recommendations.
 - i) LifeSize Room and Tandberg 6000 MXP users conducting low bandwidth calls (384 or 768 kbps) should set these systems to favor motion. Setting these systems to favor sharpness at these call speeds will yield connections at frame rates far below 30 fps.
 - ii) Polycom HDX 9002 users should set the HDX to favor sharpness because
 - a) this system is able to provide a full-motion video experience at any call speed under this setting, and b) favoring sharpness will force the system to use HD720p resolution at 1152 kbps (compared to 1920 kbps when set to favor motion).

Overall Results

The table below shows the ranking (1 = 1st place, etc.) for each of the evaluated systems in a variety of comparison areas.

	LifeSize Room	Polycom HDX 9002	Tandberg 6000 MXP
User Interface	3	1	2
Camera Quality / Performance	3	1	2
Video Quality	2	1	3
Audio Quality	2	1	2
HD Interoperability	1	1	3
SD Interoperability	1	1	1
Multimedia Performance	2	1	3
H.239 Performance	1	1	1
Internal MCU Performance	1	2	3
Price	1	3	2

Figure 1: Overall Results

Test Call Summary

The table below provides an overview of the test calls performed as a part of this project.

Call Numbers	System Types	Like to Like Calls	Video Quality Setting	H.239	Comment
A-S01 to A-S15	HD to HD	Yes	Sharpness	No	
A-S16 to A-S18	HD to HD	Yes	Sharpness	Yes	
A-M21 to A-M35	HD to HD	Yes	Motion	No	
A-M36 to A-M38	HD to HD	Yes	Motion	Yes	
A-M41 to A-M49	HD to HD	Yes	Motion	No	Low Light Level
B-S01 to B-S15	HD to HD	No	Sharpness	No	
B-S16 to B-S18	HD to HD	No	Sharpness	Yes	
B-M21 to B-M35	HD to HD	No	Motion	No	
C-M01 to C-M12	HD to SD	No	Motion	No	Polycom testing
C-S13 to C-S24	HD to SD	No	Sharpness	No	Polycom testing
C-M25	HD to SD	No	Motion	Yes	Polycom testing
C-M31 to C-M42	HD to SD	No	Motion	No	Tandberg testing
C-S43 to C-S54	HD to SD	No	Sharpness	No	Tandberg testing
C-M55	HD to SD	No	Motion	Yes	Tandberg testing
C-M61 to C-M72	HD to SD	No	Motion	No	LifeSize testing
C-S73 to C-S84	HD to SD	No	Sharpness	No	LifeSize testing
C-M85	HD to SD	No	Motion	Yes	LifeSize testing
D-S1A to D-S1C	HD to HD	No	Sharpness	Yes	Polycom MCU Testing
D-S2A to D-S2D	HD to HD	No	Sharpness	Yes	LifeSize MCU Testing
D-S3A to D-S3C	HD to HD	No	Sharpness	Yes	Tandberg MCU Testing

Figure 2: Test Call Summary

In the table above, “Like to Like” calls indicates whether the test calls were placed between the same systems (e.g. Polycom HDX 9002 to Polycom HDX 9002, etc.) or between different systems (e.g. LifeSize Room to Tandberg 6000 MXP).

Chapter 2: Reviewers Choice #3 Tandberg 6000 MXP



The Tandberg 6000 MXP is a rack mount unit designed for integrators. The device supports up to five video and six audio inputs (three mic and three audio) and features XLR connectors for the mic inputs. Out of the box, the codec supports 1.5 Mbps of IP video calls. With an optional software license, the supported bandwidth can be increased to 4 Mbps for IP and 2 Mbps for ISDN. Our test unit was limited to 1.5 Mbps, and we did not test ISDN functionality as a part of this evaluation. The optional embedded bridge can support up to 5+1 video sites (plus 5 audio sites) over a combined IP and ISDN bandwidth of 6 Mbps.



Overall, the Tandberg 6000 MXP provides acceptable audio-video quality. However, unlike the LifeSize Room and Polycom HDX units which were designed from the ground up for HD and support true 30 fps HD resolution signals, the Tandberg 6000 MXP is an SD system now tasked with processing HD resolution. As a result, the 6000 MXP's HD performance was marred by limitations and weaknesses, some of which are listed below, that prompted us to rate the unit third out of the three units tested. Note that some of these items may go unnoticed by end users who do not install the systems themselves, conduct only Tandberg-to-Tandberg video calls, or use multi-sync HD / XGA capable displays.

Understanding Tandberg's HD support requires an understanding of macro blocks. H.264 video images are comprised of macro blocks (16x16 arrays of pixels). To generate a full motion (30 fps) HD (1280x720) video signal, a video system must send 108,000 macro blocks¹ as shown below (see the green highlighted entry). Similarly, in order to receive and display a full motion (30 fps) HD video signal, a video system must be able to receive or decode 108,000 macro blocks.

The Tandberg 6000 MXP can decode a maximum of ~35,000 macro blocks. This limit makes the 6000 MXP an exceptional performer for receiving enhanced resolution signals like w288p (it can receive a full 30 fps), w448p (able to receive 26 fps), and 4SIF / 4CIF (at which it can receive 26 and 22 fps respectively). However, at HD (1280x720) resolution, the 6000 MXP's macro block capability limits its decoding frame rate to ~10 fps (see the purple highlighted entry below) or 30 fps where only one-third of the frame is new information. The remaining two-thirds of the frame contain what are called static macro blocks.

¹ To calculate the macro blocks in a signal, multiply the frame rate by the number of pixels per frame, and divide by the number of pixels per macro block. A 30 fps 1280x720 signal, for example, includes a total of 108,000 macro blocks. $(30 \times (1280 \times 720)) / (16 \times 16) = 108,000$

Resolution	Pixels		Block Req'd at each Frame Rate			Max FPS with 35,000 Blocks
	H	V	10	20	30	
SIF	352	240	3,300	6,600	9,900	106.06
CIF	352	288	3,960	7,920	11,880	88.38
w288p	512	288	5,760	11,520	17,280	60.76
w448p	768	448	13,440	26,880	40,320	26.04
4SIF	704	480	13,200	26,400	39,600	26.52
4CIF	704	576	15,840	31,680	47,520	22.10
w4CIF	1024	576	23,040	46,080	69,120	15.19
XGA	1024	768	30,720	61,440	92,160	11.39
HD (w720p)	1280	720	36,000	72,000	108,000	9.72

Figure 3: Macro Blocks and Frame Rates for Video Resolutions

Static macro blocks are a part of the H.241 standard. By using static macro blocks, Tandberg is able to achieve HD resolution, at the expense of motion handling. In low-motion situations (ex. talking head videoconferencing meetings), it is likely that less than 35,000 of the total 108,000 macro blocks will change, which means the Tandberg can decode a sufficient number of macro blocks to render an acceptable image. In high-motion situations (full motion video clips, camera zooms, etc.), the motion handling will be lacking.

By comparison, the Polycom HDX 9002 and LifeSize Room systems can decode more than 108,000 macro blocks.

One interesting item ... we noted that the word “high definition” does not appear anywhere on the 6000 MXP’s [detailed specification sheet](#). The spec sheet does, however, reference support for 1280x720 resolution images. Readers should note the subtle difference; supporting the standard for 720p resolution means supporting both the image resolution (1280x720) and the frame rate (24 fps is the accepted minimum requirement for a true HD signal). The 6000 MXP supports the image resolution, but does not *technically* support the minimum required frame rate.

During our Tandberg 6000 MXP testing, we noted the following points:

1) Weak HD Support

- The system’s default output resolution is XGA (1024x768) and specifically NOT HD 720p (1280x720). While significantly better than CIF, XGA images contain 17% fewer pixels than HD images. In the software release evaluated (F6.0), activating HD resolution required the user to run telnet and issue the following command (without the quotes): “xConfiguration Video Outputs AllowHD720p: On”. Apparently Tandberg added this command to the on-screen UI in its F6.1 software release (issued a few weeks after WR conducted our testing on the 6000 MXP system, but not tested by WR).
- The 6000 MXP’s HD motion handling at 1536 kbps is poor compared to the HD motion handling of the competing systems at 1152 kbps. WR believes this is at least partly due to the use of static macro blocks to increase the frame rate at HD resolution.

2) Weak HD Interoperability

The 6000 MXP's HD interoperability with other HD-capable video systems is limited by its use of static macro blocks. The use of static macro blocks is within the H.241 standard, so most systems know how to receive them. However, only some systems (ex. Aethra, LifeSize, and Codian MCUs) generate static macro blocks. Systems that do not generate static macro blocks accommodate the Tandberg 6000 MXP by sending either HD resolution at low frame rates or lower resolutions at higher frame rates.

We hasten to add, however, that the 6000 MXP's support for w448p video is very strong, and that many users may be unable to distinguish this enhanced resolution from "true" HD.

3) Inconsistent DVI Output

We noted that the resolution presented at the DVI output of the Tandberg 6000 MXP seemed inconsistent. When NOT in a call (and viewing the local 720p camera), the output was either XGA or HD resolution (depending upon whether the system was set to "AllowHD720p" or not). When in a call, however, the resolution was based on the incoming video resolution from the far end. If the incoming video signal was HD (or XGA), the DVI output would provide an HD (or XGA) resolution signal. If the incoming signal was SD, the DVI output would be SD. Since the resolution of the DVI output appears to change with the input, users would be well advised to use only multi-sync XGA/HD displays (see next bullet point). This issue has other implications as well.

Imagine a multipoint video call in voice activated switching (VAS) mode that is hosted on an HD-capable external MCU (Codian, Polycom, Tandberg, etc.). If an HD person speaks, HD-capable endpoints would receive an HD signal. If a non-HD person speaks, the endpoints would receive an SD signal. In this case, a Tandberg HD system participating in this call would switch from sending an HD signal to its display to sending an SD signal. The best-case scenario would be that the display would compensate and re-sync to the new resolution (after a few second delay). The worst-case would be that the display would not sync to the different resolution and the screen would go black. This situation should not be the case. Note that both the LifeSize Room and Polycom HDX 9002 maintained a consistent HD720p output signal at all times – regardless of connection state.

4) Other Issues

a) Display Compatibility

For the testing, WR used three identical Sharp Aquos LC-26DA5U 26" HD (720p) displays, each offering three HD inputs (two component and one HDMI) as well as S-video. After sourcing the proper cable (DVI for the Tandberg 6000 MXP and HDMI for the Sharp display), we noted an apparent incompatibility between the systems and the displays. Only one of the two Tandberg 6000 MXP's provided an HD-resolution signal that the Sharp displays could display, and only two of the three Sharp displays could successfully display the Tandberg provided HD-resolution signal at all. We believe this is related to output signal tolerances on the Tandberg (probably very tight to spec) and the display (likely a bit more forgiving). Either way, the 6000 MXP codec appears most comfortable with an XGA or WXGA (1366x768) display.

b) H.239 Bandwidth Allocation

Based on our testing, when H.239 is in use, it seems the Tandberg 6000 utilizes 25% to 55% of the call bandwidth for the H.239 data channel. Although the actual bit rate used for H.239 depends upon the degree of motion in the image, the bandwidth reserved for H.239 does not drop down to zero (as it does on the Polycom system).

c) Impact of H.239 on Video Resolution

Although not formally documented within this report, WR also conducted a number of H.239 test calls with all systems set to favor motion. During this testing we noted that when the Tandberg 6000 MXP was sending HD resolution, activating H.239 would cause it to drop the outgoing video resolution. For example, during a 1472 kbps test call between the Tandberg 6000 MXP and the Polycom HDX 9002, activating H.239 caused the Tandberg to drop its send resolution from HD720p to w448p.

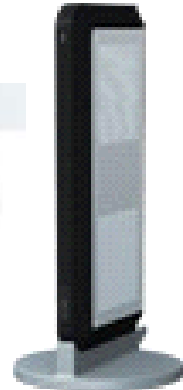
We also noted that during some HD or enhanced resolution calls, the responsiveness of the system to hand-held remote commands seemed sluggish. These items are likely related to the 6000 MXP's limited processing power.

d) Stereo Audio Support

Tandberg claims to support stereo audio --- and it does. However, the stereo audio support is for the "program" audio only, not for the microphone inputs (of the units tested, only the Polycom HDX 9002 supported stereo microphone audio). The Tandberg system backplane / IO is confusing on this point as well: To access stereo program audio, you actually use the mono VCR jack for R audio and the mono aux audio jack for L audio.

Chapter 3: Reviewers Choice #2 LifeSize Room

LifeSize Communications entered the videoconferencing market in April 2005 with the announcement of its first products and the industry's first high definition videoconferencing system. The start-up company caused quite a stir in the market with claims of performance that other systems could not match at a mainstream of the market price. The company's debut product (LifeSize Room), however, did not really begin to ship to customers until Q1-06, by which point Polycom and Tandberg were under way with their catch-up efforts.



LifeSize Room is a complete HD videoconferencing system that includes support for HD (720p) video at 30 frames per second, wideband AAC audio, a 4-way embedded bridge, and an integrated speakerphone / microphone array (including 16 mics). The system has a list price of \$12K (including the multipoint capability), offering customers a very cost effective solution for high definition videoconferencing. For those who do not need an embedded bridge, a second camera input, or support for two monitors, LifeSize also offers the LifeSize Team product (available for a list price \$8k and providing the same general performance).

During our LifeSize Room system testing, we noted the following points:

1) Overall Performance

The LifeSize codec provided a solid videoconferencing experience at all bandwidths tested. Motion handling was generally excellent, and its \$12k price point sets this codec into a value / performance class of its own.

2) Video Resolutions Supported

The LifeSize codec handles an extensive list of resolutions between CIF and HD, allowing users to get the best video for the available bandwidth. This is a notable power feature of the LifeSize platform.

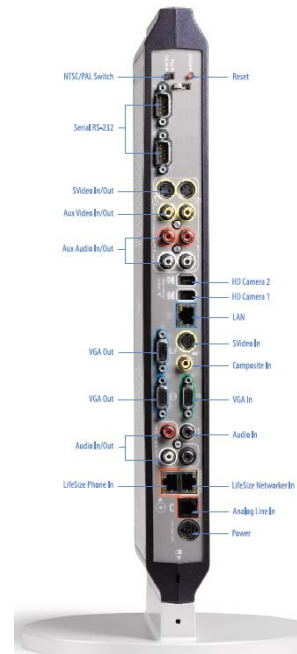
3) Embedded MCU

LifeSize's Virtual Multipoint feature allows LifeSize users participating in multipoint sessions to select (using the Call button on the remote) which video images to display in the main window, all while maintaining HD resolutions to HD-capable systems. This is definitely a power feature of the LifeSize Room system.

4) Camera Issues

The testing revealed some weaknesses in the system camera. Specific points include:

- The camera more than occasionally had difficulty maintaining focus.
- The 4x zoom offered by the LifeSize Room camera was weak compared to the 12x and 7x zooms offered by Polycom HDX 9002 and Tandberg 6000 MXP



respectively. Users seeking a greater zoom range can use a Sony HD EDI-1 camera (requires the purchase of the LifeSize SDI adapter).

- The color balance of the camera was notably off, although this may be related to our use of 4100 degree Kelvin lighting (which did not match any of the options in the LifeSize setup menu). In general, though, the unit did not seem to provide true color renditions no matter what we tried. It is worth pointing out that our assessment here was purely subjective, based on a side-by-side comparison of the image provided by each system's camera. We did not use test and measurement equipment for this part of the evaluation.
- The camera's performance in low-light-level conditions was also weak.

5) User Interface

The videoconferencing industry has never standardized on a single user interface. Even something as simple as placing or hanging up a call requires different clicks on the IR remotes / web interfaces from different vendors.

After many hours of using the system, we find that although the LifeSize Room user interface (hand held remote and web) is responsive, it is also cumbersome and somewhat counter-intuitive. Specifically, we have difficulty with the use of context-sensitive buttons to minimize the number of buttons on the remote, as this creates a need to read the on-screen prompts carefully (until one becomes totally familiar with the menu structure). That said, we believe that users can become accustomed to any user interface over time, and that personal preference plays an important role.

Chapter 4: Reviewers Choice #1 Polycom HDX 9002



Polycom introduced its first high definition videoconferencing endpoints in October 2006. The HDX series is based on an all-new hardware platform and consists of the HDX 9001, 9002, and 9004. The table below shows the key differences between the models.

	HDX 9001	HDX 9002	HDX 9004
Video Resolution	4CIF	HD (720p)	HD (720p)
Internal MCU	4-way	4-way	8-way
Max. Bandwidth	4 Mbps	6 Mbps	6 Mbps
MSRP (codec only)	\$13,999	\$15,999	\$19,999

Figure 4: Comparison of HDX 9000 Versions

The higher end HDX 9004 also has an additional video and audio input and output and RS232 connection vs. the HDX 9002. Although not available at the time this testing was conducted, Polycom has informed Wainhouse Research that a new series of HDX products, the HDX 8000, is about to be released. The HDX 8000 series starts at \$10,999 and includes the HD-capable codec, the EagleEye HD camera, HDX microphone array, and support for 2 Mbps of bandwidth (upgradeable to 4 Mbps).

