Tandberg C20

Manufacturer: Tandberg

Model: C20 Plus

Software Version: 2.1.1

Optional Features and Modifications: Premium Resolution option (1080p/30 and 720p/60); dual display option

Date of Test: 7th – 11th December 2009

A: INTRODUCTION

The Tandberg C20 Plus is a High Definition (HD) videoconferencing system with a basic picture resolution of 1280 x 720 pixels (720p) that may be extended up to 1980 x 1080 (1080p) with the Premium Resolution option. Compatibility with other H.323 CODECS is achieved across a range of resolutions from CIF (352x288 pixels) up to 1920 x 1080 depending on the capability of the remote CODEC and the connection bandwidth.

Two options are available for the Tandberg C20 Plus:

Options	Features
Dual Display	Second monitor support
Premium Resolution	Support for 1080p 30fps and 720p 60fps

The equipment supplied for evaluation had both options installed and was running version 2.1.1 software.

Feature Summary:

- A high definition videoconferencing system which supports variable resolutions up to 1920 x 1080 pixels (with Premium Resolution option)
- A CODEC, operating at connection speeds up to 6 Mbit/s over H.323.
- Supports H.261, H.263, H.263+ and H.264 video coding.

- Supports a wide range of resolutions including HD w1080p (1920 x 1080), HD w720p (1280 x 720) and w448p (768 x 448) optimal resolution.
- Supports G.711, G.722, G.722.1 and MPEG4 AAC-LD audio coding
- Separate pan and tilt HD camera with 1920 x 1080 native resolution and 12x zoom.
- Analogue stereo input for connection of PC audio output.
- Analogue stereo outputs.
- Digital audio supported on HDMI output connections.
- Supports AES encryption.
- Far end camera control.
- H.239 second video connection up to WXGA (1280 x 768) resolution.
- Digital and analogue (VGA) PC inputs
- *Analogue* VGA PC input supported at native resolutions:

With an aspect ratio of 4*3:

- 640 x 480p @ 60, 72, 75, 85 fps
- 800 x 600p @ 56, 60, 72, 75, 85 fps
- 1024 x 768p @ 60, 70, 75, 85 fps
- 1280 x 960p @ 60 fps
- 1280 x 1024p @ 60, 75 fps
- 1600 x 1200p @ 60 fps

With an aspect ratio of 16*9:

- 1280 x 720p @ 60 fps
- 1280 x 768p @ 60 fps
- 1280 x 800p @ 60 fps
- 1440 x 900p @ 60 fps
- 1680 x 1050p @ 60 fps
- 1920 x 1080p @ 60 fps

- 1920 x 1200p @ 50 fps

- *Digital* PC input supported at native resolutions

With an aspect ratio of 4*3

- 640 x 480 @ 60 fps
- 720 x 480 @ 60 fps
- 800 x 600 @ 56, 60, 72, 75, 85 fps
- 1024 x 768 @ 60, 70, 75, 85 fps
- 1280 x 1024 @ 60, 75 fps
- 1600 x 1200p @ 50 fps

With an aspect ratio of 16*9

- 1280 x 720 @ 50, 60 fps
- 1280 x 768p @ 60 fps
- 1440 x 900p @ 60 fps
- 1680 x 1050p @ 60 fps
- 1920 x 1080 @ 25, 30, 50, 60 fps
- 1920 x 1200 @ 50, 60 fps

- Extended Display Identification Data (EDID) is supported.
- LDAP global directory support.

C20 Quick Set

The C20 CODEC is also available as a budget version, the “Quick Set C20”. The resolution is limited to 1280 x 720 pixels (720p/30fps), the camera zoom range is reduced to 4x and only a single display monitor is supported. This baseline specification may be expanded with additional options to provide a second display and an increase in resolution to 1980 x 1080 pixels (1080p 30fps).

B: SETUP PROCEDURE

Setting up the C20 Plus system was straightforward. The very compact CODEC was small enough to be mounted behind a flat screen monitor. The HD camera may be positioned either above or below a picture monitor. A system microphone, an infrared remote control and an external power supply completed the package.

