Report:
A VIDEO AND AUDIO COMPRESSION STANDARD FOR SYNCHRONOUS DISTANCE LEARNING AND VIDEOCONFERENCING IN THE STATE OF NEBRASKA

As Recommended by the Video Standards Work Group of the Technical Panel of the Nebraska Information Technology Commission

Published July 13, 2004

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1.0 Authority

The Nebraska Information Technology Commission (NITC) is empowered to *"...adopt minimum technical standards, guidelines, and architecture upon recommendation by the technical panel…"* Neb. Rev. Stat. §86-516 (6). In order to accomplish this, the NITC is empowered to, *"Establish ad hoc technical advisory groups to study and make recommendations on specific topics…"* Neb. Rev. Stat. §86-516 (7). "…*The technical panel may recommend technical standards and guidelines to be considered for adoption by the commission*." Neb. Rev. Stat. §86-521 (2).

This report is to document the recommendations of the Video Standards Work Group as authorized by the Technical Panel of the NITC. This document is to be used by the NITC advisory groups, end-users, and Technical Panel to make comment on for review by the NITC. It is within the authority of the NITC to adopt, amend or reject all or any part of this recommendation.

2.0 Executive Summary

2.1 Video Standards Work Group

As authorized above, the Technical Panel of the NITC commissioned a video standards work group to study and make recommendations on video and audio standards as they apply to synchronous distance learning and videoconferencing. A standard was issued by the NITC in February 21, 2002 based upon the original report. A requirement of the standard, as originally published, was to take a follow up look after 2 years beginning in January 2004. The report in hand is a result of that process.

2.2 Video Standards Review Process

The original standards development process was a lengthy one. Since much of the groundwork was covered in the original 2002 document, and purchases of video equipment were rapidly approaching for several sub-sectors, the process for this second standards document was accelerated. The Video Standards Work Group met over several months. Based upon input from the Education Council of the NITC, a list of judging criteria was developed. The work group identified video and audio protocols to be considered. Those standards that obviously would not, in some way, be an improvement over what is currently being used in the state were eliminated. Next, a study was conducted on the remaining candidates based on the criteria. The intent was to make a comparison with the current existing standards: MPEG-2 and H.263/G.722. As a result of the criteria study, the work group chose H.264 to be compared to the current video options and G.722.1 to be compared to the current audio options. In a separate standard recommended by the Statewide Synchronous Video Work Group, the NITC approved IP as the accepted communications protocol for synchronous video networks. This document only specifies the video and audio compression standards, as the charter directs.

2.3 Video Standards Test Procedure

A test procedure was developed by the work group with the intent to allow end users to view several types of vendor hardware/software equipment for each tested protocol. This process would help ensure the findings would not be skewed by the quality of a single vendor's product. The specifics of the test are included below. By maintaining a simulated but controlled network environment, any confounding variables would be eliminated so that a test of the actual compression protocol would result.

2.4 Public Comment and Approval Process

This report is the result of all of these efforts. Upon review of this report, it is incumbent on the Technical Panel to recommend or to not recommend the conclusions. By opening up the report and recommended standards for public comment, end users and providers may submit remarks for review. Since this document will become a work product of the Technical Panel who commissioned the group, they may also choose to make changes to the document. After that process, the NITC will decide what standard to adopt.

3.0 Recommendation

3.1 Video Standard Recommendation

It is the recommendation by unanimous vote of the Video Standards Work Group that Nebraska adopt a dual video standard. For data rates above 384Kbps Nebraska should continue to use H.263 for video. For data rates at or below 384Kbps Nebraska should use H.264 (a.k.a. MPEG-4 Part 10) for video. The CODECs selected for purchase or use should be capable of accommodating both standards and be capable of manual rate selection and/or automatic rate selection. The Work Group recommends that the interconnecting CODECs be allowed to automatically negotiate the best data rate.

3.2 Audio Standard Recommendation

It is the further recommendation by unanimous vote of the Video Standards Work Group that Nebraska continue to use G.722 for audio for data rates above 128Kbps. For data rates at or below 128Kbps Nebraska should allow G.722, G.722.1 or G.728. CODECs should have the ability to use G.722 at all speeds and one or both of the other two standards listed for lower speeds. If any two CODECs do not have a common protocol at or below 128Kbps then they should continue to use G.722. The CODECs selected for purchase or use should be capable of accommodating audio standard G.722 and be capable of manual rate selection and/or automatic rate selection. The Work Group recommends that the interconnecting CODECs be allowed to automatically negotiate the best data rate.