During our testing of the Polycom HDX 9002, we noted the following points:

1) Audio Performance

The Polycom HDX 9002 we tested offers extraordinary audio performance using the company's Siren-22 wideband audio and two-channel (stereo) sound. The wideband algorithm provides excellent clarity and fidelity for speech signals, and the stereo adds an enjoyable element of realism (depending on the configuration of the speakers and microphones). We noted that even with the single microphone array that comes standard with the system, the stereo audio pickup was excellent. When we asked the speaker to move around the room while speaking, the participant on the far end could easily detect that the person had moved from one side of the room to the other. None of the other systems tested offered true stereo support for the microphone inputs.

2) Full Motion HD Video Input

The HDX 9002 was the only unit tested that allowed HD signals from a DVD player to be transmitted in full motion HD resolution. While true that watching Seabiscuit at the remote end of a video call is probably not a common business event, it did demonstrate the power of the HDX 9002 codec and its ability to handle a wide variety of audio and video motion content with nary a hiccup. The performance was very similar to what we have perceived when watching HD television.



3) Camera Performance

The Polycom camera produced excellent color rendition and the best low-light performance of the systems evaluated. It also offered the largest zoom range. The ability to zoom in close when needed during a call is always a welcome feature. While all three systems had trouble at times holding focus, the Polycom camera performed the best in this area.

4) User Interface

Of the three systems evaluated, the testing team preferred Polycom's user interface. The IR remote was comfortable in the hand and the system was responsive to any command requests. In addition, the remote includes the industry's first LCD display; a feature that we didn't use often, but expect will become extremely useful and even commonplace on remotes in the future. In addition, we were able to easily navigate Polycom's web UI. We especially appreciate that the Polycom UI (both on-screen and web) provides full statistics – including frame rate information - for those of us who are curious about such things.

5) System Packaging

The HDX 9002 is very "integrator-friendly" sporting BNC connectors for many of the video ins and outs, Phoenix connectors for audio, and support for stereo and balanced audio. The I/O is also extremely flexible, generally allowing the installer to use each input and output for any compatible signal.

Chapter 5: Equipment and Environment

Videoconferencing Endpoints

The following videoconferencing endpoints were utilized during the testing.

Qty	Manufacturer	Model	Software Version	MSRP as Tested (in US \$)
HD Systems				
2	LifeSize	Room	LS-Rm1_3.0.1(1)	\$12,000 ¹
2	Polycom	HDX 9002	2.0.0.-2198	\$24,500 ²
2	Tandberg	6000 MXP	F6.0 NTSC	\$22,490 ³
SD Systems				
1	Polycom	VSX-3000	8.7	
1	Tandberg	880MXP	F6.0 NTSC	
1	Huawei	8039	5.3.12	
1	Aethra	Vega X3	10.02.0014	
1	Sony	G-50	Host: 2.5 / DSP 03.56	
1	Emblaze-VCON	HD-3000	7.1.97	

Figure 5: HD and SD Video Endpoints Used During the Evaluation

¹ The LifeSize Room system included the following items: Codec, embedded 4-way MCU, HD camera, and microphone array/speakerphone (for a single price of \$12k).

² The Polycom HDX 9002 included the following items: \$16k codec, \$3k embedded 4-way MCU, \$5k HD camera, and ~ \$0.5k microphone array (for a total price of \$24.5k).

³ The Tandberg 6000 MXP included the 6000 MXP integrator kit (\$17,490) plus the natural presenter package (\$2,000) and the embedded MCU (\$3,000).

HD Camera Summary

	LifeSize Room	Polycom HDX 9002	Tandberg 6000 MXP
Pan	+/- 90 degrees	+/- 100 degrees	+/- 90 degrees
Tilt	+/- 45 degrees	+20/-30 degrees	+10/-20 degrees
Optical Zoom	4x	12x	7x
Field of View at minimum zoom	70 degrees	72 degrees	70 degrees horizontal 42 degrees vertical
Sensor	1280x720p CMOS	1280x720p CCD	1/3" CMOS
Price	Included with codec (\$2,999 for 2 nd camera)	\$4,999	\$6,300

Figure 6: HD Video Systems - Camera Comparison

All wide angle lenses, included those in the HD cameras evaluated, exhibit some degree of distortion. This is usually seen as straight lines that are curved at the edges of the image – especially at the widest zoom setting. We noted this during our testing, but still found the overall performance of the cameras to be better than average and even excellent under most conditions.

HD Displays

3 x Sharp 26" HD-Capable LCD Displays (720p)
Model # AQUOS LC-26DA5U

WR used three identical displays for all side-by-side tests to ensure a fair playing field for all video quality assessments. WR connected both Polycom HDX 9002 systems to one display, both LifeSize Room systems to a second display, etc. All SD systems were connected to non-HD displays (televisions or monitors) in order for us to verify call connectivity, but were not used for image or sound quality evaluations. At the start of the testing, WR set the contrast and brightness settings for all three displays to the same values.

XGA Display

1 x Acer 22" LCD Display
Model #AL2223W

Although our original intention was to use only HD-capable displays for the testing, we had to use an XGA display for the Tandberg 6000 MXP codec because of display interoperability issues and the inconsistent resolution provided by the DVI output of the codec (see the Tandberg section below for detailed information).

HD DVD Player

For the HD input signal testing, WR used a Toshiba HD-A2 HD DVD player capable of outputting both HD and SD signals. Our DVD of choice for the testing was the movie Seabiscuit.

Additional Devices / Meters

- 1) A Reed LM-81LX light meter, accurate to +/- 1 Lux, was used to measure the light levels in the test lab.
- 2) An Extech sound level meter, accurate to +/- 2 dB, was used to measure the sound levels within the test lab.

Gatekeeper / Dial Plan

For the testing, WR used a Radvision ECS gatekeeper in direct (non-routed) mode and assigned each system an E.164 alias.

Network

Each system was assigned an IP address within the public IP address space assigned to WR's Atlanta office. The majority of the video traffic remained local (on the LAN) within our facility. The only exceptions were the internal MCU test calls, during which external endpoints hosted on the Masergy MPLS network also participated in the test calls.

General Items:

- 1) The testing included only IP video calls (no ISDN).
- 2) The Polycom HDX 9002 and Tandberg 6000 MXP systems have settings to allow one to favor motion or sharpness for the primary video stream. The LifeSize Room, however, has a slider bar (range from 1 to 10) for primary video motion, with lower numbers favoring sharpness and higher numbers favoring motion. For this testing, the LifeSize slider bar was set to 1 for sharpness calls and 10 for motion calls. For the record, LifeSize recommends that users determine the appropriate setting by starting at 10 (favoring motion), and then decreasing the setting one number at a time until the desired balance between frame rate and resolution has been achieved.
- 3) The HD to HD testing (both between like HD systems and between unlike HD systems) was conducted in two parts; all systems set to favor sharpness, and then with all systems set to favor motion.
- 4) For the HD to SD testing, the HD systems were set to favor motion for the 384 and 768 kbps calls, and sharpness for the 1152 and 1472 kbps calls.
- 5) The LifeSize Room's secondary video sharpness slider, which controls the resolution of the H.239 stream, was set for maximum sharpness (value of 10 on the slider). In addition, the bandwidth allocation slider was set to use 80% of the bandwidth for the primary video signal and 20% for the secondary (H.239) video signal.
- 6) Unless otherwise noted, all other system settings on all other endpoints were set to either Default or Auto.
- 7) The Tandberg 6000 MXP units provided to WR did NOT include the extended bandwidth support option, so the maximum call rate supported by these systems was 1536 kbps (compared to the system maximum of 4Mbps for point-to-point calls and 6Mbps for multi-site calls using IP and ISDN).
- 8) During the initial round of testing, WR believed the LifeSize Room's static macro block capability was enabled. We later learned that this was not the case. We then enabled this capability and repeated several test calls between the LifeSize Room and Tandberg 6000 MXP, and found that this change did not resolve the interop issues.

Call Statistics

The real-time call statistics were pulled from one or both of the video systems as required.

- 1) Since Tandberg systems do NOT provide frame rate information, we were unable to collect frame rate information for Tandberg to Tandberg video calls.
- 2) WR noted that the LifeSize Room's call statistics, especially for frame rate and bit rates used, were often delayed by 10 or more seconds.

H.239 Notes

During the H.239 testing, WR used a single monitor configuration (so the XGA / native resolution signals were actually viewed on the HD displays for the Polycom HDX 9002 and LifeSize Room systems, and on an XGA display for the Tandberg 6000 MXP). We suspect that many users will deploy these systems in dual monitor configurations in which case the video would be displayed on a 720p HD display while the data may be displayed on an XGA display.

Subjective Assessments

To assess the performance of the systems, WR used the following methods:

1) Motion Handling / Wave Test

WR's test subject waved his hand at a rate of approximately 1 cycle (or full wave) per second, during which the test team assessed the clarity of the test subject's individual fingers.

2) Latency Testing

The latency assessments within this document were based on how quickly each far end system refreshed its display in response to sudden movement at the near end.

Sharpness vs. Motion

Most video systems allow the user (or administrator) to choose between favoring motion or sharpness in the outgoing video signal.² When set to favor motion, the systems will prioritize frame rate over resolution. When set to favor sharpness, the systems will prioritize resolution.

As shown in the test results, choosing motion over sharpness (or vice-versa) can have a significant impact on the call experience – especially at low (< 1152 kbps) call speeds. For this reason, WR placed many of the test calls twice; first prioritizing sharpness and then prioritizing motion.

WR noted during the testing that LifeSize Room and Tandberg 6000 MXP tend to apply these prioritization settings to an extreme degree. For example, when set to prioritize sharpness, these systems used HD resolution at 384 and 768 kbps call speeds – at the expense of frame rate (which may be just what the user requires). The Polycom HDX 9002, however, tempered its choices based on call experience, opting instead to use 4SIF resolution and provide 25 – 30 fps at 384 and 768 kbps (when set to prioritize sharpness). See calls A-S01 to A-S06 for detailed information.

² Most systems, including the Polycom HDX 9002 and Tandberg 6000 MXP, provide a simple drop-down menu with only two options; motion or sharpness. The LifeSize Room, however, allows one to choose between 10 different sharpness vs. motion settings.

Chapter 6: Test Results

Detailed information about all of the test calls can be found in the Appendix of this report.

Session A: Calls Between Like HD-Capable Systems

Part 1 – Standard Light Level

For this testing session, the fluorescent light fixtures in our test lab were used. Each fixture contained four fluorescent bulbs (with a color temperature of 4100 degrees Kelvin). The light level, measured horizontally at the test subject's face, was 711 Lux. In an effort to provide the best quality picture possible, the test team spent a fair amount of time using color swatches to adjust / calibrate the color balance and white balance settings of each system.

LifeSize Room – This system offers several color balance options – including two (indoor and auto) which are intended for use with fluorescent lighting, but not labeled as such. In general, the LifeSize system produced colors that were too bright or too red, and while vivid, were not entirely true-to-life.

Polycom HDX 9002 – This system provided what our team felt was the best overall color accuracy, and performed especially well for blue targets.

Tandberg 6000 MXP - This system provided a relatively accurate color rendition for red objects / targets, but the results were less positive for blue objects.

Despite vendor claims to the contrary, we do not believe that these HD video systems could be used for long distance color evaluations - at least not without careful control and monitoring of videoconferencing cameras, room lighting, and display settings.

Call Results – Set to Favor Sharpness

As a part of this testing session, WR placed 18 video calls (see calls A-S01 through A-S18 in the test call results in the Appendix) at call rates from 384 kbps to ~2 Mbps with the HD video systems set to favor sharpness over motion. Notable results include:

- All three units used the H.264 video protocol during all test calls.
- 384 kbps (calls A-S01 to A-S03)
 - The Polycom HDX 9002 system used 4SIF (a 4:3 aspect ratio) resolution and the LifeSize Room and Tandberg 6000 MXP systems used HD720p.
 - All three systems showed some pixelization, especially in the darker areas of the image and under motion.
 - Significant frame rate differences were noted; the Polycom HDX 9002 provided 25 – 30 fps, while the LifeSize Room and Tandberg 6000 MXP provided 8 – 10 fps.
 - The Polycom HDX 9002 exhibited the least latency, followed by LifeSize Room and Tandberg 6000 MXP.
 - IMPORTANT - Overall, only the Polycom HDX 9002 call provided what WR would call an “acceptable” call experience at this speed.

- 768 kbps (calls A-S04 to A-S06)
 - The pixelization and motion handling (wave test results) were slightly improved vs. the 384 kbps call.
 - The Polycom HDX 9002 was able to maintain 30 fps consistently, while the other two systems provided ~ 10 fps.
 - The Polycom HDX 9002 still showed the lowest latency, but the LifeSize Room was now a close second, with the Tandberg 6000 MXP a distant third.
 - Once again, the Polycom HDX 9002's 4SIF 30 fps experience was greatly preferred over the low frame rate HD experience provided by the other systems.
- 1152 kbps and higher calling speeds (calls A-S07 to A-S15)
 - All systems used HD720p resolution.
 - The LifeSize Room and Polycom HDX 9002 systems were able to maintain 30 fps at this call speed.
 - The LifeSize Room and Polycom HDX 9002 systems both exhibited low (and roughly the same) latency, while Tandberg 6000 MXP's latency was noticeably higher.
 - IMPORTANT - Although the Tandberg 6000 MXP's frame rate was noticeably lower than the others and the video image stuttered intermittently, all 3 systems provided what WR would call an "acceptable" HD call experience.
- Audio Protocols
 - The LifeSize Room used Siren-14 at 384 kbps and AAC-LC at higher call speeds.
 - The Polycom HDX 9002 used Siren-22 at all call speeds.
 - The Tandberg 6000 MXP used AAC-LD at all call speeds.
- Connection Rate for HD
 - The LifeSize Room provided HD720p at 384 kbps and higher.
 - The Polycom HDX 9002 provided HD720p at 1152 kbps and higher.
 - The Tandberg 6000 MXP provided HD720p at 384 kbps and higher.
- Overall Experience (with the systems set to favor sharpness)
 - The LifeSize Room provided a marginal (high resolution but low frame rate as per our sharpness setting) call experience at speeds below 1152 kbps, and a solid experience above that rate.
 - The Polycom HDX 9002 provided a solid (or better) experience at all call speeds and wisely chose to use 4SIF resolution (instead of HD) at low call speeds.
 - The Tandberg 6000 MXP calls were marginal below 1472 kbps and exhibited frame rate issues and some intermittent video image stuttering at higher call speeds.

- H.239 Testing (A-S16 to A-S18)
 - All three units performed well during the H.239 testing.
 - The Polycom HDX 9002 and Tandberg 6000 MXP sent the XGA input signal in native resolution, while the LifeSize Room used HD720p resolution. Note that this did not noticeably impact the quality of the H.239 image.
 - All three systems displayed the incoming H.239 signal in the proper aspect ratio (4:3).
 - The LifeSize Room and Tandberg 6000 MXP systems exhibited longer latency (time between slide flips) and lower frame rates than the Polycom.
 - The Polycom and Tandberg systems dynamically adjusted the bit rate of the H.239 channel as required, while the LifeSize used a constant 106 kbps. Only the Polycom dropped the bit rate to 0 kbps lacking motion.

Call Results – Set to Favor Motion

As a part of this testing session, WR placed 15 video calls (see calls A-M21 – A-M38 in the test call results in the Appendix) at call rates from 384 kbps to ~2 Mbps with the HD video systems set to favor motion over sharpness.

The table below shows the resolutions sent by each system at the various calling speeds. As shown, each system used a different video resolution for the 384, 768, and 1152 kbps test calls.

	Video Resolution Used		
Call Speed	LifeSize Room	Polycom HDX 9002	Tandberg 6000 MXP
384 kbps	768x432	SIF	w288p
768 kbps	1088x608	2SIF	w448p
1152 kbps	HD720p	4SIF	w448p
1472 kbps	HD720p	4SIF	HD720p
1920 kbps	HD720p	HD720p	HD720p (at 1536 kbps)

Figure 7: Video Resolutions Used During HD Test Calls (Set to Favor Motion)

Notable test call results include:

- All three units used the H.264 video protocol during all test calls.
- The Polycom HDX 9002's used 4:3 resolutions (SIF, 2SIF, 4SIF) at speeds below 1920 kbps. While WR did not expect a call between two 16:9 capable systems to use 4:3 images, this did not appear to negatively impact the image quality.
- At 384 and 768 kbps, the frame rates provided by all three systems dropped in response to significant motion. At higher call speeds, frame rates remained high.