The connections for basic operation were clearly illustrated on the installation reference card and in the documentation available on the web, and involved:

- Mounting the camera adjacent to the monitor.
- Connecting the separate HDMI-HDMI video and DSUB-RJ45 control cables between the camera and the CODEC.
- Connecting the supplied HDMI-HDMI cables between the CODEC and the monitor/s.
- Cabling the microphone to the CODEC.

- Establishing an Ethernet IP network connection through the single RJ45-RJ45 cable.
- Connecting the external power unit to the CODEC.

System setup was conveniently configured through the on-screen menus via the hand-held remote control. IP address, IP Gateway, Subnet mask and Gatekeeper address were all entered through these menus.

Approximate set-up time: 20 minutes

Documentation quality: The supplied installation card and web sourced Administrators guide were both concise and easy to follow.

C: Hardware Description

General

This compact CODEC may either be mounted within a monitor cabinet or positioned

adjacent to the monitor. It is also small enough to be mounted behind a flat screen monitor. Provided with a single auto switching 10/100 Ethernet connection and capable of conferencing up to a bandwidth of 6 Mbit/s, the system is able to display a maximum image resolution of 1080p at 60 frames/second.

The basic CODEC provides a single display monitor output but with the “Dual Display” option, dual high definition monitor outputs are available that support up to w1080p widescreen images.

In addition to the digital audio output carried via the main HDMI connection separate analogue audio outputs are also available.

The C20 Plus system supports thirteen video resolutions including:

- The basic CIF format resolution of 352 x2 88 pixels
- w288p at 512 x 288
- Optimal resolution w448p at 768 x 448
- High definition w720p at 1280 x 720

- High definition w1080p at 1920 x 1080 (requires the Premium Resolution option)

The image resolution is dependent on the call connection bandwidth:

Connection Bandwidth	**Resolution**
128 Kbit/s	w288p
384 Kbit/s	w288p
768 Kbit/s	1024*576
1 Mbit/s	w720p
2 Mbit/s	w720p
4 Mbit/s	w1080p
6 Mbit/s	w1080p

The resolutions above are negotiated when the CODEC camera input is optimised for

“motion”. When the input is optimised for “sharpness”, provided that the connection bandwidth is 384 Kbit/s or greater the negotiated resolution is always 1920 x 1080 irrespective of bandwidth.

In addition to the traditional Picture in Picture (PIP) display format, the CODEC also supports Picture outside Picture (POP). This allows both near and far end images to be displayed simultaneously on a single picture monitor.

Full screen of the far end image with near image Picture in Picture (PIP)

Large far image, small near image: Picture outside Picture (POP)

POP is particularly useful when a single large screen display device such as a plasma/LCD panel or video/data protector is used as it permits greater flexibility in the choice of image layout.

In single display mode the layout button on the remote control selects the type of screen display:

- Full screen of the far end image
- Full screen of the far end image with near image PIP
- Large far image, small near image.

Positioning the POP images vertically rather than side by side enables both images to be displayed wide screen while retaining the image aspect ratio.

In dual display mode, when H.329 dual images are either transmitted or received the remote control layout button selects various combinations of screen layout:

- Full screen of the presentation image
- Full screen of the presentation image with near image PIP
- Large presentation image, small near and far images
- Medium presentation and far images, small near image
- Large far image, small near and presentation images.

Full screen of the presentation image

Image not found or type unknown

Large presentation image, small near and far images

Image not found or type unknown

Medium presentation and far images, small near image

Image not found or type unknown

Large far image, small near and presentation images

In dual monitor mode without presentation material the monitors display:

	Layout 1	**Layout 2**
Main monitor	Far image	Far image with near image PIP
Second monitor	Near image	Blank

When presentation material is transmitted or received the presentation image is displayed on the second monitor as selected through the remote control layout button. Various combinations of main monitor screen layout are possible:

- Full screen of the far image
- Full screen of the far image with near image PIP
- Large far image, small near image.

Image not found or type unknown

Large far image, small near image

The main video output of the C20 Plus CODEC contains the on-screen menus including the soft key legends at the bottom of the screen.