3.3 Present Video Standards

MPEG-2 and H.263/G.722 are the current Nebraska video/audio standards. In that selection process H.263 was chosen for data rates lower than 1.5Mbps. At that time, processing speed was such that users did not perceive the video quality as acceptable for use in the distance learning classrooms. In the testing process used for this new document, users are clearly satisfied with the video quality of H.263 and H.264 at 768Kbps and higher. A reasonable percentage also felt H.264 at 384Kbps was of reasonable quality. The committee attributes this change to higher chip processing speeds.

3.4 MPEG-2

MPEG-2 was not included as a recommended standard in this process for several reasons. H.263 and H.264 were very acceptable to users at data rates as high as 768Kbps and 1.92Mbps. Tests show that MPEG-2 quality is not acceptable to distance education users below 2Mbps. With the advent of Internet2, multi-state and international videoconferencing is using the H.26X family of low-bandwidth protocols, and more participants are interconnecting over a wider geographic area. Nebraska education and telehealth participants will be able to use H.263/H.264 to videoconference with other Internet2 members and outside their own geographic area with minimal transport costs. The NITC has adopted IP as the Nebraska standard for communications protocol making hardware choices more available.

3.5 JPEG Transition

For those distance learning sites currently using JPEG, a change in technology is inevitable. Providers of JPEG systems have incentive to change technologies as maintenance of JPEG equipment is increasingly problematic. The Statewide Synchronous Video Network Work Group, working closely with providers, is intending to implement the specified IP-based networks using wide area, high bandwidth networking. The intended result is flexibly provisioned bandwidth so that video and audio become applications on a larger data network. The H.26x and G.72x family are perfectly compatible with high bandwidth networking, allow multiple, simultaneous video connections, and use considerably less bandwidth than JPEG or MPEG-2 to accomplish it.

3.6 MPEG-2 Transition

There are two K-12 distance learning consortia that chose MPEG-2 as a result of the last standards process. One of those was an upgrade from analog optical fiber, the other was a new installation where there had been no previous system. These recent implementations, still in the early years of contract, complicate transition. On the part of the providers and the state, a considerable investment was made in this technology with a considerable lifespan. The cost/benefit ratio of an accelerated upgrade may be too great to consider. However, every effort is being made to supplement the H.26X upgrade with alternative funding so that these MPEG-2 sites will be able to interconnect with hundreds of other schools. These issues are addressed in greater detail in the *Protocol Implementation* section of this document.

4.0 Chronology

4.1 Adoption of original standard by NITC

From the minutes of the NITC meeting, February 21, 2002:

REPORTS – TECHNICAL PANEL
Walter Weir, Chair

Video Standards. The Video Standards Work Group was charged with developing this standard and involved representatives from the video industry, K-12 and higher education in the development and/or testing of the proposed standards. The following recommendation for dual video standards was forwarded for approval by the NITC (section below was taken from Video Architecture Standards and Guidelines document):

C. Standards
MPEG-2

- MPEG-2 is specifically intended for applications that require high quality video or "full motion video."
- Expected data rates include T-1 (1.5 Mbps) or higher.

H.263 video with G.722 audio

- Low data rate teleconference applications.
- Expected data rates less than T-1 (1.5 Mbps).

D. Applicability
These standards apply to synchronous distance learning and videoconferencing facilities as follows:

- If utilizing state-owned or state-leased communications networks:
    - Any synchronous distance learning facility or videoconferencing application which utilizes state-owned or state-leased communications networks must comply with the compression standards listed in Section C; or
    - The entity must provide, or arrange for, the necessary gateway technology to comply with the standards.
- If using state funding:
    - All new facilities or applications receiving state funding must comply with the compression standards listed in Section C, unless the facility is joining an existing, non-compliant consortium contract.
    - All existing facilities or applications receiving state funding for ongoing operations must convert to the standards listed in Section C as soon as fiscally prudent or upon renewal of any existing communications service contract, whichever comes first.