- 384 kbps (calls A-M21 to A-M23)
 - Minor pixelization was noted from all 3 systems at this call speed.
 - Motion handling was strong on the Polycom HDX 9002 and acceptable on the LifeSize Room and Tandberg 6000 MXP.
 - All three systems provided a full-motion experience (~ 25 - 30 fps).
 - The Polycom HDX 9002 showed the lowest latency, with the LifeSize Room a very close second and the Tandberg 6000 MXP a very close third.
 - All three systems provided what WR would call a “good” experience considering the low connection rate.
- 768 kbps (calls A-M24 to A-M26)
 - The Polycom HDX 9002 exhibited the strongest motion handling, followed closely by the LifeSize Room, and then followed by the Tandberg 6000 MXP.
 - All three systems provided a full-motion experience (~ 25 - 30 fps).
 - The Polycom HDX 9002 and the LifeSize Room exhibited the same very low latency. The Tandberg 6000 MXP’s latency was roughly one half a second higher than the other two.
 - Once again, all three systems provided a solid call experience.
- 1152 kbps (calls A-M27 to A-M30)
 - Call results were very similar to prior 768 kbps call, but the additional bandwidth improved motion handling and decreased pixelization.
 - The Tandberg 6000 MXP exhibited some intermittent video stuttering and short-term frame rate drops at this call speed.
 - Overall, all three systems provided a very good call experience (barring the Tandberg 6000 MXP’s video issues)
- 1472 kbps (calls A-M30 to A-M32)
 - The LifeSize Room and Tandberg 6000 MXP systems used HD720p resolution, while the Polycom HDX 9002 used 4SIF. Based on results of the sharpness test (call A-S10), the Polycom HDX 9002 clearly has the ability to send HD720p at ~30 fps at this call speed – but opted not to.
 - The Tandberg 6000 MXP exhibited additional motion handling artifacts – mostly related to limited frame rate (compared to the other two systems).
 - Once again, all systems provided a high quality video call experience.
- 1920 kbps (calls A-M33 to A-M35)
 - Call results very similar to 1472 kbps test calls.
 - All three systems provided a solid HD video call experience.

- Audio Protocols
 - The LifeSize Room used Siren-14 at 384 kbps and AAC-LC at higher call speeds.
 - The Polycom HDX 9002 used Siren-22 at all call speeds.
 - The Tandberg 6000 MXP used AAC-LD at all call speeds.
- Connection Rate for HD
 - The LifeSize Room provided HD720p at 1152 kbps and higher.
 - The Polycom HDX 9002 provided HD720p at 1920 kbps.
 - The Tandberg 6000 MXP provided HD720p at 1472 kbps and higher.
- Overall Experience (with the systems set to motion)
 - The LifeSize Room provided a solid (or better) experience at all call speeds, and used HD resolution at 1152 kbps and above.
 - The Polycom HDX 9002 provided a solid (or better) experience at all call speeds, but did not use HD resolution at call speeds below 1920 kbps. Based on prior test results, WR believes Polycom is being extremely conservative by using 4SIF instead of HD720p at 1152 and 1472 kbps.
 - The Tandberg 6000 MXP provided a solid call experience, but intermittent video stuttering / frame rate drops were noted.
- H.239 Testing (A-M36 to A-M38)
 - All three units performed well during the H.239 testing.
 - The Polycom HDX 9002 and the Tandberg 6000 MXP sent the XGA input signal in native resolution, while the LifeSize Room used HD resolution (which did not noticeably impact the quality of the H.239 image).
 - All three systems displayed the incoming H.239 signal in the proper aspect ratio (4:3).
 - The LifeSize Room and Tandberg 6000 MXP systems exhibited longer latency (time between slide flips) and lower frame rates than the Polycom HDX 9002.
 - The Polycom HDX 9002 and Tandberg 6000 MXP systems dynamically adjusted the bit rate of the H.239 channel as required, while the LifeSize used a consistent 106 kbps. Only the Polycom HDX 9002 dropped the bit rate to 0 kbps lacking motion.

Part 2 – Low Light Level

For this testing session, a low light level of 165 Lux (similar to that found in poorly lit conference rooms) generated by front-facing halogen studio lighting fixtures was used.

Prior to making the test calls, WR re-evaluated the color rendition / quality of the camera images from each system. At this low light setting, the Polycom HDX 9002's camera produced the most "true" color rendition. The LifeSize Room's camera, however, needed to be manually re-set from "auto" to "halogen" to produce what we deemed to be "usable" results. Even after this change, the LifeSize image was still noticeably off-color. In addition, the LifeSize camera had difficulty locking focus when zoomed in.

Call Results – Set to Favor Motion

As a part of this testing session, WR placed 9 video calls (see calls A-M41 to A-M49 in the test call results in the Appendix) at call rates from 384 to 1472 kbps. Notable results include:

- The lower light level presented challenges to all of the systems in terms of motion processing.
- The Polycom HDX 9002 clearly handled the low-light environment best, followed by the Tandberg. The LifeSize exhibited the most noticeable deterioration in overall video quality.
- As expected, the light level settings in the test lab did not prompt the video systems to negotiate different audio or video protocols or resolutions.

Session B: Calls Between Unlike HD-Capable Systems

In our experience, enterprises tend to standardize on one vendor for videoconferencing endpoints. Although WR expects this trend to continue in the HD video arena, it is reasonable to assume that HD video system users will expect an HD experience even when communicating with a system from a different vendor. This section focuses on assessing the degree of interoperability between HD systems from different vendors.

Call Results – Set to Favor Sharpness

As a part of this testing session, WR placed 18 video calls (see calls B-S01 through B-S18 in the test call results in the Appendix) at call rates from 384 kbps to 2 Mbps. Notable results include:

- We were pleased to note that the level of interoperability between the Polycom HDX 9002 and LifeSize Room systems was very high.
- Both the Polycom HDX 9002 and LifeSize Room had issues interoperating with (specifically sending HD720p resolution video to) the Tandberg 6000 MXP.
- When sending non-HD resolutions, the Polycom HDX 9002 call statistics indicated that the HDX 9002 was sending 4:3 aspect ratio video (e.g. SIF, 2SIF, 4SIF) – even when communicating with other 16:9 capable systems.
- All of the 384 kbps and 768 kbps connections took advantage of enhanced resolution video (image resolutions were higher than standard CIF or SIF but not as high as HD720p).
- Polycom HDX 9002 to LifeSize Room Connection
 - At 384 and 768 kbps, the Polycom HDX 9002 sent 4SIF at 30 fps to the LifeSize Room. The LifeSize, however, sent 4CIF (at 384 kbps) and HD720p (at 768 kbps) at only 10 fps, which we believe is related to LifeSize's interpretation of the favor sharpness setting and NOT to an interoperability issue between these systems.
 - At 1152 kbps, the Polycom HDX 9002 to LifeSize Room connection utilized HD video and Siren-14 audio resolution in both directions.
 - At higher call speeds, the quality improved only slightly beyond that exhibited at 1152 kbps.
 - Siren-14 wideband audio was used in both directions for all calls.
 - H.239 Test – Sending from the Polycom HDX 9002
 - Polycom sent native resolution at 7 fps to the LifeSize
 - This was a properly functioning H.239 call.
 - H.239 Test – Sending from the LifeSize Room
 - LifeSize sent 4CIF at 7 fps to the Polycom
 - Because the incoming H.239 image was relatively small (4CIF), Polycom displayed the image in proper 4:3 aspect ratio with left, right, top, and bottom windowing. When the PoP (picture outside picture) mode was used to view the H.239 and video windows simultaneously, the H.239 image was squeezed. This was NOT

the case when the Polycom HDX 9002 sent the data to the LifeSize.

- It is worth noting that the Polycom HDX 9002 to LifeSize Room connection was the only inter-vendor HD call during which the video and H.239 data channel both employed H.264.
- Polycom HDX 9002 to Tandberg 6000 MXP Connection
 - Although all call connections were successful, the Polycom HDX 9002 sent 4SIF to the Tandberg 6000 MXP at all call speeds. The reason the Polycom did not send HD720p to the Tandberg is related to Tandberg's use of static macro blocks (see the Tandberg section for detailed information).
 - The Tandberg 6000 MXP, on the other hand, sent HD720p (with intermittent video stuttering) to the Polycom HDX 9002 at call speeds of 768 kbps and above. This indicates that the Polycom was able to decode all 108,000 macro blocks (including both static and dynamic macro blocks) being sent by the Tandberg.
 - G.722 (narrow band audio) was used in both directions for all calls.
 - Overall, and especially at the higher call speeds, the Polycom HDX 9002 to Tandberg 6000 MXP calls were good, although wide-band audio was not used during any of the calls.
 - H.239 Test – Sending from the Polycom HDX 9002
 - Polycom sent native resolution at 7 fps to the Tandberg.
 - This was a properly functioning H.239 call.
 - H.239 Test – Sending from the Tandberg 6000 MXP
 - Activating H.239 send from the Tandberg caused the system to drop its frame rate on the primary video channel from 30 to 15 fps.
 - Tandberg sent native resolution at 7 fps to the Polycom
 - Although the Tandberg's H.239 bit rate was dynamic, it used ~ 400 kbps without motion. This is more than we'd expect.
 - This was a properly functioning H.239 call.
- LifeSize Room to Tandberg 6000 MXP Connection
 - At all call speeds, both systems used HD720p resolution.
 - Although all call connections were successful, the LifeSize Room was unable to send more than 6 fps to the Tandberg 6000 MXP, regardless of call speed. At first, WR believed this was related to the Tandberg's use of static macro blocks. However, we have since learned that the LifeSize is able to generate static macro blocks. For this reason, WR believes this to be an interoperability issue.
 - As call speed increased, the quality (pixelization, motion handling) and frame rate of the image sent by the Tandberg to the LifeSize improved.
 - G.722 (narrow band audio) was used in both directions for all calls.

- Due to the interoperability issue above, LifeSize Room to Tandberg 6000 MXP calls, with both systems set to sharpness, were deemed unacceptable.
- H.239 Test – Sending from the LifeSize Room
 - LifeSize sent the XGA H.239 signal in proper aspect ratio (4:3) embedded within an HD720p signal at an estimated 4 – 5 fps to the Tandberg. Although not native resolution (XGA is not the same as HD720p), the use of HD resolution in the H.239 channel was not objectionable.
 - This was a properly functioning H.239 call.
- H.239 Test – Sending from the Tandberg 6000 MXP
 - Although the Tandberg's H.239 bit rate was dynamic, it used ~ 500 kbps without motion. This is more than we'd expect.
 - Activating H.239 caused the Tandberg 6000 MXP to decrease its outgoing frame rate from 30 fps to 13 (according to the statistics provided by the LifeSize).
 - This was a properly functioning H.239.

Call Results – Set to Favor Motion

As a part of this testing session, WR placed 18 video calls (see calls B-M21 through B-M35 in the test call results in the Appendix) at call rates from 384 kbps to 2 Mbps. Notable results include:

- We were pleased to note that the level of interoperability between all three HD systems was high.
- According to the call statistics, all systems sent 30 fps at all times.
- When sending non-HD resolutions, the Polycom HDX 9002 call statistics indicated that the HDX 9002 was sending 4:3 video (e.g. SIF, 2SIF, 4SIF) – even when communicating with other 16:9 capable systems.
- Polycom HDX 9002 to LifeSize Room Connection
 - As call speed increased, the video resolution sent by each system increased.
 - At 384 kbps, the LifeSize Room sent the Polycom HDX 9002 an XGA (4:3) signal. This appears to be a bug.
 - At 768 kbps, the LifeSize Room sent 1120x624 resolution. Although this resolution uses a 16:9 aspect ratio, the Polycom displayed the incoming video signal squeezed. It is possible the Polycom did not know how to deal with this resolution.
 - Siren-14 wideband audio was used in both directions for all calls.
 - In all cases, the systems provided a solid, high quality video call.
- Polycom HDX 9002 to Tandberg 6000 MXP Connection
 - At 384 and 768 kbps, call quality was strong.
 - At 1152 kbps and above, the image sent from the Tandberg 6000 MXP to the Polycom HDX 9002 exhibited motion handling issues (pixelization, frame rate drops, image stuttering). Although in most cases this type of issue is related to the use of a higher resolution, in this case it appears related to an increase in the incoming resolution from the Polycom.
 - At 1472 kbps, the Tandberg to Polycom transmission exhibited longer latency than the other direction.
 - As with the prior interoperability test between the Polycom and Tandberg, the Polycom was unable to send HD resolution to the Tandberg. This is likely related to the Tandberg's use of static macro blocks.
 - G.722 (narrow-band) audio was used in both directions for all calls.
 - Overall, the call experience was solid – especially at higher call rates – although wide-band audio and HD resolution would have made the experience even better.
- LifeSize Room to Tandberg 6000 MXP Connection
 - At all call speeds, the LifeSize Room sent w400p (720x400) resolution to the Tandberg 6000 MXP.

- At 384 and 768 kbps, and despite the LifeSize Room reporting that it was sending 16:9 aspect ratio images, the Tandberg 6000 MXP displayed the incoming image squeezed.
- At 1152 kbps and above, the Tandberg intermittently displayed a black screen. During one test call this issue corrected itself after roughly 30 seconds. Note that the call statistics did not indicate that there was any issue with the image being sent from the LifeSize to the Tandberg.
- G.722 (narrow-band) audio was used in both directions for all calls.
- Overall, the Tandberg 6000 MXP to LifeSize Room connection was such that the call experience on the LifeSize end was solid, but the experience on the Tandberg end was plagued by a variety of issues.

Session C: Calls between HD-Capable and SD Systems

We suspect it will be some time before 100% of the videoconferencing systems at any reasonably-sized enterprise will be HD-capable, hence the interoperability with SD systems will be of great importance.

For this round of testing, we tested general interoperability (basically connectivity and successful audio/video transfer) with SD systems from Aethra, Emblaze-VCON, Huawei, Polycom, Sony, and Tandberg. All of the SD systems were connected to 4:3 displays, while the HD systems were connected to 16:9 displays; a configuration we believe will be common.

IMPORTANT NOTE:

For the 384 and 768 kbps calls, the HD systems were set to favor motion. For the 1152 and 1472 kbps calls, the HD systems were set to favor sharpness.

In general, we were pleased with the results.

Call Results from the Polycom HDX 9002:

As a part of this testing session, WR placed 24 video calls (see calls C-M01 through C-M24 in the test call results in the Appendix) from the Polycom HDX 9002 to the SD systems at call rates from 384 kbps to 1472 Mbps. Notable results include:

- Connections to all six SD systems at all bit rates tested worked perfectly, with the exception of the 1152 and 1472 kbps calls to the one SD system that “allowed” the HDX 9002 to send an HD resolution signal; the Emblaze-VCON HD-5000. Based on the call results, it appears the Emblaze-VCON system was unable to successfully decode the HD signal sent by the HDX 9002.
- The video resolution and audio protocol sent by each SD video system to the HDX 9002 did not vary by call speed. For example, the Aethra Vega X3 sent SIF video resolution and G.722 audio to the HDX 9002 at 384, 768, 1152, and 1472 kbps call speeds.
- The HDX 9002 sent CIF video resolution to the Polycom VSX-3000, the Aethra Vega X3, and the Sony G-50 at all call speeds. As call speed increased, the HDX 9002 sent increasing resolutions to the other systems (Tandberg 880MXP, Huawei 8039, and Emblaze-VCON HD-5000).
- In some cases the video resolution statistics on the send and receive systems were slightly different. For example, at 384 kbps the HDX 9002 indicated that it was sending SIF, but the Huawei 8039 indicated it was receiving CIF.
- Several of the calls were asymmetrical. For example, during the 768 kbps call between the Polycom HDX 9002 and Polycom VSX-3000, the HDX 9002 sent an H.263 signal and the VSX sent an H.264 signal.
- The H.239 test (an add-on to call C-M07) performed as expected with native resolution being sent from the HDX 9002 to the VSX-3000.

Call Results from the Tandberg 6000 MXP:

As a part of this testing session, WR placed 24 video calls (see calls C-M31 through C-S54 in the test call results in the Appendix) from the Tandberg 6000 MXP to the SD systems at call rates from 384 kbps to 1472 Mbps. Notable results include:

- All calls to the Polycom VSX-3000, Tandberg 880MXP, Aethra Vega X3, and Sony G-50 were successful.
- When default settings were used, we were unable to establish two-way video communications between the Tandberg 6000 MXP and the Huawei. When H.264 was disabled on the 6000 MXP, the systems negotiated successful H.263 connections. This appears to be a Huawei-related H.264 interop issue.
- During the 384 kbps call from the Tandberg 6000 MXP to the Tandberg 880MXP, the 6000 MXP sent w288p to the Tandberg 880 MXP, while the 880 MXP sent 400p to the 6000 MXP. Considering the additional processor power within the 6000 MXP compared to the 880 MXP, this is the opposite of what we expected. At 768kbps, the 6000 MXP sent 448p video to the 880 MXP, so perhaps this is related to decoding limitations on the 880 MXP.
- The 384 kbps call to the Emblaze-VCON worked well, but the rest of the calls to that system had issues (mostly frozen incoming video). WR believes this may be related to a difference between the resolutions the VCON “advertises” (tells the Tandberg 6000 MXP) that it can decode, and what it can actually decode at different call speeds.
- During the 384 and 768 kbps calls, the Tandberg 6000 MXP sent H.264 video to all SD endpoints. At 1152 and 1472 kbps, the 6000 MXP sent H.264 video to three of the SD systems, and H.263+ to the other three.
- The H.239 test call (an add-on to call C-M38) performed as expected with the Tandberg 6000 MXP sending native resolution to the Tandberg 880 MXP. However, activating H.239 caused the 6000 MXP to decrease its send resolution from 448p to 288p. It is possible that the need to encode / send two streams simultaneously taxed the processing power of the 6000 MXP.