The precision 1080p high definition (HD) camera features pan, tilt and zoom functions and has a native resolution of 1920 x 1080 pixels at 60 frames per second. If ceiling

mounted (upside down) the camera image will automatically switch to the correct orientation. The lens offers a wide horizontal viewing angle of 72 degrees and includes a lens hood to prevent ‘flare’. A 5 metre long HDMI-HDMI camera video interconnect cable together with a 5 metre control cable are supplied. Remote camera control is supported. The camera was silent in operation. Problems with the auto focus in earlier cameras with version 1.1.0 software appear to have been overcome.

A Kensington lock slot is provided on the camera body for increased security.

The C20 Plus CODEC includes one DVI-I input in addition to the HDMI HD camera input. The DVI input may be manually set to the following signal formats:

- Analogue RGB
- Digital.

Alternatively the CODEC will auto detect the signal input type.

The HDMI and DVI inputs do not support High Definition Content Protection (HDCP).

A PC may be directly connected to the CODEC via the DVI-I interface. The following resolutions and frame rates are indicated as being supported within the system documentation:

Using the RGB VGA Analogue PC input

At an aspect ratio of 4x3

- 640 x 480p @ 60, 72, 75, 85 fps
- 800 x 600p @ 56, 60, 72, 75, 85 fps
- 1024 x 768p @ 60, 70, 75, 85 fps
- 1280 x 960p @ 60 fps
- 1280 x 1024p @ 60, 75 fps
- 1600 x 1200p @ 60 fps

At an aspect ratio of 16x9

- 1280 x 720p @ 60 fps
- 1280 x 768p @ 60 fps
- 1280 x 800p @ 60 fps
- 1440 x 900p @ 60 fps
- 1680 x 1050p @ 60 fps
- 1920 x 1080p @ 60 fps
- 1920 x 200p @ 50 fps

Using the Digital PC input

At an aspect ratio of 4x3

- 640 x4 80 @ 60 fps
- 720 x 480 @ 60 fps
- 800 x 600 @ 56, 60, 72, 75, 85 fps
- 1024 x 768 @ 60, 70, 75, 85 fps

- 1280 x 1024 @ 60, 75 fps
- 1600 x 1200p @ 50 fps

At an aspect ratio of 16x9

- 1280 x 720 @ 50, 60 fps
- 1280 x 768p @ 60 fps
- 1440 x 900p @ 60 fps
- 1680 x 1050p @ 60 fps
- 1920 x 1080 @ 25, 30, 50, 60 fps
- 1920 x 1200 @ 50, 60 fps

If the DVI input is set to receive analogue RGB input signals, EDID only reports the following resolutions as being available:

- 1280 x 720p @ 60 fps
- 1280 x 768p @ 60 fps
- 1280 x 800p @ 60 fps
- 1920 x 1080p @ 60 fps
- 1920 x 1200p @ 50 fps

If the DVI input is set to auto select the input signals, EDID does not report the following resolutions as being available for either analogue RGB or digital signal inputs:

- 1280 x 1024p @ 60, 75 fps
- 1440 x 900p @ 60 fps
- 1680 x 1050p @ 60 fps

Dual video coding H.239 provides a second unidirectional video channel during H.323 calls but without a second audio channel. Thus presentation material from a camera and material from a PC could be transmitted simultaneously and displayed on two monitors at the remote site. When two C20 Plus systems conferenced together with a 6Mbit/s connection it was possible to transmit two simultaneous high resolution images also at a high frame rate between the units: the main channel at 1080p 30 and the H2.39 channel at 1280 x 768 WXGA.

To preserve the integrity of moving sequences, calls are selected as “motion priority”. If the call bandwidth is reduced then the image resolution will also be reduced to preserve accurate movement rendition i.e. a high frame rate. If however high resolution is more important than accurate movement rendition then “Sharpness” would be selected as the priority. The table below illustrates this:[1]

Main Channel Only		**Main Plus Presentation**		**Main Plus Presentation**		
Call Bandwidth	*Main set to Motion*	*Main set to Sharpness*	*Main set to Motion*	*Presentation set to Motion*	*Main set to Motion*	*Presentation set to Sharpness*

6Mbit/s	1920x1080	1920x1080	1920x1080	1280x768	1920x1080	1280x768
4Mbit/s	1920x1080	1920x1080	1280x720	1280x768	1280x720	1280x768
2Mbit/s	1280x720	1920x1080	1024x576	1280x768	1024x576	1280x768
1Mbit/s	1280x720	1920x1080	768x448	512x288	768x448	1280x768
768 kbit/s	1024x576	1920x1080	512x288	640x480	512x288	1280x768
384 kbit/s	512x288	1920x1080	512x288	353x288	512x288	1280x768
128 kbit/s	512x288	1024x576	256x144	256x144	256x144	1280x768

Several audio formats are supported by the C20 Plus CODEC. Tandberg has implemented the ITU standard MPEG-4 AAC-LD audio protocol giving 20KHz analogue audio bandwidth with low latency/delay and only requiring 64Kb/s connection bandwidth.