Commissioner Smith moved to approve Video Architecture Standards and Guidelines. Commissioner Brown seconded the motion. Roll call vote: Kuck-Yes, Brown-Yes, Adams-Yes, Smith-Yes, Kosman-Yes, and Heineman-Yes. Results: 6-Yes and 0-No. The motion

was carried by unanimous vote.

Discussions occurred regarding: consortiums being held back with new standards not an issue; industry participation; high costs of T1 lines in rural areas like Scottsbluff; and the influence of the NITC in making connectivity affordable to communities.

4.2 Original charter renewed by Technical Panel

From the minutes of the Technical Panel January 13, 2004:

Video Architecture – Video and Audio Compression Standard for Synchronous Distance Learning and Videoconferencing
Mike Beach

The standard is up for review. Mr. Beach reviewed changes to the Charter as well as membership of the work group. Members need to be knowledgeable about technology, dedicated, and attend meetings. For the membership section of the charter, it was recommended to change the wording to read "Membership of the Work Group may include representatives from the following areas:" and to list the areas such as State Government and not list specific agencies or groups.

Mr. Henderson moved to adopt the Work Group charter with the recommended changes. Ms. Horn seconded the motion. Roll call vote: Henderson-Yes, Beach-Yes, Weir-Yes, Becker-Yes, Langer-Yes, and Horn-Yes. The motion was carried by unanimous vote.

Mr. Beach stated that the research, testing and review should not take as long this time. The proposed timeline for the review of the standard was distributed to the panel members.

Nebraska Information Technology Commission Technical Panel
Video Standards Work Group Charter

Purpose	The purpose of the Video Standards Work Group is to recommend a video and audio standard to the NITC Technical Panel that will enable all existing and future synchronous distance learning and videoconferencing facilities to achieve interoperability and an acceptable quality of service.
Sponsor	Michael Beach
Scope/ Boundaries	This work group should define the technical audio and video standard that will be supported by the multipurpose core backbone infrastructure in order to interconnect synchronous videoconferencing sites across the State. The standard shall apply to a. all future investments of state funds to upgrade existing facilities; b. all future investments of state funds to purchase new facilities and equipment; c. all videoconferencing and distance learning traffic that is carried and supported by the multipurpose core backbone infrastructure.
Goals and Outcomes	a. Collection of input from and involvement of a broad constituency of end-users; b. Listing of all possible standards under consideration; c. Establishment of criteria on which to judge the possible standards; d. Elimination of any standards that will not improve efficiency or meet current or projected needs; e. Conduction of research and testing to determine the most appropriate standard for public sector usage; f. Demonstrations to the Technical Panel as needed or requested; g. Creation of a detailed report that will describe integration of the new or standard with existing in-state systems, integration of new or revised standard with existing out-of-state systems, migration plan leading to a total implementation, and estimate of financial impact.
Authority	This work group is charged to: Formulate and present recommendations to the Technical Panel regarding the audio/video standard for interactive videoconferencing and distance learning serving education, communities, and state government. Neb. Rev. Stat. 86-516 (6). "(The Nebraska Information Technology Commission shall) adopt minimum technical standards, guidelines, and architectures upon recommendation by the technical panel."
Membership	Membership of the Work Group may include representatives from the following sub-sectors: • State Government • Education • Communities • Technical Panel • NITC Councils and other members as determined by the sponsor
Reporting	The sponsor of the work group will report to the Technical Panel as needed.
Timeframe	This work group will function until this charter is repealed. Once approved, the recommended standard will be reviewed in February, 2006.

Draft charter proposed and approved by the Technical Panel on January 13, 2004.

4.3 Membership adopted

From minutes of Technical Panel meeting February 10, 2004:

Per the recommendation of Technical Panel, the video standards are scheduled for a review beginning in January 2004. Mr. Beach presented the proposed slate of members for the Video Standards Work Group. He noted that some of the members served on first review. A telehealth representative is still needed and suggestions and/or recommendations were asked of the panel.
Mr. Beach moved to approve the membership slate. Mr. Schafer seconded the motion. Roll call vote: Decker-Yes, Beach-Yes, Weir-Yes, Schafer-Yes, Langer-Yes, and Horn-Yes. Results: 6-Yes, 0-No. The motion was carried by majority vote.