Call Results from the LifeSize Room:

As a part of this testing session, WR placed 24 video calls (see calls C-M61 through C-S84 in the test call results in the Appendix) from the LifeSize Room to the SD systems at call rates from 384 kbps to 1472 Mbps. Notable results include:

- All calls at all speeds connected with H.264 video, except for the calls made to the Aethra X3 and the Polycom VSX 3000 at rates above 1Mbps, in which case the systems negotiated using H.263 video for at least one part of the call.
- The LifeSize Room system was able to negotiate enhanced resolutions with the Tandberg 880MXP at all call speeds. For the 1152 and 1472 kbps calls, during which the LifeSize Room was set to favor sharpness, the LifeSize Room sent HD720p resolution at 6 fps (an unacceptably low frame rate – even considering the LifeSize Room system was set to favor sharpness). This is the same interoperability issue noted during the prior LifeSize Room to Tandberg 6000 MXP calls.
- At 384 and 768 kbps, the Emblaze-VCON software application would terminate immediately after receiving the call. During the 1152 and 1472 kbps calls, the incoming video to the Emblaze-VCON froze intermittently. WR believes this is the same issue described above during the Polycom HDX 9002 and Tandberg 6000 MXP to Emblaze-VCON testing.
- At 768 kbps and above, the Huawei did not send audio to the LifeSize Room system. This was reflected in the call statistics and verified during our testing.
- The H.239 test call (an add-on to call C-M70) performed as expected with the LifeSize room sending native resolution (XGA) to the Aethra X3.

Session D: Multipoint Calls Using an Embedded Bridge

All of the HD units evaluated were equipped with an embedded multipoint bridge (included as a part of the base price on the LifeSize Room, and available as an option on the Polycom HDX 9002 and Tandberg 6000 MXP systems). For this exercise, WR evaluated the continuous presence (CP) performance of each video bridge.

To test the capability and performance of each system's embedded MCU, WR completed the following:

- 1) Set each HD system to favor sharpness to ensure that HD resolution would be used, if possible, during the test call.
- 2) Placed an HD to HD call at either 1472 kbps or 1920 kbps between systems from the same vendor.
- 3) Added another HD-capable endpoint (if possible from the same vendor) to the call at the same call speed.
- 4) Documented the connection statistics of the 3-way multipoint call.
- 5) Activated H.239 and sent a native resolution XGA signal from the host site to the other participating sites in the multi-point call.
- 6) Added a fourth system at the same call speed to the multipoint call.
- 7) Documented the connection statistics of the 4-way multipoint call.

Call Results for the Polycom HDX 9002:

For detailed call information, please see calls D-S1A through D-S1C in the test call results in the Appendix). Notable results include:

- For the test calls, the HDX 9002's multipoint bridge was set to discussion mode (continuous presence).
- In order to host HD 720p resolution multipoint calls, transcoding had to be disabled (via the Network, Call Preference menu) in advance on the host HDX system, which meant that all sites participating in the multipoint call had to use the same call speed and video protocols. During our initial multipoint test call, transcoding was enabled (which is apparently the default setting), which caused the host site to send each participating system a SIF image.
- The Polycom HDX 9002 behaved exactly as expected throughout this round of testing and was able to successfully host 3 and 4-way continuous presence multipoint calls.
- The host site (HDX 9002) sent each participating site an HD720p video signal at roughly 30 fps. Each participating site sent a video resolution of 640x368, which is approximately one-quarter HD720p (or q720p).
- During a 3-site multipoint call, the HDX 9002 hosting the multipoint call is able to show a side-by-side view of only the two far-end sites on the local display, essentially hiding its own camera image. Seeing only the remote sites but not the self-view is a display option preferred by many users.
- In 3 or 4-site multipoint calls, the participating sites receive a single 3 or 4-site CP view of all participating sites (including themselves).
- The HDX 9002's CP view includes an indicator (a yellow / orange border) highlighting which site is currently speaking.
- The HDX 9002's support for H.239 during a multi-point call was flawless. All far-end sites received a native-resolution H.263 signal at roughly 7 fps.
- Minor note - While in a multipoint H.239 call on the HDX 9002, adding an additional site caused the H.239 stream to drop, forcing us to restart the data collaboration session. Since activating H.239 on the HDX 9002 requires only a single button press on the remote, this was more an annoyance than a fatal flaw. According to Polycom, this is a feature intended to protect the confidentiality of the data in case an uninvited site enters the call.

The HDX 9002's internal bridge has two other power features that were not tested, but are worthy of mention:

- Stereo audio support is maintained during multipoint calls. In voice-switched mode (when a single site is displayed on the screen), participating sites with stereo audio capabilities receive a stereo audio signal from the speaking site. In continuous presence mode, the system uses the stereo audio to provide virtual positioning. For example, 80% of the audio coming in from sites displayed on the left side of the screen comes out of the left channel / speaker.
- The internal bridge on the HDX 9004 is able to support 8-way continuous presence multipoint calls in HD720p resolution.

Call Results for the Tandberg 6000 MXP:

For detailed call information, please see calls D-2A through D-2C in the test call results in the Appendix). Notable results include:

- Due to the limited bandwidth licensed on the Tandberg 6000 MXP units in our lab, the Tandberg 1700 MXP was used to host the multipoint test calls.
- Adding a third site to the call caused the Tandberg 1700MXP hosting the multipoint call to drop the outgoing call speed to each site to 1152 kbps. The outgoing video resolution also dropped from HD720p (in point-to-point mode) to CIF, while each of the participating Tandberg 6000MXP systems sent the host site w576p video resolution.
- Adding a fourth site (Polycom VSX-3000) to the call caused the Tandberg 1700MXP hosting the multipoint call to drop the outgoing call speed to each site to 768 kbps. The outgoing video resolution remained CIF, and the participating sites sent either w576p or SIF resolution (which means the embedded bridge was able to transcode between two different incoming video resolutions).
- Each participating site in the multipoint call displayed a quad-screen continuous presence layout (including the self-view in one quadrant). During a 3-site multipoint call, one quadrant was empty.
- Although Tandberg does not provide frame rate information in its call statistics, WR estimates the frame rate of the call to be ~ 10 – 15 fps.
- The Tandberg 1700 MXP's support for H.239 during the multi-point test call was flawless. All far-end sites received a native-resolution H.239 signal at an estimated 5 - 7 fps.

Call Results for the LifeSize Room:

LifeSize Room systems include an innovative feature called Virtual Multipoint. With Virtual Multipoint, the video stream sent from the host LifeSize Room system to each participating LifeSize system actually contains an individual sub-stream of every other participating site, at one-quarter of the overall video resolution.

To illustrate this capability, imagine a 4-way multipoint call containing three LifeSize Room systems and one Polycom HDX system (see call D-S2D in the test call results). The host LifeSize Room system will receive an HD720p video stream from each site. The host LifeSize Room will then send the following stream(s) to each participating site. In the table below, q720p refers to a video resolution of one-quarter HD720p (or roughly 640x360).

	Received by LifeSize System 2	Received by LifeSize System 3	Received by the Polycom HDX
Sub-Stream 1	LifeSize System 1 (host site) at q720p resolution	LifeSize System 1 (host site) at q720p resolution	4-way HD720p image
Sub-Stream 2	LifeSize System 3 at q720p resolution	LifeSize System 2 at q720p resolution	N / A
Sub-Stream 3	Polycom HDX at q720p resolution	Polycom HDX at q720p resolution	N / A

Figure 8: LifeSize Virtual Multipoint Function

LifeSize Systems

Each LifeSize system (including the host and each participating LifeSize system) has the ability to select (using the Call button on the remote) which of the video images to display - either the 4-way HD720p image or a single site in the main window (with the other participating sites displayed in either PoP or PiP windows).

As shown above, the LifeSize sites participating in a Virtual Multipoint meeting do NOT receive their own image back from the host site. Instead, the LifeSize sites use a local (non-processed) camera image on screen. This not only improves the user experience, but also saves bandwidth (or leaves more bandwidth available to receive the images of the other sites) and processing power.

Non LifeSize Sites

Non-LifeSize participating sites receive only a single stream containing a CP view of the participating systems.

For detailed call information, please see calls D-S2A to D-S2D in the test call results in the Appendix). Notable results include:

- The LifeSize Room behaved exactly as expected during this round of testing and was able to successfully host a 4-site HD720p continuous presence multipoint call.
- Each participating site sent and received HD720p resolution at roughly 30 fps. The frame rate provided by the host site to the participating sites decreased slightly under significant motion.

- WR was especially pleased by the Virtual Multipoint feature which allowed participating LifeSize sites to select from a variety of display options during multipoint calls. WR also appreciates that LifeSize systems participating in a multipoint call show a local (non-processed) version of their own image on screen. This feature very effectively hides from the local participants the latency and video artifacts inherent in multipoint videoconferencing.
- WR also performed a test call including three LifeSize Room systems and a Polycom HDX 9002. The results were exactly as expected.
- The LifeSize Room's H.239 performance during the multipoint call was flawless, with the host site sending (and each participating site receiving) an HD720p signal in the H.239 content stream.

Although not tested, the LifeSize Room's internal MCU supports up to six sites in VAS (voice activated switching) mode.

Session E: Microphone Audio Performance

For our audio evaluation testing, WR created a stereo recording including the following sections:

- 1) Speech audio on each channel independently and then both channels simultaneously.
- 2) Program audio (music) on each channel independently and then both channels simultaneously.

To facilitate the testing, WR performed the following:

- 1) Connected calls between like systems (LifeSize Room to LifeSize Room, etc.)
- 2) Played the audio track through stereo speakers positioned in such a way as to simulate the likely positions of two different participants in a typical meeting room. Note – the sound level at the microphones was measured to be approximately 65 db SPL, C weighted.
- 3) Captured the audio using the microphones of the “originating” systems
- 4) Had three people assess the clarity, fidelity, and spatial capabilities of the audio received by each video system

To enable real-time comparison between signals, the audio output of each receiving system was connected to an audio switcher, and the output of the switcher was connected to a set of headphones.

The table below shows the average ratings from the three reviewers for each system (higher scores are better).

Audio Test Results	LifeSize Room	Polycom HDX 9002	Tandberg 6000 MXP
Fidelity (Accuracy)	7.0	9.0	6.7
Clarity	6.3	9.0	6.7
Stereo Separation	0.0	8.3	0.0
Spatial Effect	0.0	8.0	0.0
Background Noise Handling	7.3	6.7	6.7
Distance Test (12 ft.)	5.7	7.7	7.0
Overall Feel	7.3	9.0	7.5

Figure 9: Microphone Audio Performance Test Results

Session F: Multimedia Audio / Video Testing

During the past few years, the inclusion of rich-media sources (full motion video clips, high quality audio sources, etc.) has become commonplace in the videoconferencing environment. With the introduction of HD-support, the interest in rich media has become even stronger.

To test each system’s ability to provide far-end participants with a high quality rich media experience, WR:

- 1) Connected the audio and video outputs of the HD-capable DVD player (playing the movie Seabiscuit in HD) to the video inputs of each “originating” system.
- 2) Placed calls from each “originating” system to each “receiving” system (e.g. LifeSize Room to LifeSize Room, etc.).
- 3) Instructed the codec to send the DVD signal to the far end system
- 4) Assessed the quality of the audio and video signals at the “receive” system.

Part 1 – HD Signal Source Testing

Of the HD systems evaluated, the Polycom HDX 9002 was the only one offering an HD-capable 30 fps digital video input³ (other than the primary camera input). For this reason, our HD signal multimedia testing was limited to the HDX 9002.

We were very pleased with the results of the test. The signal received by the far end was of exceptionally high quality. The video was sent at full HD resolution at 30 fps, and the motion handling was excellent. In addition, the audio sent using Polycom’s Siren-22 protocol was superb, providing what we’d call a “near-theatre” level experience.

Part 2 – SD Signal Source Testing

Since all three systems provide SD video inputs, we used a signal splitter to allow us to conduct side-by-side comparisons of each system’s performance. The results of the testing are summarized in the table below. In each case, three viewers were asked to compare the three audio and video results and rank quality on a score of one to ten.

	LifeSize Room	Polycom HDX 9002	Tandberg 6000 MXP
Video Protocol	H.264	H.264	H.264
Video Resolution	720x480	4SIF	400p
Audio Protocol	AAC-LC	Siren-22	AAC-LD
Video Quality	Very Good	Excellent	Mediocre – horizontal lines shown across screen (almost lost sync)
Motion Handling	Best of systems tested	Strong – tiling noted on fast motion	Poor – even with limited motion
Color Rendition	OK, but a bit red	Excellent	OK
Audio Quality	Acceptable / OK	Very Good	Acceptable / OK
Score (out of 10)	8	8	5

Figure 10: Multimedia Performance Test Results

³ The Tandberg 6000 MXP has a DVI-I input intended for capturing hi-res PC signals with low frame rates (~ 5 – 7 fps). In addition, the LifeSize Room has an analog VGA input that when used as the primary video source can provide HD720p (1280x720) resolution at up to 30 fps.

Appendix A: Detailed Call Results

The pages that follow include detailed information about the test calls performed by Wainhouse Research during this high definition videoconferencing evaluation.

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

A) HD to HD Testing - Between Like Systems (Video Quality set to "Sharpness")

Light Level 1: High = 711 Lux (horizontal) - Using fluorescents from above with 4100 degree Kelvin bulbs

A-S01	Polycom HDX 9000 - L (7003)	Polycom HDX 9000 - R (7002)		384	Y	384	Y	H.264	4SIF (704x480)	30	Siren-22	H.264	4SIF (704x480)	30	Siren-22
A-S02	Tandberg 6000 MXP - L (7005)	Tandberg 6000 MXP - R (7004)		384	Y	384	Y	H.264	HD720p (1280x720)		AAC-LD	H.264	HD720p (1280x720)		AAC-LD
A-S03	LifeSize Room - R (7006)	LifeSize Room - L (7007)		384	Y	384	Y	H.264	HD720p (1280x720)	8	Siren-14	H.264	HD720p (1280x720)	8	Siren-14

Notes (A-S01 - A-S03): Pixelization noted on all 3 systems - especially on background and under motion.

Motion handling strong on the Polycom, mediocre on the LifeSize and Tandberg (during wave test, subject's fingers were clear on the Polycom, and somewhat blurry on the LifeSize and Tandberg).

Significant frame rate differences noted --- Polycom maintained 25 - 30 fps, LifeSize and Tandberg provided approximately 8 - 10 fps.

Polycom showed very low latency, LifeSize was a distant second, and Tandberg was a close third (perhaps 3/4 of a second in total behind the Polycom).

Overall Comment - the Polycom's use of a lower (and for some reason 4:3 aspect ratio) video resolution at this low call speed provides a far better call experience.

A-S04	Polycom HDX 9000 - R (7002)	Polycom HDX 9000 - L (7003)		768	Y	768	Y	H.264	4SIF (704x480)	30	Siren-22	H.264	4SIF (704x480)	30	Siren-22
A-S05	Tandberg 6000 MXP - R (7004)	Tandberg 6000 MXP - L (7005)		768	Y	768	Y	H.264	HD720p (1280x720)		AAC-LD	H.264	HD720p (1280x720)		AAC-LD
A-S06	LifeSize Room - L (7007)	LifeSize Room - R (7006)		768	Y	768	Y	H.264	HD720p (1280x720)	10	AAC-LC	H.264	HD720p (1280x720)	10	AAC-LC

Notes (A-S04 - A-S06): Pixelization improved over 384 kbps call, but still noticable under motion. Motion handling (wave test results) slightly improved compared to 384 kbps call.

Polycom now maintaining 30 fps consistently. LifeSize and Tandberg now providing perhaps 10 fps.

Polycom still showing very low latency, but LifeSize is now a close second with the Tandberg a distant third (perhaps 1/2 of a second behind the Polycom).

Overall Comment - The Polycom's 4SIF (again 4:3 aspect ratio) call experience is quite good, especially when compared to the ~10 fps HD resolution provided by the other two systems.

A-S07	Polycom HDX 9000 - L (7003)	Polycom HDX 9000 - R (7002)		1152	Y	1152	Y	H.264	HD720p (1280x720)	30	Siren-22	H.264	HD720p (1280x720)	30	Siren-22
A-S08	Tandberg 6000 MXP - L (7005)	Tandberg 6000 MXP - R (7004)		1152	Y	1152	Y	H.264	HD720p (1280x720)		AAC-LD	H.264	HD720p (1280x720)		AAC-LD
A-S09	LifeSize Room - R (7006)	LifeSize Room - L (7007)		1152	Y	1152	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC

Notes (A-S7 - A-S9): Polycom now providing HD720p, resulting in slightly increased pixelization compared to prior calls using 4SIF.