PC audio and analogue stereo audio are both available via industry standard RCA-Phono connectors. The main HDMI output carries the digital stereo signals.

Encryption is available at all connection speeds through Advanced Encryption Standard (AES) with a 128 bit session key.

D: SYSTEM OPERATION

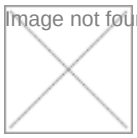
The system may be operated locally from the infrared remote control. The on-screen menus are logical and easy to follow. The system may also be configured via a web browser from a network connected PC. For security this remote web connection is password protected. An IP network connection is used to interface the CODEC conveniently to a room control system.

The CODEC remote control includes a single presentation source button:

- Pressing this button for a short period selects the PC presentation source.
- Pressing the button again for a short period reselects the main camera.
- Pressing and holding down for a longer period displays a sub-menu. The appropriate source selection is then enabled through the cursor keys and the ? menu button.

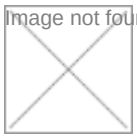
The addition of a “Home” button is a useful enhancement over earlier Tandberg remote

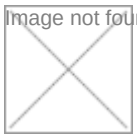
controls.



Tandberg Remote Control

Five context sensitive soft keys are located at the top of the remote control. The function of these keys is indicated by on-screen menus which appear when the soft key functions are appropriate. The text within these on-screen soft keys was fairly small so care is required in selection of screen size to ensure accurate selection.





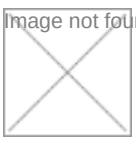
Soft Key Menus

An H.239 connection is initiated and terminated through the remote control via the on-screen graphical interface. The main camera occupies one channel and the source connected to the DVI-I input the second channel: this is normally a PC or laptop. At the remote site these two images may either be viewed on two separate monitors or using POP displayed on a single large screen. The DVI-I input may also be switched to transmit on the main channel if H.239 is not in use.

The system takes a significant period to boot up from cold (nearly 2 minutes). During this time there is no on-screen indication that the system is booting up, simply a flashing light on the CODEC and the camera. The user may think that the system is inoperative due to the lack of any on-screen feedback. When not in a call the system automatically goes into sleep mode after a period of time. It can also be put into standby mode via the remote control. An incoming call or movement of the remote control (picking it up) will return the system to active mode.

The system information menu displays call status data including connection speed, compression protocols and packet loss.

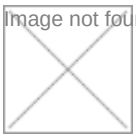
The system may also be configured via a web browser from a network connected PC: this password protected facility is however limited to configuration and call connection and disconnection only. Call status, remote control and web snapshots are not available.



C20 Web Configuration Interface

The C20 system includes a Tandberg proprietary microphone with an inbuilt mute button. The

button is illuminated green when live and red when in mute. A second microphone may also be connected to the CODEC.



Tandberg Desk Microphone

System Operation Problems Encountered

HDMI Monitor Input

When the CODEC output was set to 1080p (the system's native resolution) and the signals were fed to the main monitor via the HDMI input, a degree of image cropping was apparent. This resulted in some menu legends being shifted off screen. In particular the soft key legends were rendered unreadable. If the DVI input on the main monitor was used instead then this cropping was not seen.

The monitors in use for the tests were Dell 2709Wb. There appeared to be a degree of over-scan of the image from the monitor HDMI input, even though the edge of the active image was visible on the monitor.

E: VIDEO TESTS SUMMARY

A conference between two C20 Plus systems using the Tandberg HD cameras produced excellent results at both 720p and 1080p resolutions. The ability to transmit two high resolution, high frame rate images simultaneously, i.e. 1080p 30 on the main channel and WXGA on the content channel, was impressive.