Video Standards Work Group Proposed Membership February 10, 2004

Michael Beach, Chair and member of Tech Panel
Chief Technology Officer
Nebraska Educational Telecommunications
mbeach@unl.edu
402-472-9333 x348

1. Bob Huber (representing NET)
Asst. Director of Engineering - Network Operations
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2. Dan Ward (representing DOC)
Data Communications Network Manager
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3. Jim Copley (representing K-12 ESU-NOC)
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4. John Stritt (representing K-12 DL Consortia)
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***Invited, unconfirmed candidates in italics*

5. John Dunning (representing Higher Education)
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6. Craig Carlson (representing Higher Education)
Distance Learning Director
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7. Max Thacker (representing Telehealth)
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8. Telehealth Representative

Tom Rolfes (Staff Liaison)
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Bruce Sandhorst (Internet2 Liaison)
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4.4 Original Timeline for Review adopted February 10, 2004

Proposed Timeline for Review of Video/Audio Standards for the State of Nebraska

Tue, January 13, 2004	Technical Panel Meeting; Reconstitution of Video/Audio Standards Work Group **charter**
Tue, February 10, 2004	Technical Panel Meeting; Approval of Video/Audio Standards Work Group **members**
Feb. 10-April 13, 2004	Work Group researches standards, updates Video/Audio Standards document, and makes recommendation to the Technical Panel
Tue, March 9, 2004	Technical Panel Meeting; update from Video/Audio Standards Work Group
Tue, April 13, 2004	Technical Panel Meeting; Approval of Video/Audio draft document and posting for 30-day public comment period
Tue, May 11, 2004	Technical Panel Meeting; Review of comments and changes to draft document; forward to NITC
Thu, June 3, 2004	NITC Meeting; review and approval of revised Video/Audio Standards document
Fri, June 4, 2004	Posting to "Technical Infrastructure - Standards and Guidelines" Website: http://www.nitc.state.ne.us/standards/index.html

4.5 Revised Criteria Study

From meeting notes of Video Standards Work Group on February 27, 2004:

The work group decided to include additional factors in the upcoming criteria study. These included Availability with sub-factors of Video/Audio Combinations and List of Manufacturers. The group discussed briefly the upgrade implications of existing facilities on the network integrity as a criterion but made no recommendation for inclusion. The group will include far-end cameral control as a sub-factor of one of the review criteria.

4.6 Revised Timeline for Review of Video Standards

From meeting notes of the Video Standards Work Group on March 26, 2004:

Revised Timeline for Review of Video/Audio Standards for the State of Nebraska

Tue, January 13, 2004	Technical Panel Meeting; Reconstitution of Video/Audio Standards Work Group charter
Tue, February 10, 2004	Technical Panel Meeting; Approval of Video/Audio Standards Work Group members
Feb. 10-April 13, 2004	Work Group researches standards, updates Video/Audio Standards document, and makes recommendation to the Technical Panel
Tue, March 9, 2004	Technical Panel meeting was cancelled
Month of April	Gather manufacturer CODECs for testing of technical attributes and prepare UNK site for testing; Finish criteria studies and research for draft report.
Tue, May 11, 2004	Technical Panel Meeting; Update from the Video Standards Work Group; early May includes technical bench tests; late May includes user tests
May 26, 2004	Subjective and technical video and audio testing at ESU-10
July 13, 2004	Technical Panel Meeting; Present Video/Audio Standards draft document Post Video/Audio Standards draft document for ~30-day public comment period
August 10, 2004	Technical Panel Meeting; Review of comments and changes to draft document; forward to NITC
Thu, Sept 9, 2004	NITC Meeting; Approval of revised Video/Audio Standards document
Fri, Sept 10, 2004	Post document to "Technical Infrastructure—Standards and Guidelines" Website: http://www.nitc.state.ne.us/standards/index.html

5.0 The Decision Process

a. The work group tried to identify all the applicable standards to be considered. It was the goal of the work group to then determine which of those protocols identified represented technology that was in use or older than what was currently used. In connection with this, the work group decided to exclude technology that would be somehow less efficient than what was currently being used. After doing this, the remaining protocols were to be examined more closely.

b. The work group decided to conduct a study of the remaining protocols based upon criteria. The work group examined the criteria established in the last study and decided to add one more to the list. The criteria were developed with input from the members of the work group, the Education Council, and the Technical Panel. This process followed the same set-up as in the original standard recommendation process from 2001-02.