LifeSize now exhibiting the least pixelization, with the Polycom just slightly behind and the Tandberg a distant third.

Motion handling significantly improved vs. 768 kbps call. Polycom and LifeSize very strong. Tandberg good, but the video image stuttered intermittently.

Polycom and LifeSize both maintaining 30 fps - even under some motion. Tandberg providing an estimated 15 - 20 fps.

Overall Comment - All 3 of these calls are now very good. This call speed (1152 kbps) appears to be a sweet spot for the Polycom and LifeSize systems.

A-S10	Polycom HDX 9000 - L (7003)	Polycom HDX 9000 - R (7002)		1472	Y	1472	Y	H.264	HD720p (1280x720)	30	Siren-22	H.264	HD720p (1280x720)	30	Siren-22
A-S11	Tandberg 6000 MXP - L (7005)	Tandberg 6000 MXP - R (7004)		1472	Y	1472	Y	H.264	HD720p (1280x720)		AAC-LD	H.264	HD720p (1280x720)		AAC-LD
A-S12	LifeSize Room - R (7006)	LifeSize Room - L (7007)		1472	Y	1472	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC

Notes (A-S10 - A-S12): Pixelization improved but still noted on the Polycom and Tandberg - specifically in the background. LifeSize pixelization very limited.

Motion handling (wave test results) now solid on all 3 systems (Polycom and LifeSize very strong, Tandberg good). Tandberg video image still stuttered intermittently, but only slightly.

Overall Comment - High quality HD video calls provided by all 3 systems.

A-S13	Polycom HDX 9000 - L (7003)	Polycom HDX 9000 - R (7002)		1920	Y	1920	Y	H.264	HD720p (1280x720)	30	Siren-22	H.264	HD720p (1280x720)	30	Siren-22
A-S14	Tandberg 6000 MXP - L (7005)	Tandberg 6000 MXP - R (7004)		1536	Y	1536	Y	H.264	HD720p (1280x720)		AAC-LD	H.264	HD720p (1280x720)		AAC-LD
A-S15	LifeSize Room - R (7006)	LifeSize Room - L (7007)		1920	Y	1920	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC

Notes (A-S13 - A-S15): Little or no difference noted from prior call.

High Definition Videoconferencing Evaluation

Call Configuration			Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To	BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

A) HD to HD H.239 Testing - Between Like Systems (Video Quality set to "Sharpness")

Light Level 1: High = 711 Lux (horizontal) - Using fluorescents from above with 4100 degree Kelvin bulbs

Notes: The H.239 testing was conducted by repeating test calls A-S04, A-S05, and A-S06 and then activating H.239 as documented below

A-S16	Polycom HDX 9000 - R (7002)	Polycom HDX 9000 - L (7003)			768	Y		768	Y		H.264	4SIF (704x480)	30	Siren-22		H.264	4SIF (704x480)	30	Siren-22
H.239 Test - H.239 signal sent from the Polycom					H.239 Tx from 7002		Up to 500				H.264	XGA (1024x768)	7						
					H.239 Rx at 7003		Up to 500				H.264	XGA (1024x768)	7						

H.239 Notes: Properly functioning H.239 call including native resolution and proper aspect ratio.
 The receive site displayed the H.239 signal window boxed, in native resolution (XGA), and using the native 4:3 aspect ratio.
 The bandwidth allocated by the Polycom for the H.239 stream was dynamic, ranging from 0 to 500 kbps depending upon the level of motion in the PC source signal.
 PPT Test - Both image quality and text quality was excellent.
 Motion Video Clip Test - Very good image quality (especially for 7 fps).

A-S17	Tandberg 6000 MXP - R (7004)	Tandberg 6000 MXP - L (7005)			768	Y		768	Y		H.264	HD720p (1280x720)		AAC-LD		H.264	HD720p (1280x720)		AAC-LD
H.239 Test - H.239 signal sent from Tandberg 6000 MXP - R (7004)					H.239 Tx from 7004		Up to 420				H.264	XGA (1024x768)	Est. 4 - 5						
					H.239 Rx at 7005		Up to 420				H.264	XGA (1024x768)	Est. 4 - 5						

H.239 Notes: The bandwidth allocated by the Tandberg for the H.239 stream was dynamic, ranging from ~ 240 to 420 kbps depending upon the level of motion in the PC source signal.
 The receive site displayed the H.239 signal window boxed, in native resolution (XGA), and using the native 4:3 aspect ratio.
 PPT Test - Good quality with slight delay noted on slide flips.
 Motion Video Clip Test - Very good image quality, but lower frame rate (estimated 4 - 5 fps) was noticeable compared to the Polycom.

A-S18	LifeSize Room - L (7007)	LifeSize Room - R (7006)			768	Y		768	Y		H.264	HD720p (1280x720)	10	AAC-LC		H.264	HD720p (1280x720)	10	AAC-LC
H.239 Test - H.239 signal sent from LifeSize Room - R (7006)					H.239 Tx from 7007		106				H.264	HD720p (1280x720)	Est. 3 - 4						
					H.239 Rx at 7006		106				H.264	HD720p (1280x720)	Est. 3 - 4						

H.239 Notes: Unlike the other systems, the LifeSize did not use dynamic bandwidth allocation for the H.239 signal. The bandwidth utilized remained at 106 kbps, regardless of level of motion
 The LifeSize allows one to set the division of bandwidth between the primary and secondary signals. For our testing we used 80% / 20%.
 The LifeSize converted the XGA input signal to HD720p for H.239 transmission.
 The receive site displayed the H.239 signal window boxed and using the native 4:3 aspect ratio.
 PPT Test - Good image quality, but not as clear as the Polycom image. Also slight delay noted on slide flips.
 Motion Video Clip Test - Acceptable, but low frame rate video quality. Long latency also noted (images took > 1 second to update).

H.239 Testing Notes:

All 3 of the systems performed well on the H.239 testing, but the Tandberg and LifeSize H.239 signals had longer latency and lower frame rate.

WR repeated the H.239 test for calls A-S10 through A-S12 above (at 1472 kbps) and noted the same results as above with one exception - the systems each used more bandwidth for the H.239 data channel.

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

A) HD to HD Testing - Between Like Systems (Video Quality set to "Motion")

Light Level 1: High = 711 Lux (horizontal) - Using fluorescents from above with 4100 degree Kelvin bulbs

A-M21	Polycom HDX 9000 - L (7003)	Polycom HDX 9000 - R (7002)		384	Y	384	Y	H.264	SIF (352x240)	30	Siren-22	H.264	SIF (352x240)	30	Siren-22
A-M22	Tandberg 6000 MXP - L (7005)	Tandberg 6000 MXP - R (7004)		384	Y	384	Y	H.264	w288p (512x288)		AAC-LD	H.264	w288p (512x288)		AAC-LD
A-M23	LifeSize Room - R (7006)	LifeSize Room - L (7007)		384	Y	384	Y	H.264	768x432	30	Siren-14	H.264	768x432	30	Siren-14

Notes (A-M21 - A-M22): Good image quality from all 3 systems with minor pixelization noted under motion.

Motion handling (clarity of image under motion) very strong on the Polycom, acceptable on the LifeSize and Tandberg.

It appears that all systems are providing full motion 30 fps.

Polycom showing lowest latency, LifeSize a very close second, and Tandberg a very close third (perhaps half a second behind the Polycom).

Overall - Good quality low bandwidth video call from all 3 systems.

A-M24	Polycom HDX 9000 - R (7002)	Polycom HDX 9000 - L (7003)		768	Y	768	Y	H.264	2SIF (704x240)	30	Siren-22	H.264	2SIF (704x240)	30	Siren-22
A-M25	Tandberg 6000 MXP - R (7004)	Tandberg 6000 MXP - L (7005)		768	Y	768	Y	H.264	w448p (576x448)		AAC-LD	H.264	w448p (576x448)		AAC-LD
A-M26	LifeSize Room - L (7007)	LifeSize Room - R (7006)		768	Y	768	Y	H.264	1088x608	30	AAC-LC	H.264	1088x608	30	AAC-LC

Notes (A-M24 - A-M26): Pixelization on the Polycom and Tandberg basically the same as at 384 kbps. Slightly more pixelization noted on the LifeSize.

Motion handling differences noted during the wave test - Polycom was very strong, LifeSize was good, Tandberg was acceptable.

Once again, all systems appear to be providing full motion 30 fps.

Polycom and LifeSize now exhibited the same very low latency, with Tandberg a distant third (roughly half a second behind the other two).

Overall - Once again, a good / excellent call experience provided by all systems.

A-M27	Polycom HDX 9000 - L (7003)	Polycom HDX 9000 - R (7002)		1152	Y	1152	Y	H.264	4SIF (704x480)	30	Siren-22	H.264	4SIF (704x480)	30	Siren-22
A-M28	Tandberg 6000 MXP - L (7005)	Tandberg 6000 MXP - R (7004)		1152	Y	1152	Y	H.264	w448p (576x448)		AAC-LD	H.264	w448p (576x448)		AAC-LD
A-M29	LifeSize Room - R (7006)	LifeSize Room - L (7007)		1152	Y	1152	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC

Notes (A-M27 - A-M29): Very minor pixelation noted on all 3 systems.

Motion handling good on all systems - Polycom very strong, LifeSize and Tandberg both good.

All systems providing solid motion (~ 30 fps), but the Tandberg exhibited intermittent video stuttering / short term frame rate drops.

As per prior call, Polycom and LifeSize latency very low, Tandberg half a second behind.

Overall - Solid video experience provided by all 3, except when the Tandberg video stutters.

A-M30	Polycom HDX 9000 - L (7003)	Polycom HDX 9000 - R (7002)		1472	Y	1472	Y	H.264	4SIF (704x480)	30	Siren-22	H.264	4SIF (704x480)	30	Siren-22
A-M31	Tandberg 6000 MXP - L (7005)	Tandberg 6000 MXP - R (7004)		1472	Y	1472	Y	H.264	HD720p (1280x720)		AAC-LD	H.264	HD720p (1280x720)		AAC-LD
A-M32	LifeSize Room - R (7006)	LifeSize Room - L (7007)		1472	Y	1472	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC

Notes (A-M30 - A-M32): Call experience very similar to prior test call.

Tandberg exhibited some additional motion handling artifacts (mostly related to frame rate).

Overall - Once again, all 3 systems provided a high quality video call experience.

Note - Based on the results of the prior sharpness test, the Polycom clearly has the ability to send HD720p at this speed. WR believes Polycom is being overly conservative by using 4SIF.

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol
A-M33	Polycom HDX 9000 - L (7003)	Polycom HDX 9000 - R (7002)		1920	Y	1920	Y	H.264	HD720p (1280x720)	30	Siren-22	H.264	HD720p (1280x720)	30	Siren-22
A-M34	Tandberg 6000 MXP - L (7005)	Tandberg 6000 MXP - R (7004)		1536	Y	1536	Y	H.264	HD720p (1280x720)		AAC-LD	H.264	HD720p (1280x720)		AAC-LD
A-M35	LifeSize Room - R (7006)	LifeSize Room - L (7007)		1920	Y	1920	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC

Notes (A-M33 - A-M35): Call experience very similar to prior test call.

Once again, Polycom motion handling superior, LifeSize a very close second, and Tandberg a distant third (during the wave test, the subject's hand was very clear on the Polycom, clear on the LifeSize, and somewhat blurry on the Tandberg).

Overall - Three solid HD video calls.

A) HD to HD H.239 Testing - Between Like Systems (Video Quality set to "Motion")

Light Level 1: High = 711 Lux (horizontal) - Using fluorescents from above with 4100 degree Kelvin bulbs

Notes: The H.239 testing was conducted by repeating test calls A-M24, A-M25, and A-M26 and then sending data as documented below

A-M36	Polycom HDX 9000 - R (7002)	Polycom HDX 9000 - L (7003)		768	Y	768	Y	H.264	2SIF (704x240)	30	Siren-22	H.264	2SIF (704x240)	30	Siren-22
H.239 Test - H.239 signal sent from Polycom HDX 9000 - R (7002)				H.239 Tx from 7002		Up to 500		H.264	XGA (1024x768)	8					
				H.239 Rx at 7003		Up to 500		H.264	XGA (1024x768)	8					

H.239 Notes: The Polycom allocated dynamic bandwidth to the H.239 signal ranging from 0 to 500 kbps, depending upon how much motion was in the PC signal.

H.239 XGA signal displayed window boxed on the display in native resolution and using the native aspect ratio (4:3).

PPT Test - Excellent image quality and text clarity.

Motion Video Clip Test - Very good image quality (especially for 7 fps).

A-M37	Tandberg 6000 MXP - R (7004)	Tandberg 6000 MXP - L (7005)		768	Y	768	Y	H.264	w448p (576x448)		AAC-LD	H.264	w448p (576x448)		AAC-LD
H.239 Test - H.239 signal sent from Tandberg 6000 MXP - R (7004)				H.239 Tx from 7004		Up to 420		H.264	XGA (1024x768)	Est. 4 - 5					
				H.239 Rx at 7005		Up to 420		H.264	XGA (1024x768)	Est. 4 - 5					

H.239 Notes: The TANDBRG allocated dynamic bandwidth to the H.239 signal ranging from 240 to 420 kbps (roughly), depending upon how much motion was in the PC signal.

H.239 XGA signal was displayed window boxed, in native resolution, and using the native aspect ratio (4:3).

PPT Test - Good quality native resolution with excellent text clarity.

Motion Video Clip Test - Very good image quality, but lower frame rate (estimated 4 - 5 fps) was noticeable compared to the Polycom.

A-M38	LifeSize Room - L (7007)	LifeSize Room - R (7006)		768	Y	768	Y	H.264	1088x608	30	AAC-LC	H.264	1088x608	30	AAC-LC
H.239 Test - H.239 signal sent from LifeSize Room - R (7006)				H.239 Tx from 7007		106		H.264	HD720p (1280x720)	Est. 3 - 4					
				H.239 Rx at 7006		106		H.264	HD720p (1280x720)	Est. 3 - 4					

H.239 Notes: Unlike the other systems, the LifeSize did not have dynamic bandwidth allocation for the H.239 signal. It used a constant 106 kbps.

The LifeSize allows you to allocate what percentage of bandwidth goes to the primary and secondary signals. For our testing we used 80% / 20%.

H.239 XGA signal displayed window boxed on the display in native resolution and using the native aspect ratio (4:3).

PPT Test - Good image quality, but not as clear as the Polycom image.

Motion Video Clip Test - Acceptable, but low frame rate video quality. Long latency also noted (images took > 1 second to update).

H.239 Testing Notes:

WR repeated the H.239 test for calls A-M30 through A-M32 (at 1.5 Mbps) and noted the same results as above with one exception - each system used more bandwidth for the H.239 data channel.

High Definition Videoconferencing Evaluation

Call Configuration			Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To	BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

A) HD to HD Testing - Between Like Systems (Video Quality set to "Motion")

Light Level 2: Low = 165 Lux (horizontal) - Using front-facing halogen studio lighting

A-M41	Polycom HDX 9000 - L (7003)	Polycom HDX 9000 - R (7002)			384	Y		384	Y		H.264	SIF (352x240)	30	Siren-22		H.264	SIF (352x240)	30	Siren-22
A-M42	Tandberg 6000 MXP - L (7005)	Tandberg 6000 MXP - R (7004)			384	Y		384	Y		H.264	w288p (512x288)		AAC-LD		H.264	w288p (512x288)		AAC-LD
A-M43	LifeSize Room - R (7006)	LifeSize Room - L (7007)			384	Y		384	Y		H.264	768x432	30	Siren-14		H.264	768x432	30	Siren-14

Notes (A-M41 - A-43): Significant motion handling differences noted at this relatively low light level.

LifeSize had difficulty locking focus when zoomed in.

LifeSize was initially set to Auto white balance, but WR had to set this to "Halogen" in order to get acceptable color balance (the Polycom and Tandberg systems compensated for the lighting change automatically).

Even with the white balance setting change, the LifeSize image was noticeably red / rosy. The Polycom had the most natural color scheme. The Tandberg's camera image was acceptable, but slightly red.

During the wave test, the person's fingers were 1) relatively clear on the Polycom, 2) acceptable on the Tandberg, and 3) somewhat blurry on the LifeSize.

A-M44	Polycom HDX 9000 - R (7002)	Polycom HDX 9000 - L (7003)			768	Y		768	Y		H.264	2SIF (704x240)	30	Siren-22		H.264	2SIF (704x240)	30	Siren-22
A-M45	Tandberg 6000 MXP - R (7004)	Tandberg 6000 MXP - L (7005)			768	Y		768	Y		H.264	w448p (576x448)		AAC-LD		H.264	w448p (576x448)		AAC-LD
A-M46	LifeSize Room - L (7007)	LifeSize Room - R (7006)			768	Y		768	Y		H.264	1088x608	30	AAC-LC		H.264	1088x608	30	AAC-LC

Notes (A-M44 - A-M46): Some motion handling improvement noted compared to the 384 kbps call.

LifeSize had difficulty locking focus when zoomed in.