When highly detailed widescreen images with fast motion were transmitted from a high specification laptop on the main channel at 720p, the images were free from any significant artefacts for links of 4Mbit/s bandwidth and above. The high definition camera coped well with difficult lighting conditions and the inclusion of a lens hood improved the image quality when compared with earlier Tandberg HD cameras. The camera was silent in operation.

F: AUDIO TESTS SUMMARY

Setup The echo canceller is fully automatic in operation. The quality of echo cancellation and doubletalk from the system was excellent.

	Lecture Theatre	Room
Audio levels adequate? (Yes/no)	Not tested	Yes

Audio quality acceptable? (Yes/no)	Not tested	Yes
Echo cancellation acceptable? (Yes/no)	Not tested	Yes
Quality of double talk	Not tested	Excellent

G: DATA TESTS

A PC may be connected to the C20 Plus CODEC directly via the DVI-I interface.

H: CONNECTIVITY

H.323

There were no problems connecting between the Tandberg C20 Plus units at Edinburgh and Newcastle over IP.

Time to Connect with encryption On

H.323

All speeds	4 seconds

During an H.323 call the network connection was removed and reconnected after a specific time.

5 Seconds	Picture froze – picture goes to black - successful reconnection, call does not terminate
15 Seconds	Picture froze – picture goes to black - successful reconnection, call does not terminate
30 Seconds	Picture froze - picture goes to black, call then terminates on network reconnection

Connectivity with Other Machines (models listed with comments)

H.323

Successful connections were made in each direction with the following CODECs, where the systems supported H.239 presentation material was also shared.

CODEC	Call Bandwidth	Resolution Transmitted by the C20 Plus	Resolution Received by the C20 Plus
Polycom® VS4000	2 Mbit/s	CIF	CIF
Tandberg 6000 Classic (B version hardware)	2 Mbit/s	CIF	CIF
Polycom® VSX8000	2 Mbit/s	CIF	CIF
Connectivity with JANET Videoconferencing Switching Service (JVCSS)			
Tandberg 990 MXP*	2 Mbit/s	720p	448p
Tandberg Edge 95*	2 Mbit/s	720p	720p
Tandberg 6000 MXP*	4 Mbit/s	720p	720p
Polycom HDX 9002	6 Mbit/s	720p	720p
Lifesize Team	4 Mbit/s	720p	720p
Lifesize Room 200**	6 Mbit/s	720p	720p

ConnectC

*In calls to the Tandberg MXP Systems, when PC content was transmitted from the C20 with a resolution of 1280 x 720 the systems negotiated H.239 Content resolution of only 512 x 288 resulting in the received Content image quality being very poor.

*In calls to the Lifesize Team Content could not be successfully transmitted from the C20 to the Lifesize. The Content channel opened and closed repeatedly every few seconds.

The resolution of the parameters in the table above expressed in pixels:

CIF	352 x 288
448p	576 x 488
720p	1280 x 720

H.323

The CODEC connected successfully to the JVCS MGC MCU negotiating H.263 video, CIF resolution and G.722 audio with video and audio in both directions. H.239 content was also successfully shared via the MCU. The received audio level was measured as peaking to -4dBm.

The Tandberg C20 Plus connected successfully to the JVCS Codian MCU negotiating H.264 video, 720p resolution and AAC-LD audio with video and audio in both directions. H.239 content was also successfully shared via the MCU. The received audio level was measured as peaking to -4dBm.

Procedure for making a call

1. Press Connect button on the remote control
2. Input IP address
3. Press the Connect button

Or use the local contacts directory available from the user interface Phone Book or the Recent Calls lists.

Appendix 1 Detailed Physical Information

Dimensions: (w x h x d) 35 x 3 x 13 cm

Both CODEC and HD camera include a Kensington Lock fitting.

Video Inputs	Analogue RGB Analogue Y Pb Pr Composite/YC Digital	Connector
Main camera	Digital	HDMI
PC input	**Analogue RGB** Digital	DVI-I*

*The DVI-I input may be manually set to the following signal formats:

- Analogue RGB
- Digital

Alternatively the CODEC will auto detect between them

The HDMI and DVI inputs do not support High Definition Content Protection (HDCP)

Video Outputs	Analogue RGB Analogue Y Pb Pr Composite/YC Digital	Connector
Main monitor	Digital	HDMI*
Second monitor	Digital	HDMI

Note: The Main Monitor HDMI* output includes embedded audio.