5.1 Existing Protocols

a. There were 3 main protocols that existed in the state when the work group first began this process. These standards were those being used specifically for synchronous live delivery of two-way teleconference classes.

b. JPEG CODEC's have been implemented throughout many K-12 consortia. Telephone companies have primarily supplied this network solution.

c. In accordance with the current standard, H.263/G.722 is used by the State in both the Neb*Sat Network 3 two-way conference system, as well as the NVCN terrestrial system. Both networks have used this protocol in the ISDN H.320 communications mode, however, the NVCN system has more recently added IP H.323 ports on its switch. Neb*Sat has not yet adopted H.323 (IP) protocol, but has experimented with it and is able to migrate. NDE has also adopted H.263/G.722 for its statewide meetings. NDE has deployed a number of these videoconference systems.
http://www.nde.state.ne.us/TECHCEN/dist/graphics/NDE_ESU_Polycoms.gif

d. H.263/G.722 has also seen some implementation in a few institutions of higher learning such as UNO, UNK, UNL, UNMC and Wayne State College. This standard is being used in both the H.320 ISDN version and the H.323 IP version. The Southeast Nebraska Distance Learning Consortium and the southern Tri-Valley Distance Education Consortium schools have adopted this standard in the IP mode.

e. MPEG-2 is the other optional standard adopted in the 2002 document. Since the standards adoption by the NITC, this protocol has been deployed in the Sandhills Technology Education Program Consortium and the Crossroads Distance Learning Consortium.

f. The Nebraska Statewide Telehealth Network (NSTN) project has been developed to bring together an interconnected network of hospitals that will provide new and expanded

capabilities and access to the hospitals of Nebraska and the patients and communities that they serve. In addition to this improvement in the mechanics of care, education and support, the NSTN also will allow for connection of these hospitals to the Public Health Departments located across the State of Nebraska, the Nebraska State Capital Building, the Nebraska State Office Building, the State Bioterrorism Lab and the seven regional bioterrorism labs. Such connections shall allow not only for a time-sensitive connection to provide for an emergency alert response, but also for educational and administrative connections as well.

g. The NSTN plan has been developed to encompass a number of critical components including equipment, connectivity between and among entities, compatibility of the equipment and systems, sustainability and technical support.

h. Key entities involved in making the Plan functional include:

- The Hospitals across the State of Nebraska
- The Nebraska Hospital Association
- The Nebraska Health and Human Services System
- The Telecommunications Providers from the State of Nebraska
- The Nebraska Office of the Chief Information Officer
- The Nebraska Division of Communications
- The Nebraska Information Network
- The Nebraska Public Service Commission
- The Universal Service Administrative Company
- The University of Nebraska
- Public Health Departments located in Nebraska

5.2 Initially Identified Protocols

Video Standard	Criteria Study
NTSC	No
JPEG	No
H.261/G.722	No
MPEG-1	No
MPEG-2	Yes
MPEG 4 Part 2	Yes
MPEG 7	No
H.263	Yes
Wavelet	No
H.264/MPEG 4 Part 10	Yes

Audio Standard	Criteria Study
MPEG-2 (MPEG 3)	Yes
MPEG 4 (MPEG 3)	Yes
G.711	No
G.722	Yes
G.722.1	Yes
G.723	Yes
G.728	Yes

a. For those standards adopted in the 2002 standards document, the criteria study was already conducted except for the one additional criterion added this time. The former information was used in comparison to the new standards being considered.

5.3 Criteria Developed For the Follow Up Study

5.3.1 COSTS

Site Costs: What are the uniquely required hardware/software cost at each site?

Hub Costs: If a hub such as an MCU is required then what are the hardware/software costs?

Operational Costs:

a. These include: maintenance requirements, technicians, connectivity bandwidth, and scheduling personnel.

b. Site and hub costs are assumed to be capital in nature. In some current contracts, the classroom is owned by the school and the CODEC is owned by the provider. The provider may lease the CODEC to the school or simply build its cost into the monthly service fee. In the case of Neb*Sat and NVCN, the CODEC is owned by the State.

c. Operational costs are more difficult to pin down since they depend greatly on who owns what. In order to understand operational costs one must know where the line of demarcation is in a network as to what's on the provider side of the line and what's on the client side of the line. This is unique to each contract.