During the wave test, the person's fingers were 1) totally clear on the Polycom, 2) basically clear on the Tandberg, and 3) slightly blurry on the LifeSize (like at 384k).

Tandberg's frame rate dropped intermittently during the test call.

A-M47	Polycom HDX 9000 - L (7003)	Polycom HDX 9000 - R (7002)			1472	Y		1472	Y		H.264	4SIF (704x480)	30	Siren-22		H.264	4SIF (704x480)	30	Siren-22
A-M48	Tandberg 6000 MXP - L (7005)	Tandberg 6000 MXP - R (7004)			1472	Y		1472	Y		H.264	HD720p (1280x720)		AAC-LD		H.264	HD720p (1280x720)		AAC-LD
A-M49	LifeSize Room - R (7006)	LifeSize Room - L (7007)			1472	Y		1472	Y		H.264	HD720p (1280x720)	30	AAC-LC		H.264	HD720p (1280x720)	30	AAC-LC

Notes (A-M47 - A-M49): Some motion handling improvement noted compared to the 768 kbps call.

LifeSize had difficulty locking focus when zoomed in.

During the wave test, the person's fingers were 1) totally clear on the Polycom, 2) clear on the Tandberg, and 3) still a bit blurry on the LifeSize.

Note that as the bandwidth of the call increased, the clarity / quality of the LifeSize image improved gradually.

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

B) HD to HD Testing - Between Unlike Systems (Video Quality set to "Sharpness")

B-S01	Polycom HDX 9000 - R (7002)	LifeSize Room - R (7006)		384	Y	384	Y	H.264	4SIF (704x480)	30	Siren14	H.264	4CIF (704x576)	10	Siren14
Notes:	Polycom to LifeSize - high quality image, full motion, limited pixelization. LifeSize to Polycom - significant motion handling issues (related primarily to frame rate).														
B-S02	Polycom HDX 9000 - R (7002)	Tandberg 6000 MXP - L (7005)		384	Y	384	Y	H.264	4SIF (704x480)	30	G.722	H.264	w288p (512x288)	15	G.722
Notes:	Polycom to Tandberg - Good quality video image with notable motion artifacts (hand blurry during the wave test). Tandberg to Polycom - Acceptable video image with notable pixelization and low frame rate (< 15 fps).														
B-S03	LifeSize Room - L (7007)	Tandberg 6000 MXP - L (7005)		384	Y	384	Y	H.264	HD720p (1280x720)	6	G.722	H.264	HD720p (1280x720)	15	G.722
Notes:	LifeSize to Tandberg - High resolution (HD) image being sent, but at unacceptably low frame rate. This appears to be an interop issue. Tandberg to LifeSize - Acceptable video quality with notable pixelization and low frame rate (< 15 fps).														
B-S04	Polycom HDX 9000 - R (7002)	LifeSize Room - R (7006)		768	Y	768	Y	H.264	4SIF (704x480)	30	Siren14	H.264	HD720p (1280x720)	10	Siren14
Notes:	Polycom to LifeSize - high quality image, full motion, limited pixelization. LifeSize to Polycom - significant motion handling issues (related primarily to frame rate).														
B-S05	Polycom HDX 9000 - R (7002)	Tandberg 6000 MXP - L (7005)		768	Y	768	Y	H.264	4SIF (704x480)	30	G.722	H.264	HD720p (1280x720)	15	G.722
Notes:	Polycom to Tandberg - Very high quality image, good motion handling, consistent 30 fps. Tandberg to Polycom - significant frame rate drop and increased latency (at least 500 ms), presumably related to use of HD resolution.														
B-S06	LifeSize Room - L (7007)	Tandberg 6000 MXP - L (7005)		768	Y	768	Y	H.264	HD720p (1280x720)	6	G.722	H.264	HD720p (1280x720)	15	G.722
Notes:	LifeSize to Tandberg - High resolution (HD) image being sent, but at unacceptably low frame rate. This appears to be an interop issue. Tandberg to LifeSize - Good overall video quality with noted motion artifacts.														
B-S07	Polycom HDX 9000 - R (7002)	LifeSize Room - R (7006)		1152	Y	1152	Y	H.264	HD720p (1280x720)	30	Siren14		HD720p (1280x720)	30	Siren14
Notes:	Polycom to LifeSize - high quality, full motion HD image LifeSize to Polycom - high quality, full motion HD image Note - This is exactly what WR would want to see from a 1 Mbps HD interop call.														
B-S08	Polycom HDX 9000 - R (7002)	Tandberg 6000 MXP - L (7005)		1152	Y	1152	Y	H.264	4SIF (704x480)	30	G.722		HD720p (1280x720)	30	G.722
Notes:	Polycom to Tandberg - Very good image quality, but intermittent video stuttering noted (likely from stress on Tandberg from sending HD at 30 fps). Tandberg to Polycom - Very good image quality with slight motion issue (hand slightly blurry during the wave test).														
B-S09	LifeSize Room - L (7007)	Tandberg 6000 MXP - L (7005)		1152	Y	1152	Y	H.264	HD720p (1280x720)	6	G.722		HD720p (1280x720)	30	G.722
Notes:	LifeSize to Tandberg - High resolution (HD) image being sent, but at unacceptably low frame rate. This appears to be an interop issue. Tandberg to LifeSize - High quality HD video signal being sent and received.														

High Definition Videoconferencing Evaluation

Call Configuration			Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To	BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol
B-S10	Polycom HDX 9000 - R (7002)	LifeSize Room - R (7006)	1472	Y	1472	Y	H.264	HD720p (1280x720)	30	Siren14	H.264	HD720p (1280x720)	30	Siren14
Notes:	Polycom to LifeSize - high quality, full motion HD image LifeSize to Polycom - high quality, full motion HD image Note - This is only trivially better than the same call at 1152 kbps.													
B-S11	Polycom HDX 9000 - R (7002)	Tandberg 6000 MXP - L (7005)	1472	Y	1472	Y	H.264	4SIF (704x480)	30	G.722	H.264	HD720p (1280x720)	30	G.722
Notes:	Polycom to Tandberg - Excellent video quality, but still not HD (likely due to Tandberg's use of static macro blocks) Tandberg to Polycom - Excellent video quality, with slight motion blurriness.													
B-S12	LifeSize Room - L (7007)	Tandberg 6000 MXP - L (7005)	1472	Y	1472	Y	H.264	HD720p (1280x720)	6	G.722	H.264	HD720p (1280x720)	30	G.722
Notes:	LifeSize to Tandberg - High resolution (HD) image being sent, but at unacceptably low frame rate. This appears to be an interop issue. Tandberg to LifeSize - High quality HD video signal being sent and received.													
B-S13	Polycom HDX 9000 - R (7002)	LifeSize Room - R (7006)	1920	Y	1920	Y	H.264	HD720p (1280x720)	30	Siren14	H.264	HD720p (1280x720)	30	Siren14
Notes:	Polycom to LifeSize - high quality, full motion HD image LifeSize to Polycom - high quality, full motion HD image Again - only a slight improvement over the 1152 and 1472 calls (probably not worth the additional bandwidth)													
B-S14	Polycom HDX 9000 - R (7002)	Tandberg 6000 MXP - L (7005)	1536	Y	1536	Y	H.264	4SIF (704x480)	30	G.722	H.264	HD720p (1280x720)	30	G.722
Notes:	Polycom to Tandberg - Excellent video quality, but still not HD (likely due to Tandberg's use of static macro blocks) Tandberg to Polycom - Excellent video quality, with slight motion blurriness.													
B-S15	LifeSize Room - L (7007)	Tandberg 6000 MXP - L (7005)	1536	Y	1536	Y	H.264	HD720p (1280x720)	6	G.722	H.264	HD720p (1280x720)	30	G.722
Notes:	LifeSize to Tandberg - High resolution (HD) image being sent, but at unacceptably low frame rate. This appears to be an interop issue. IMPORTANT - When set to favor sharpness, the LS is unable to send more than 6 fps to the Tandberg system, regardless of the speed (tested at 384, 768, 1152, 1472, and 1536 kbps). Tandberg to LifeSize - High quality HD video signal being sent and received.													

High Definition Videoconferencing Evaluation

Call Configuration			Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To	BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

B) HD to HD H.239 Testing - Between Unlike Systems (Video Quality set to "Sharpness")

Notes: The H.239 testing was conducted by repeating test calls B-10, B-11 and B-12 and then sending data as documented below

B-S16	Polycom HDX 9000 - R (7002)	LifeSize Room - R (7006)			1472	Y		1472	Y		H.264	HD720p (1280x720)	30	Siren14		H.264	HD720p (1280x720)	30	Siren14
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H.239 Test - H.239 signal sent from the Polycom to the LifeSize

H.239 TX from 7002		708			H.264	XGA (1024x768)	7
H.239 Rx at 7006		708			H.264	XGA (1024x768)	

H.239 Notes: Properly functioning H.239 call including native resolution and proper aspect ratio.
 Polycom is using dynamic bit rate (drops to 0 with no motion)
 Polycom and LifeSize both provide different viewing options (16:9, 4:3, PiP, PoP, etc.).
 The LS provides an especially high number of layout options.

H.239 Test - H.239 signal sent from the LifeSize to the Polycom

H.239 TX from 7006		200			H.264	4CIF (704x576)	
H.239 Rx at 7002		200			H.264	4CIF (704x576)	7

H.239 Notes: H.239 from the LifeSize to the Polycom was not as strong as the other direction (4CIF vs. XGA resolution)
 LifeSize is not using dynamic bit rate for H.239 (rate does not drop below 188 k - even lacking motion)
 Send image from the LifeSize is smaller (4CIF vs. XGA), so image is displayed with left, right, top and bottom windowing.
 Noted that when picture outside of picture is in use to show far and near end, the PC image was squeezed left to right.
 This was NOT the case when the data was sent in the other direction (from the PLCM to the LS).

B-S17	Polycom HDX 9000 - R (7002)	Tandberg 6000 MXP - L (7005)			1472	Y		1472	Y		H.264	4SIF (704x480)	30	G.722		H.264	HD720p (1280x720)	30	G.722
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H.239 Test - H.239 signal sent from the Polycom to the Tandberg

H.239 TX from 7002		704			H.263	XGA (1024x768)	7
H.239 Rx at 7005		632			H.263	XGA (1024x768)	

H.239 Notes: Properly functioning H.239 call including native resolution and proper aspect ratio.
 Polycom is using dynamic bit rate for H.239, but does not drop below ~ 100 kbps.
 Polycom and Tandberg both provide different viewing options (16:9, 4:3, PiP, PoP, etc.).

H.239 Test - H.239 signal sent from the Tandberg to the Polycom

H.239 TX from 7005		800			H.263	XGA (1024x768)	
H.239 Rx at 7003		800			H.263	XGA (1024x768)	7

H.239 Notes: Activating H.239 send from the Tandberg caused it to drop its transmit frame rate on the primary video channel from 30 to 15 fps.
 Properly functioning H.239 call including native resolution and proper aspect ratio
 Tandberg is using dynamic bit rate for H.239, but does not drop below ~ 400 kbps (which is quite high).
 Polycom and Tandberg both provide different viewing options (16:9, 4:3, PiP, PoP, etc.).

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

B-S18	LifeSize Room - L (7007)	Tandberg 6000 MXP - L (7005)		1472	Y	1472	Y	H.264	HD720p (1280x720)	6	G.722	H.264	HD720p (1280x720)	30	G.722
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Notes Same interop issue noted on the primary video channel (max frame rate from the LifeSize to the Tandberg is 6 fps when set for sharpness)

H.239 Test - H.239 signal sent from the LifeSize to the Tandberg

H.239 TX from 7007		200			H.263+	HD720p (1280x720)	
H.239 Rx at 7005		200				HD720p (1280x720)	

H.239 Notes: Although not native resolution (XGA), the use of HD resolution in the H.239 channel was not objectionable (the image quality was as we would have expected).
LifeSize is using dynamic bit rate for H.239, but the rate does not drop below ~ 190 kbps - even lacking motion.
LifeSize and Tandberg both provide different viewing options (16:9, 4:3, PiP, PoP, etc.).

H.239 Test - H.239 signal sent from the Tandberg to the LifeSize

H.239 TX from 7005		700				XGA (1024x768)	
H.239 Rx at 7007		700			H.263	XGA (1024x768)	

H.239 Notes: Activating H.239 send from the Tandberg caused it to drop its transmit frame rate on the primary video channel from 30 to 15 fps.
Properly functioning H.239 call including native resolution and proper aspect ratio.
Tandberg used dynamic bit rate for H.239, but did not drop below ~ 500 kbps.
LifeSize and Tandberg both provide different viewing options (16:9, 4:3, PiP, PoP, etc.).

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

B) HD to HD Testing - Between Unlike Systems (Video Quality set to "Motion")

B-M21	Polycom HDX 9000 - R (7002)	LifeSize Room - R (7006)		384	Y	384	Y	H.264	SIF (352x240)	30	Siren14	H.264	VGA (640x480)	30	Siren14
Notes:	Polycom to LifeSize - Good low bandwidth H.264 image quality with some motion handling issues. LifeSize to Polycom - Similar motion-handling issues as above, but LS is taking its 16:9 camera image and squeezing it into a 4:3 (VGA) signal. As a result, Polycom is displaying a squeezed incoming signal.														
B-M22	Polycom HDX 9000 - R (7002)	Tandberg 6000 MXP - L (7005)		384	Y	384	Y	H.264	SIF (352x240)	30	G.722	H.264	w288p (512x288)	30	G.722
Notes:	Polycom to Tandberg - Good low bandwidth H.264 image quality with some motion handling issues. Tandberg to Polycom - Good low bandwidth H.264 image quality with some motion handling issues.														
B-M23	LifeSize Room - L (7007)	Tandberg 6000 MXP - L (7005)		384	Y	384	Y	H.264	720x400 (w400p)	30	G.722	H.264	w288p (512x288)	30	G.722
Notes:	LifeSize to Tandberg - Good low bandwidth H.264 image quality, but the Tandberg is showing a squeezed incoming video signal. This also happened in the LifeSize to Polycom low call speed interop testing. Tandberg to LifeSize - Good low bandwidth H.264 call.														
B-M24	Polycom HDX 9000 - R (7002)	LifeSize Room - R (7006)		768	Y	768	Y	H.264	2SIF (704x240)	30	Siren14	H.264	1120x624	30	Siren14
Notes:	Polycom to LifeSize - Solid full motion video call. Resolution increased and frame rate / motion handling were maintained. LifeSize to Polycom - Solid full motion video call, but once again the Polycom is showing a squeezed incoming video signal. In this case, since the LifeSize is sending a 16:9 image (1120x624), the squeezing issue is probably related to the uncommon resolution used.														
B-M25	Polycom HDX 9000 - R (7002)	Tandberg 6000 MXP - L (7005)		768	Y	768	Y	H.264	2SIF (704x240)	30	G.722	H.264	w448p (576x448)	30	G.722
Notes:	Polycom to Tandberg - Resolution increased appropriately while maintaining frame rate and motion handling. Tandberg to Polycom - Resolution increased appropriately while maintaining frame rate and motion handling.														
B-M26	LifeSize Room - L (7007)	Tandberg 6000 MXP - L (7005)		768	Y	768	Y	H.264	720x400 (w400p)	30	G.722	H.264	w448p (576x448)	30	G.722
Notes:	LifeSize to Tandberg - Solid video quality, but once again Tandberg is showing a squeezed incoming video signal. Tandberg to LifeSize - Solid enhanced resolution video quality with minor motion artifacts.														
B-M27	Polycom HDX 9000 - R (7002)	LifeSize Room - R (7006)		1152	Y	1152	Y	H.264	4SIF (704x480)	30	Siren14	H.264	HD720p (1280x720)	30	Siren14
Notes:	Polycom to LifeSize - An excellent, full motion, 4SIF video signal. LifeSize to Polycom - A solid, full motion HD video signal. Note that the aspect ratio described above (calls B-M21 and B-M24) has disappeared.														
B-M28	Polycom HDX 9000 - R (7002)	Tandberg 6000 MXP - L (7005)		1152	Y	1152	Y	H.264	4SIF (704x480)	30	G.722	H.264	w448p (576x448)	30	G.722
Notes:	Polycom to Tandberg - Once again, resolution increase was noted, and frame rate / motion handling remained strong. Tandberg to Polycom - Motion handling issues noted (decreased frame rate, intermittent video stuttering).														
B-M29	LifeSize Room - L (7007)	Tandberg 6000 MXP - L (7005)		1152	Y	1152	Y	H.264	w400p (720x400)	30	G.722	H.264	w448p (576x448)	30	G.722
Notes:	LifeSize to Tandberg - Intermittent issue of the Tandberg not showing the incoming LifeSize video signal (black screen) Tandberg to LifeSize - An excellent enhanced resolution video call.														