Audio Inputs	Level	Connector

Microphone 1	**Microphone**	3.5mm Mini-jack
Microphone 2	**Microphone**	3.5mm Mini-jack
PC Stereo left	**Line**	RCA Phono
PC Stereo right	**Line**	RCA Phono

Audio Outputs	Level	Connector
Main output	Digital	HDMI
Main output left	Line	RCA Phono
Main output right	Line	RCA Phono

Data

1. 1 off LAN 10/100 Mbits/s Ethernet connection (RJ45)
2. 1 off USB connector (future use)

Cables Supplied with the Demonstration System

1 off - Camera control cable, 5 metres 9 pin D type – RJ45

1 off - Camera signal cable, 5 metres HDMI-HDMI

1 off - Network cable, 5 Metres RJ45 – RJ45

2 off - 3 metres HDMI-HDMI

Mobility

The Tandberg C20 Plus is small, portable and lightweight. It can be moved easily. To establish a connection, each new location will need the local area network information re-entered into the configuration menu.

Appendix 2 Detailed Video Tests

It was not possible to force either the video or audio protocols in the C20 Plus CODECs: hence we were only able to carry out detailed tests on H.264 video coding. At all speeds the audio protocol AAC-LD 64K was negotiated.

Objective Video Tests: Signal measurements

1. 75% EBU bars
2. Grey scale

Subjective Video Impairments Tested:

Lip synchronisation	**LS**
Block distortion (tiling)	**BLK**
Blurring (reduced edge sharpness and spatial detail)	**BLR**
Colour errors	**CLR**
Jerkiness (distortion of smooth motion)	**JRK**
Object persistence (lagging images from previous frames as faded or outline images)	**OP**
Scene cut response (i.e. time to build up the new image)	**SCR**

Scale of impairments:	
Imperceptible	**1**
Perceptible	**2**
Slightly annoying	**3**
Annoying	**4**

Very annoying **5**

Test DVD:

Signals recorded	Time on tape
1. EBU colour bars	1min 30secs
2. Grey scale	1.40 - 2.40
3. Blue field	2.50 - 3.50
4. Medium close up female face, still	4.00 - 5.00
5. Medium close up female face, talking	5.10 - 6.10
6. Close up face, nodding	6.20 - 7.20
7. Close up face, shaking head side to side	7.30 - 8.30
8. Zoom out slowly to wide angle three people	8.40 - 9.40
9. Zoom in quickly to close up of centre person	9.50 - 10.50
10. Turntable speeds: 1,2,3 and 4	11.00 - 15.30
11. Football sequence	15.40 - 16.40
12. Zoom in and out of “A to Z” map	16.50 - 17.50
13. Text legibility, font sizes 20 to 12 pt	20.30 - 20.50
14. Cut tests, scenes various with camera movements	21.00 - 22.00
15. Man teaching at whiteboard	22.10 - 23.23

(Insert 75% EBU bars at local site, measure at remote site)

Test 1c (H264): Colour bar test

Any waveform aberrations? None

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	1	1	1	1	1
BLR	2	1	1	1	1
CLR	1	1	1	1	1

Test 2c (H.264): Grey scale

Any waveform aberrations? None

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	1	1	1	1	1
BLR	2	1	1	1	1
CLR	1	1	1	1	1

Test 3c (H.264): Blue screen

Any waveform aberrations? None

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	1	1	1	1	1
CLR	1	1	1	1	1

Test 4c (H.264): Medium close up female (still)

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	1	1	1	1	1
BLR	2	1	1	1	1

CLR	1	1	1	1	1

Test 5c (H.264): Medium close up female (talking)

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
LS	1	1	1	1	1
BLK	1	1	1	1	1
BLR	2	1	1	1	1
CLR	1	1	1	1	1
JRK	1	1	1	1	1

Test 6c (H.264): Close up head (nodding)

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	2	1	1	1	1
BLR	2	1	1	1	1
CLR	1	1	1	1	1
JRK	1	1	1	1	1

Test 7c (H.264): Close up head (shaking side to side)

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	2	2	1	1	1
BLR	3	2	1	1	1
CLR	1	1	1	1	1
JRK	1	1	1	1	1