High Definition Videoconferencing Evaluation

Call Configuration			Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats									
Call #	From	To	BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol						
B-M30	Polycom HDX 9000 - R (7002)	LifeSize Room - R (7006)			1472	Y			1472	Y		H.264	4SIF (704x480)	30	Siren14		H.264	HD720p (1280x720)	30	Siren14
Notes:	Polycom to LifeSize - An excellent call (little or no difference compared to same call at 1152). LifeSize to Polycom - An excellent call (little or no difference compared to same call at 1152).																			
B-M31	Polycom HDX 9000 - R (7002)	Tandberg 6000 MXP - L (7005)			1472	Y			1472	Y		H.264	4SIF (704x480)	30	G.722		H.264	HD720p (1280x720)	30	G.722
Notes:	Polycom to Tandberg - An excellent, full motion, 4SIF video signal (ideally, Polycom would have sent HD) Tandberg to Polycom - Excellent video quality with slight motion artifacts noted. Also, relatively long latency (compared to other direction).																			
B-M32	LifeSize Room - L (7007)	Tandberg 6000 MXP - L (7005)			1472	Y			1472	Y		H.264	w400p (720x400)	30	G.722		H.264	HD720p (1280x720)	30	G.722
Notes:	LifeSize to Tandberg - Same interop issue noted (no image displayed on the Tandberg), but this time it corrected itself ~ 30 seconds after connecting. Tandberg to LifeSize - Solid HD video signal with only minor video artifacts.																			
B-M33	Polycom HDX 9000 - R (7002)	LifeSize Room - R (7006)			1920	Y			1920	Y		H.264	HD720p (1280x720)	30	Siren14		H.264	HD720p (1280x720)	30	Siren14
Notes:	Polycom to LifeSize - Increased resolution noted and frame rate maintained at 30 fps. Slight motion artifacting observed. LifeSize to Polycom - Solid performance as per prior calls.																			
B-M34	Polycom HDX 9000 - R (7002)	Tandberg 6000 MXP - L (7005)			1536	Y			1536	Y		H.264	4SIF (704x480)	30	G.722		H.264	HD720p (1280x720)	30	G.722
Notes:	Polycom to Tandberg - No change from 1472 kbps call. Tandberg to Polycom - No change from 1472 kbps call.																			
B-M35	LifeSize Room - L (7007)	Tandberg 6000 MXP - L (7005)			1536	Y			1536	Y		H.264	w400p (720x400)	30	G.722		H.264	HD720p (1280x720)	30	G.722
Notes:	LifeSize to Tandberg - Same interop issue noted (no image displayed on the Tandberg). This time the issue did not correct itself over time. Tandberg to LifeSize - Solid HD video signal with only minor video artifacts.																			

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

C) HD to SD Testing

Notes: For calls at 384 and 768, the sending unit was set for "Motion." For calls at 1152 and 1472, the sending unit was set for "Sharpness."

Part 1: Polycom HDX Testing

C-M01	Polycom HDX 9000 - R (7002)	Polycom VSX 3000 - (7010)		384	Y	384	Y	H.264	SIF (352x240)	30	SirenStereo	H.264	SIF (352x240)	30	SirenStereo
C-M02	Polycom HDX 9000 - R (7002)	Tandberg 880 MXP - (7011)		384	Y	384	Y	H.264	SIF (352x240)	30	G.722	H.264	400p (528x400)	30	G.722
C-M03	Polycom HDX 9000 - R (7002)	Huawei 8039 - (7012)		384	Y	384	N	H.264	SIF (352x240)	30	G.722	H.263	CIF (352x288)	30	G.722
C-M04	Polycom HDX 9000 - R (7002)	Aethra Vega X3 - (7013)		384	Y	384	Y	H.264	SIF (352x240)	30	G.722	H.264	SIF (352x240)	30	G.722
C-M05	Polycom HDX 9000 - R (7002)	Sony G-50 - (7014)		384	Y	384	Y	H.264	SIF (352x240)	30	G.722	H.264	CIF (352x288)	30	G.722
C-M06	Polycom HDX 9000 - R (7002)	Emblaze-VCON HD-5000 - (7016)		384	Y	384	Y	H.264	SIF (352x240)	30	G.722	H.264	SIF (352x240)	30	G.722

Notes (C-M01 - C-M06): Call C-M02 - The Polycom HDX 9000 stats screen shows "Ext-528x400" for incoming video format, but the Tandberg 880 MXP says its sending 400p.

Call C-M03 - The Polycom HDX 9000 stats screen shows SIF for outgoing video format, but the Huawei says its receiving CIF

C-M07	Polycom HDX 9000 - R (7002)	Polycom VSX 3000 - (7010)		768	Y	768	Y	H.263+ ITNW	SIF (352x240)	60	SirenStereo	H.264	SIF (352x240)	30	SirenStereo
C-M08	Polycom HDX 9000 - R (7002)	Tandberg 880 MXP - (7011)		768	Y	768	Y	H.264	2SIF (704x240)	30	G.722	H.264	400p (528x400)	30	G.722
C-M09	Polycom HDX 9000 - R (7002)	Huawei 8039 - (7012)		768	Y	768	N	H.264	SIF (352x240)	30	G.722	H.263	CIF (352x288)	30	G.722
C-M10	Polycom HDX 9000 - R (7002)	Aethra Vega X3 - (7013)		768	Y	768	Y	H.264	SIF (352x240)	30	G.722	H.264	SIF (352x240)	30	G.722
C-M11	Polycom HDX 9000 - R (7002)	Sony G-50 - (7014)		768	Y	768	Y	H.264	SIF (352x240)	30	G.722	H.264	CIF (352x288)	30	G.722
C-M12	Polycom HDX 9000 - R (7002)	Emblaze-VCON HD-5000 - (7016)		768	Y	768	Y	H.264	2SIF (704x240)	30	G.722	H.264	SIF (352x240)	30	G.722

Notes (C-M07 - C-M12): Call C-M08 - The Polycom HDX 9000 stats screen shows "Ext-528x400" for incoming video format, but the Tandberg 880 MXP says its sending 400p.

Call C-M09 - The Polycom HDX 9000 stats screen shows SIF for outgoing video format, but the Huawei says its receiving CIF

C-S13	Polycom HDX 9000 - R (7002)	Polycom VSX 3000 - (7010)		1152	Y	1152	Y	H.263+ITNW	SIF (352x240)	60	SirenStereo	H.263	SIF (352x240)	30	SirenStereo
C-S14	Polycom HDX 9000 - R (7002)	Tandberg 880 MXP - (7011)		1152	Y	1152	Y	H.264	4SIF (704x480)	30	G.722	H.264	400p (528x400)	30	G.722
C-S15	Polycom HDX 9000 - R (7002)	Huawei 8039 - (7012)		1152	Y	1152	N	H.264	2SIF (704x240)	30	G.722	H.263	CIF (352x288)	30	G.722
C-S16	Polycom HDX 9000 - R (7002)	Aethra Vega X3 - (7013)		1152	Y	1152	Y	H.263	SIF (352x240)	30	G.722	H.263	SIF (352x240)	30	G.722
C-S17	Polycom HDX 9000 - R (7002)	Sony G-50 - (7014)		1152	Y	1152	Y	H.264	SIF (352x240)	30	G.722	H.264	CIF (352x288)	30	G.722
C-S18	Polycom HDX 9000 - R (7002)	Emblaze-VCON HD-5000 - (7016)		1152	Y	1152	Y	H.264	HD720p (1280x720)	20	G.722	H.264	SIF (352x240)	20	G.722

Notes (C-S13 - C-S18): Call C-S14 - The Polycom HDX 9000 stats screen shows "Ext-528x400" for incoming video format, but the Tandberg 880 MXP says its sending 400p.

Call C-S15 - The Polycom HDX 9000 stats screen shows 2SIF for outgoing video format, but the Huawei says its receiving "50/60F."

Call C-S18 - Significant frame rate drops and screen freezes noted in both directions for this call.

C-S19	Polycom HDX 9000 - R (7002)	Polycom VSX 3000 - (7010)		1472	Y	1472	Y	H.263+NW	SIF (352x240)	60	SirenStereo	H.263	SIF (352x240)	30	SirenStereo
C-S20	Polycom HDX 9000 - R (7002)	Tandberg 880 MXP - (7011)		1472	Y	1472	Y	H.264	4SIF (704x480)	30	G.722	H.264	400p (528x400)	30	G.722
C-S21	Polycom HDX 9000 - R (7002)	Huawei 8039 - (7012)		1472	Y	1472	N	H.264	2SIF (704x240)	15	G.722	H.263	CIF (352x288)	30	G.722
C-S22	Polycom HDX 9000 - R (7002)	Aethra Vega X3 - (7013)		1472	Y	1472	Y	H.263	SIF (352x240)	30	G.722	H.263	SIF (352x240)	30	G.722
C-S23	Polycom HDX 9000 - R (7002)	Sony G-50 - (7014)		1472	Y	1472	Y	H.264	SIF (352x240)	30	G.722	H.264	CIF (352x288)	30	G.722
C-S24	Polycom HDX 9000 - R (7002)	Emblaze-VCON HD-5000 - (7016)		1472	Y	1472	Y	H.264	HD720p (1280x720)	20	G.722	H.264	SIF (352x240)	20	G.722

Notes (C-S19 - C-S24): Call C-S20 - The Polycom HDX 9000 stats screen shows "Ext-528x400" for incoming video format, but the Tandberg 880 MXP says its sending 400p.

Call C-S21 - The Polycom HDX 9000 stats screen shows 2SIF for outgoing video format, but the Huawei says its receiving "50/60F."

Call C-S24 - Significant frame rate drops and screen freezes noted in both directions for this call.

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol
C-M25	Polycom HDX 9000 - R (7002)	Polycom VSX 3000 - (7010)		768	Y	768	Y	H.263+ ITNW	SIF (352x240)	60	SirenStereo	H.264	SIF (352x240)	30	SirenStereo
	H.239 Test - H.239 signal sent from Polycom HDX 9000					256-512		H.263+IT	XGA (1024x768)	5					
				H.239 Notes: This is a normal, native-resolution H.239 call.											

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

C) HD to SD Testing (continued)

Notes: For calls at 384 and 768, the sending unit was set for "Motion." For calls at 1152 and 1472, the sending unit was set for "Sharpness."

Part 2: Tandberg 6000 Testing

C-M31	Tandberg 6000 MXP - L (7005)	Polycom VSX 3000 - (7010)		384	Y	384	Y	H.264	CIF (352x288)	25	G.722	H.264	SIF (352x240)	30	G.722
C-M32	Tandberg 6000 MXP - L (7005)	Tandberg 880 MXP - (7011)		384	Y	384	Y	H.264	w288p (512x288)		AAC-LD	H.264	400p (528x400)		AAC-LD
C-M33	Tandberg 6000 MXP - L (7005)	Huawei 8039 - (7012)		384	Y	384	N	H.264	w288p (512x288)	0	G.722	H.263	CIF (352x288)	30	G.711
C-M34	Tandberg 6000 MXP - L (7005)	Aethra Vega X3 - (7013)		384	Y	384	Y	H.264	CIF (352x288)	20	AAC-LD	H.264	SIF (352x240)	15	AAC-LD
C-M35	Tandberg 6000 MXP - L (7005)	Sony G-50 - (7014)		384	Y	384	Y	H.264	CIF (352x288)	30	G.722	H.264	CIF (352x288)	30	G.722
C-M36	Tandberg 6000 MXP - L (7005)	Emblaze-VCON HD-5000 - (7016)		384	Y	384	N	H.264	w288p (512x288)	30	AAC-LD	H.264	SIF (352x240)	30	AAC-LD

Notes (C-M31 - C-M36): Call C-M32 - WR wonders why the 6000 MXP sent w288p to the 880 MXP instead of w400p (which it received from the SD system). The 6000 MXP should have adequate horsepower.

Call C-M33 - The frame rate from Tandberg to Huawei shows as 0, and Huawei did not receive incoming video. We then disabled H.264 on the Tandberg, repeated the call, and the video issue was resolved. This appears to be an H.264 interop issue.

C-M37	Tandberg 6000 MXP - L (7005)	Polycom VSX 3000 - (7010)		768	Y	768	Y	H.264	CIF (352x288)	25	G.722	H.264	SIF (352x240)	30	G.722
C-M38	Tandberg 6000 MXP - R (7004)	Tandberg 880 MXP - (7011)		768	Y	768	Y	H.264	w448p (576x448)		AAC-LD	H.264	400p (528x400)		AAC-LD
C-M39	Tandberg 6000 MXP - L (7005)	Huawei 8039 - (7012)		768	Y	768	N	H.264	w288p (512x288)	0	G.722	H.263	CIF (352x288)	30	G.711
C-M40	Tandberg 6000 MXP - L (7005)	Aethra Vega X3 - (7013)		768	Y	768	Y	H.264	CIF (352x288)	20	AAC-LD	H.264	SIF (352x240)	15	AAC-LD
C-M41	Tandberg 6000 MXP - L (7005)	Sony G-50 - (7014)		768	Y	768	Y	H.264	CIF (352x288)	30	G.722	H.264	CIF (352x288)	30	G.722
C-M42	Tandberg 6000 MXP - L (7005)	Emblaze-VCON HD-5000 - (7016)		768	Y	768	N	H.264	w448p (576x448)	15	AAC-LD	H.264	SIF (352x240)	30	AAC-LD

Notes (C-M37 - C-M42): Call C-M39 - The frame rate from Tandberg to Huawei shows as 0, and Huawei did not receive incoming video. We then disabled H.264 on the Tandberg, repeated the call, and the video issue was resolved. This appears to be an H.264 interop issue.

Call C-M42 - The incoming video on the Emblaze-VCON froze intermittently. This may be related to the high resolution (w448p) being sent by the Tandberg.

C-S43	Tandberg 6000 MXP - L (7005)	Polycom VSX 3000 - (7010)		1152	Y	1152	Y	H.263+	4CIF (704x576)	15	G.722	H.263+	SIF (352x240)	30	G.722
C-S44	Tandberg 6000 MXP - L (7005)	Tandberg 880 MXP - (7011)		1152	Y	1152	Y	H.264	HD720p (1280x720)		AAC-LD	H.264	400p (528x400)		AAC-LD
C-S45	Tandberg 6000 MXP - L (7005)	Huawei 8039 - (7012)		1152	Y	1152	N	H.264	w288p (512x288)	0	G.722	H.263	CIF (352x288)	30	G.711
C-S46	Tandberg 6000 MXP - L (7005)	Aethra Vega X3 - (7013)		1152	Y	1152	Y	H.263+	4CIF (704x576)	20	AAC-LD	H.263+	SIF (352x240)	15	AAC-LD
C-S47	Tandberg 6000 MXP - L (7005)	Sony G-50 - (7014)		1152	Y	1152	Y	H.263+	4CIF (704x576)	15	G.722	H.264	CIF (352x288)	30	G.722
C-S48	Tandberg 6000 MXP - L (7005)	Emblaze-VCON HD-5000 - (7016)		1152	Y	1152	N	H.264	HD720p (1280x720)	15	AAC-LD	H.264	SIF (352x240)	30	AAC-LD

Notes (C-S43 - C-S48): Call C-S45 - The frame rate from Tandberg to Huawei shows as 0, and Huawei did not receive incoming video. We then disabled H.264 on the Tandberg, repeated the call, and the video issue was resolved. This appears to be an H.264 interop issue.

Call C-S48 - As with call C-M42 above, the incoming video on the Emblaze-VCON was mostly frozen and rendered the call unusable. It is likely that the high resolution (HD720p) being sent by the Tandberg is taxing the Emblaze-VCON system.

This may also be related to Tandberg's use of static macro blocks for HD.

C-S49	Tandberg 6000 MXP - L (7005)	Polycom VSX 3000 - (7010)		1472	Y	1472	Y	H.263+	4CIF (704x576)	15	G.722	H.263+	SIF (352x240)	30	G.722
C-S50	Tandberg 6000 MXP - L (7005)	Tandberg 880 MXP - (7011)		1472	Y	1472	Y	H.264	HD720p (1280x720)		AAC-LD	H.264	400p (528x400)		AAC-LD
C-S51	Tandberg 6000 MXP - L (7005)	Huawei 8039 - (7012)		1472	Y	1472	N	H.264	w288p (512x288)	0	G.722	H.263	CIF (352x288)	30	G.711
C-S52	Tandberg 6000 MXP - L (7005)	Aethra Vega X3 - (7013)		1472	Y	1472	Y	H.263+	4CIF (704x576)	20	AAC-LD	H.263+	SIF (352x240)	15	AAC-LD
C-S53	Tandberg 6000 MXP - L (7005)	Sony G-50 - (7014)		1472	Y	1472	Y	H.263+	4CIF (704x576)	30	G.722	H.264	CIF (352x288)	30	G.722
C-S54	Tandberg 6000 MXP - L (7005)	Emblaze-VCON HD-5000 - (7016)		1472	Y	1472	N	H.264	HD720p (1280x720)	15	AAC-LD	H.264	SIF (352x240)	30	AAC-LD

Notes (C-S49 - C-S54): Call C-S51 - The frame rate from Tandberg to Huawei shows as 0, and Huawei did not receive incoming video. We then disabled H.264 on the Tandberg, repeated the call, and the video issue was resolved. This appears to be an H.264 interop issue.