Test 8c (H.264): Medium close up, slow zoom out to three shot

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	2	1	1	1	1
BLR	2	1	1	1	1
CLR	1	1	1	1	1
JRK	2	2	1	1	1

Test 9c (H.264): Three shot, quick zoom in to medium close up centre person

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s

BLK	2	1	1	1	1
BLR	2	1	1	1	1
CLR	1	1	1	1	1
JRK	2	2	1	1	1

Test 10c (H.264): Turntable speed 1

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	1	1	1	1	1
BLR	1	1	1	1	1
CLR	1	1	1	1	1
JRK	2	2	1	1	1

Test 10f (H.264): Turntable speed 2

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	1	1	1	1	1
BLR	1	1	1	1	1

CLR	1	1	1	1	1
JRK	2	2	2	1	1

Test 10i (H.264): Turntable speed 3

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	1	1	1	1	1
BLR	2	2	2	2	2
CLR	1	1	1	1	1
JRK	2	2	2	1	1

Test 10l (H.264): Turntable speed 4

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	2	1	1	1	1
BLR	2	2	2	2	2
CLR	1	1	1	1	1
JRK	2	2	2	1	1

Test 11c (H.264): Football sequence

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	3	2	1	1	1
BLR	3	3	2	2	2
CLR	2	2	2	2	2
JRK	2	1	1	1	1

Test 12c (H.264): Zoom in and zoom out of ‘A to Z’ map

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	2	2	1	1	1
BLR	3	2	2	2	2
CLR	1	1	1	1	1
JRK	2	2	2	2	1

Test 13c (H.264): Text legibility (% of screen height) at viewing distance approx.

5x screen diagonal

Legibility H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
20 pt (3.5%)	Yes	Yes	Yes	Yes	Yes
16 pt (3%)	Yes	Yes	Yes	Yes	Yes
14 pt (2.5%)	Yes	Yes	Yes	Yes	Yes
12 pt (2.3%)	No	No	No	Yes	Yes

Test 14c (H.264): Video with several vision cuts

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
BLK	3	2	1	1	1
BLR	3	2	2	2	1
CLR	1	1	1	1	1
OP	1	1	1	1	1
SCR	2	2	2	2	2
JRK	2	1	2	1	1

Test 15c (H.264): Man teaching with flip chart

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2 Mbit/s	4 Mbit/s	6 Mbit/s
LS	1	1	1	1	1
BLK	2	1	1	1	1
BLR	2	1	1	1	1
CLR	1	1	1	1	1
JRK	1	1	1	1	1

Test 16: Playback from a domestic VHS videotape player

Is picture stable?

There are no analogue video inputs into the system so this test could not be carried out.

Appendix 3 Detailed Audio Tests

The C20 Plus CODECs do not permit the audio protocols to be forced, hence we were only able to carry out detailed tests on G.722.1 and AAC-LD audio coding.

Test 1: Frequency response (-3 dB)

(Insert -6 dB signal at local site, measure at remote site)

G.722.1	AAC-LD, 64K
7.00 KHz	20.0 KHz

Test 2: Headroom (measured on AAC-LD signal coding)

(Insert increasing amplitude 1 KHz tone at local site, monitor for overload distortion at remote site)

Overload occurs at: +12dBm

Test 3: Audio level

(Insert -6dBm 1KHz tone at local site, monitor received level at remote site.)

As the audio output level is affected by the volume control this test was not carried out.

Test 4: Echo Cancellation

Setup The echo canceller is fully automatic in operation. The quality of echo cancellation and doubletalk from the system was excellent.

	Lecture Theatre	Room
Audio levels adequate? (Yes/no)	Not tested	Yes
Audio quality acceptable? (Yes/no)	Not tested	Yes
Echo cancellation acceptable? (Yes/no)	Not tested	Yes
Quality of double talk	Not tested	Excellent

[1] Tandberg states: “The resolution table on page 10 of the report indicates it is possible to send content while having a video resolution of 1080p. This we believe is inaccurate as the C20 can only send video resolutions of up to 720p when content sharing is used.” This could not be re-tested by the VTAS reviewers because the equipment had at that stage been returned to the manufacturers.Tandberg C20