Call C-S54 - As with call C-M42 above, the incoming video on the Emblaze-VCON was mostly frozen and rendered the call unusable. It is likely that the high resolution (HD720p) being sent by the Tandberg is taxing the Emblaze-VCON system.

High Definition Videoconferencing Evaluation

Call Configuration			Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To	BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

C-M55	Tandberg 6000 MXP - R (7004)	Tandberg 880 MXP - (7011)			768	Y		768	Y		H.264	w448p (576x448)		AAC-LD		H.264	400p		AAC-LD
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Now activating H.239. Because this changed the connection between the 2 sites, the call stats were re-documented below.

H.239 Test - H.239 signal sent from the Tandberg 6000 MXP

	768	Y		768	Y		H.264	w288p (512x288)		AAC-LD		H.264	400p		AAC-LD
H.239 TX from 7004				260-380				XGA (1024x768)							

H.239 Notes: Activating H.239 send from Tandberg 6000 causes Tandberg 6000 to drop it's SEND resolution for the video channel from w448p to w288p.

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

C) HD to SD Testing (continued)

Notes: For calls at 384 and 768, the sending unit was set for "Motion." For calls at 1152 and 1472, the sending unit was set for "Sharpness."

Part 3: LifeSize Room Testing

C-M61	LifeSize Room - L (7007)	Polycom VSX 3000 - (7010)		384	Y	384	Y	H.264	SIF (352x240)	30	Siren-14	H.264	SIF (352x240)	30	Siren-14
C-M62	LifeSize Room - L (7007)	Tandberg 880 MXP - (7011)		384	Y	384	Y	H.264	w400p (720x400)	30	G.722	H.264	400p (528x400)	30	G.722
C-M63	LifeSize Room - L (7007)	Huawei 8039 - (7012)		384	Y	384	N	H.264	CIF (352x288)	30	G.722	H.263	CIF (352x288)	20	G.722
C-M64	LifeSize Room - L (7007)	Aethra Vega X3 - (7013)		384	Y	384	Y	H.264	SIF (352x240)	30	G.722	H.264	CIF (352x288)	30	G.722
C-M65	LifeSize Room - L (7007)	Sony G-50 - (7014)		384	Y	384	Y	H.264	CIF (352x288)	30	G.722	H.264	SIF (352x240)	30	AAC-LC
C-M66	LifeSize Room - L (7007)	Emblaze-VCON HD-5000 - (7016)		384	Y	Interop issue - After connecting, Emblaze-VCON software application would terminate.									

Notes (C-M61 - C-M66): The Emblaze-VCON software application terminated a few seconds after the call was made.

Since LifeSize does not offer an SD-only system, we could not do a LifeSize HD to LifeSize SD test call.

C-M67	LifeSize Room - L (7007)	Polycom VSX 3000 - (7010)		768	Y	768	Y	H.264	SIF (352x240)	30	Siren-14	H.264	SIF (352x240)	30	Siren-14
C-M68	LifeSize Room - L (7007)	Tandberg 880 MXP - (7011)		768	Y	768	Y	H.264	w400p (720x400)	30	G.722	H.264	400p (528x400)	30	G.722
C-M69	LifeSize Room - L (7007)	Huawei 8039 - (7012)		768	Y	768	N	H.264	CIF (352x288)	30	G.722	H.263	CIF (352x288)	30	
C-M70	LifeSize Room - L (7007)	Aethra Vega X3 - (7013)		768	Y	768	Y	H.264	CIF (352x288)	30	G.722	H.264	SIF (352x240)	30	G.722
C-M71	LifeSize Room - L (7007)	Sony G-50 - (7014)		768	Y	768	Y	H.264	CIF (352x288)	30	AAC-LC	H.264	CIF (352x288)	30	AAC-LC
C-M-72	LifeSize Room - L (7007)	Emblaze-VCON HD-5000 - (7016)		768	Y	Interop issue - After connecting, Emblaze-VCON software application would terminate.									

Notes (C-M67 - C-M72): The Huawei was not sending audio to the LifeSize in this call.

The Emblaze-VCON software application terminated a few seconds after the call was made.

C-S73	LifeSize Room - L (7007)	Polycom VSX 3000 - (7010)		1152	Y	1152	Y	H.263+	4CIF (704x576)	15	Siren-14	H.263+	CIF (352x288)	15	Siren-14
C-S74	LifeSize Room - L (7007)	Tandberg 880 MXP - (7011)		1152	Y	1152	Y	H.264	HD720p (1280x720)	6	G.722	H.264	400p (528x400)	30	G.722
C-S75	LifeSize Room - L (7007)	Huawei 8039 - (7012)		1152	Y	1152	N	H.264	CIF (352x288)	30	G.722	H.264	CIF (352x288)	30	
C-S76	LifeSize Room - L (7007)	Aethra Vega X3 - (7013)		1152	Y	1152	Y	H.264	CIF (352x288)	30	G.722	H.263	CIF (352x288)	30	G.722
C-S77	LifeSize Room - L (7007)	Sony G-50 - (7014)		1152	Y	1152	Y	H.264	CIF (352x288)	30	AAC-LC	H.264	CIF (352x288)	30	AAC-LC
C-S78	LifeSize Room - L (7007)	Emblaze-VCON HD-5000 - (7016)		1152	Y	1152	Y	H.264	HD720p (1280x720)	30	G.722	H.264	SIF (352x240)	30	G.722

Notes (C-S73 - C-S78): The Huawei was not sending audio to the LifeSize in this call.

Call C-S78 - Issues noted (long latency, packet loss, pixelization, frozen video) on the incoming video on the Emblaze-VCON. It appears that the high resolution (HD720p) signal being sent by the LifeSize is taxing the Emblaze-VCON.

C-S79	LifeSize Room - L (7007)	Polycom VSX 3000 - (7010)		1472	Y	1472	Y	H.263	4CIF (704x576)	15	Siren-14	H.263	CIF (352x288)	15	Siren-14
C-S80	LifeSize Room - L (7007)	Tandberg 880 MXP - (7011)		1472	Y	1472	Y	H.264	HD720p (1280x720)	6	G.722	H.264	400p (528x400)	30	G.722
C-S81	LifeSize Room - L (7007)	Huawei 8039 - (7012)		1472	Y	1472	N	H.264	CIF (352x288)	30	G.722	H.264	CIF (352x288)	30	
C-S82	LifeSize Room - L (7007)	Aethra Vega X3 - (7013)		1472	Y	1472	Y	H.264	CIF (352x288)	30	G.722	H.263	CIF (352x288)	30	G.722
C-S83	LifeSize Room - L (7007)	Sony G-50 - (7014)		1472	Y	1472	Y	H.264	CIF (352x288)	30	AAC-LC	H.264	CIF (352x288)	30	AAC-LC
C-S84	LifeSize Room - L (7007)	Emblaze-VCON HD-5000 - (7016)		1472	Y	1472	Y	H.264	HD720p (1280x720)	30	G.722	H.264	SIF (352x240)	30	G.722

Notes (C-S79 - C-S84): The Huawei was not sending audio to the LifeSize in this call.

Call C-S84 - As with call C-S78 above, issues noted on the incoming video on the Emblaze-VCON.

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol
C-M85	LifeSize Room - L (7007)	Aethra Vega X3 - (7013)		768	Y	768	Y	H.264	CIF (352x288)	30	G.722	H.264	SIF (352x240)	30	G.722
	H.239 Test - H.239 signal sent from the LifeSize			H.239 TX from 7004		70		H.263+	XGA (1024x768)						
				H.239 Notes: Since LifeSize does not make an SD-only endpoint, WR used the Aethra X3 for this H.239 test.											

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

D) HD Systems - Embedded MCU Testing (including H.239) Polycom Multipoint Testing

Notes: In order to host an HD720p multipoint call, transcoding must be turned off on the host HDX system, which means that all sites must use the same call speed, video protocols, and video resolutions.

D-S1A	Polycom HDX 9000 - R (7002)	Polycom HDX 9000 - L (7003)		1920	Y		1920	Y		H.264	HD720p (1280x720)	30	Siren-22 Stereo		H.264	HD720p (1280x720)	30	Siren-22 Stereo
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Now adding a 3rd site to the call. Note that this changed the connection between the first two sites in the session.

D-S1B	Polycom HDX 9000 - R (7002)	Polycom HDX 9000 - L (7003)		1920	Y		1920	Y		H.264	SIF (352x240)	30	Siren-22 Stereo		H.264	2SIF (704x240)	30	Siren-22 Stereo
		Polycom HDX 9000 (External)		1920	Y		1920	Y		H.264	SIF (352x240)	30	Siren-22 Stereo		H.264	640x368	30	Siren-22 Stereo

Notes: The HDX offers several MPT modes as listed below. For the testing, Discussion mode (standard CP) was used.
 Discussion mode = Standard continuous presence
 Presentation mode = Participating sites see full screen view of current speaker, current speaker sees CP view of all participating sites.
 Full screen mode = participating sites see full screen view of current speaker, current speaker sees full screen view of last speaker.

Host site - The HDX system hosting the 3-site multi-point call is able to show a side-by-side view of only the two far-end sites on the local display (basically hiding its own camera image).

Participating sites - The participating sites receive a single 3-site CP view of all sites (including themselves).

The CP view also includes an indicator (yellow / orange border) around the speaking site.

H.239 Test - H.239 signal sent from Polycom HDX hosting the call

H.239 send to 2nd HDX	64			H.264	XGA (1024x768)	7
H.239 send to LifeSize	64			H.264	XGA (1024x768)	7

H.239 Notes: The HDX behaved as one would expect, hosting the 3-way multipoint call properly and supporting the send of a native-resolution H.239 (XGA) signal to all participating sites.

Activating H.239 changes the layout options / view on the host HDX site as described below:

Option 1: Host HDX sees content side by side next to full screen view of last speaker.

Option 2: Host HDX sees content in large screen with PoPs of each of the two other participating sites (this is a VERY strong mode).

Option 3 : Full screen of the data.

Participating sites receive a CP view of all 3 participating sites and a full-screen view of the content (H.239 stream).

Now adding a 4th site to the call.

D-S1C	Polycom HDX 9000 - R (7002)	Polycom HDX 9000 - L (7003)		1920	Y		1920	Y		H.264	SIF (352x240)	30	Siren-22 Stereo		H.264	640x368	30	Siren-22 Stereo
		Polycom HDX 9000 (External)		1920	Y		1920	Y		H.264	SIF (352x240)	30	Siren-22 Stereo		H.264	640x368	30	Siren-22 Stereo
		Polycom HDX 9000 (External)		1920	Y		1920	Y		H.264	SIF (352x240)	30	Siren-22 Stereo		H.264	640x368	30	Siren-22 Stereo

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

D) HD Systems - Embedded MCU Testing (including H.239) LifeSize MultiPoint Testing

D-S2A	LifeSize Room - R (7006)	LifeSize Room - L (7007)		1472	Y	1472	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC
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Now adding 3rd site to the call.

D-S2B	LifeSize Room - R (7006)	LifeSize Room - L (7007)		1472	Y	1372	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC
		LifeSize Room - External		1472	Y	1372	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC

H.239 Test - H.239 signal sent from the LifeSize Room hosting the call

H.239 send to 2nd LS	181		H.264	HD720p (1280x720)
H.239 send to 3rd LS	181		H.264	HD720p (1280x720)

Now adding 4th site to the call.

D-S2C	LifeSize Room - R (7006)	LifeSize Room - L (7007)		1472	Y	1372	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC
		LifeSize Room - External		1472	Y	1372	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC
		LifeSize Room - External		1472	Y	1372	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC

H.239 Test - H.239 signal sent from the LifeSize Room hosting the call

H.239 send to 2nd LS	181		H.264	HD720p (1280x720)
H.239 send to 3rd LS	181		H.264	HD720p (1280x720)
H.239 send to 4th LS	181		H.264	HD720p (1280x720)

Notes: The MPT call appears to be operating in a 16:9 aspect ratio (all camera images are wide-screen and uncropped / not letterboxed).

Host Site - The LS system hosting the call has the following display options:

Option 1 - Show CP view of all participating sites (note that the view of itself is actually a local - not encoded / delayed view of itself at 30 fps).

Option 2 - Show one site in large window (smaller than full screen) and the others in PoP windows. Pressing the Call button switches between which site is shown in the large window.

Option 3 - Show one site in large window and the others in PiP windows. Pressing the Call button switches between which site is shown in the large window. The PiP windows disappear after ~10 seconds.

Participating Site (LifeSize) - Each participating LifeSize system has the same display options as the host LS system. This is a very powerful feature. Please see the HD Evaluation main document for a detailed description of this capability.

Now disconnecting the 4th LifeSize Room system and adding a Polycom HDX 9000 to the call (to test the performance of the Virtual Multipoint feature).

D-S2D	LifeSize Room - R (7006)	LifeSize Room - L (7007)		1472	Y	1372	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC
		LifeSize Room - External		1472	Y	1372	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC
		Polycom HDX 9000 - L (7003)		1472	Y	1372	Y	H.264	HD720p (1280x720)	30	AAC-LC	H.264	HD720p (1280x720)	30	AAC-LC

H.239 Test - H.239 signal sent from the LifeSize Room hosting the call

H.239 send to 2nd LS	181		H.264	HD720p (1280x720)
H.239 send to 3rd LS	181		H.264	HD720p (1280x720)
H.239 send to HDX	181		H.264	HD720p (1280x720)

H.239 Notes: Display options for the host and participating LifeSize sites is as before.

Participating Site (Polycom HDX) - The HDX received a single 4-way CP image from the LifeSize at 720p resolution.

High Definition Videoconferencing Evaluation

Call Configuration				Call Request		Call Results		Actual Outgoing Stats				Actual Incoming Stats			
Call #	From	To		BW	Encrypt	BW	Encrypt	V Protocol	Resol	FPS	A Protocol	V Protocol	Resol	FPS	A Protocol

D) HD Systems - Embedded MCU Testing (including H.239) Tandberg MultiPoint Testing

Note: Due to the limited bandwidth licensed on the 6000 MXP units, we used the Tandberg 1700 MXP to host this multipoint test call.

D-S3A	Tandberg 1700 MXP - (7018)	Tandberg 6000 MXP - R (7004)		1472	Y	1472	Y	H.264	HD720p (1280x720)		AAC-LD	H.264	HD720p (1280x720)		AAC-LD
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Now adding a 3rd site to the call. Note that this changed the connection between the first two sites in the session.

D-S3B	Tandberg 1700 MXP - (7018)	Tandberg 6000 MXP - R (7004)			Y	1152 / 1280	Y	H.264	CIF (352x288)		AAC-LD	H.263+	w576p (1024x576)		AAC-LD
		Tandberg 6000 MXP - L (7005)			Y	1152 / 1280	Y	H.264	CIF (352x288)		AAC-LD	H.263+	w576p (1024x576)		AAC-LD

Notes: The MPT call appears to be operating in a 16:9 aspect ratio (all camera images are wide-screen and uncropped / not letterboxed).

Adding 3rd site (Tandberg 6000 MXP) to the call caused the host Tandberg 1700 MXP to decrease the connection rate and resolution it sends to each participating site.

Although the Tandberg does not provide frame rate information, WR estimates the frame rate of the call to be ~ 10-15 fps.

In addition, significant latency (at least 1 full second) was noted.

Host and Participating Sites -

View options limited to CP view plus or minus local view (in different size configurations).

H.239 Test - H.239 signal sent from Tandberg 6000#1system

H.239 send to 1700 MXP	256		H.264	XGA (1024x768)	~ 5 - 7
H.239 send to 2nd 6000	256		H.264	XGA (1024x768)	~ 5 - 7

H.239 Notes:

Note that we were unable to get the 1700 MXP to show our notebook (IBM Thinkpad) image, so we sent the H.239 source signal from a 6000 MXP.
Note that when the 1700 MXP was set to use display as local PC monitor (but could not detect our XGA signal), calls to the 6000 MXP failed.

Host Site (1700 MXP) and Participating Sites(s):

View options allow one to see the full-screen content, CP view of participating sites, or self-view in a variety of on-screen window sizes / combinations.

Now adding a 4th site to the call. Note that this impacted the settings of the prior 3-site MPT call.

D-S3C	Tandberg 1700 MXP - (7018)	Tandberg 6000 MXP - R (7004)			Y	768 / 1280	Y	H.264	CIF (352x288)		AAC-LD	H.263+	w576p (1024x576)		AAC-LD
		Tandberg 6000 MXP - L (7005)			Y	768 / 1280	Y	H.264	CIF (352x288)		AAC-LD	H.263+	w576p (1024x576)		AAC-LD
		Polycom VSX 3000 - (7010)			Y	768 / 768	Y	H.264	CIF (352x288)	25	G.722	H.264	SIF (352x240)	30	G.722

Notes: Adding 4th site (Polycom VSX 3000) to the call caused the host Tandberg 1700 MXP to decrease its outgoing bit rate.

Host and Participating Sites -

View options limited to CP view plus or minus local view (in different size configurations).