5.3.2 BANDWIDTH

Minimum quality: This is the data rate required for NVCN / Network 3 like quality. Since the earlier report, this quality has improved so the bar for minimum quality has been raised in this report.

High quality: This is difficult to define. In the last report this was defined as the rate required for full-motion quality. This was used then because there were still some systems using analog technology. We have modified this to mean "good enough" for classroom use.

Lip readable: The data rate required for language classes. Lip motion must coincide well with the audio.

ASL readable: The data rate required for American Sign Language or any other sign language. Frame rate must be high enough to be able to see subtle hand movements.

Flexibility: In a given protocol, what are the highest and lowest available data rates?
Can a user define any rate between the extremes, or are their set choices?
If the choices are set, what are they?

Negotiation

a. Is bandwidth determined automatically by CODEC devices, or does the user have to set it up manually?

b. One of the messages that was loud and clear from the end users of the videoconferencing and distance learning systems was that quality was important to them. They defined quality in several ways. First they talked about the concept of "full motion." It was difficult to pin down a definition of this concept, but the general sense among the consortia members was that full motion meant at least JPEG quality. Next we heard that there ought to be a way to insure that a teacher using sign language for hearing impaired students would need to be able to use the system. A special requirement for teachers of foreign language was expressed. It was important that students not only hear the words, but also be able to synchronously watch how the teacher shapes their mouth to form the words. Finally, as a committee we decided that some "minimum" quality ought to be defined. We decided to use the current quality of NVCN and Neb*Sat Network 3 as examples of minimum quality. All of these "defined" qualities are subjective, so a test would have to be designed to somehow put quantitative measures to each of these quality levels.

c. In the digital world, bandwidth equates to data rate (speed). Some systems will have preset data rates (steps), which can be selected. Other systems use an upper and lower bandwidth limit and any speed can be selected between the limits in small increments. These ideas refer to the concept of flexibility. Negotiation directly relates. In order for two stations to talk to each other, they would need to interoperate at some speed. This might be accomplished by manually setting the equipment at both ends at the same speed. It might also be done by having the equipment automatically attempt to find the highest speed each can communicate over. Finally, a third device might be used to "gateway" between them such as a switch. Negotiation is the process required to get all sites talking at some speed. It is also possible that a site might send at one speed and receive at a different speed.

5.3.3 CONNECTIVITY

Ubiquity: How widely used is this protocol?

Broadcast / multicast: Can it be streamed one-to-many?

Point-to-point: Can it be shared directly between two interactive sites?

Teleconference: Can several interactive sites have 2-way communication? Is an MCU or switch required?

Dial up / dial out: What is the ability for an external site to connect into a conference and not have to be brought in? Can the internal site connect to an external system as well?

Latency

a. How much delay is introduced by encoding process?

b. When one speaks of connectivity, one is referring to the network options available to be used with the given protocol. Ubiquity refers to how many different network environments the video and audio protocol in question can be transported. The kind of network then helps to understand what kinds of communications links are possible. Nebraska uses different configurations as listed above (broadcast, point-to-point, and teleconference). Dial up / dial out refers to the ability of an outside system to "join" a conference, or for a conference to "bring in" an outside system.

c. Latency is a very specific technical issue that affects the quality of the user experience. When one of the current classroom video cameras shoots a picture, it is looking at an analog world, which it records in an analog fashion. The same is true with a microphone and sound. These analog video and audio signals eventually reach a CODEC. The job of the coding portion of this device is to change these analog signals into a data stream. The decoding portion receives the returning data stream from the far site and converts it to an analog signal to be displayed on the video monitors and audio speakers. The device codes and decodes, hence the name CODEC. Whenever a device digitally processes a signal, the stream is delayed slightly. This time delay is known as latency. Some small amount

of latency is inherent in all such systems. Excessive latency can make communication difficult. A network also introduces latency, but since that is variable with every network design, we intended to document only latency introduced by the digital processing in a CODEC of the given protocol.

5.3.4 COMPATIBILITY

Standard type: Are there software-based CODEC systems that can be used on an off-the-shelf computer, or is specialized hardware required?

Backward compatibility: What is the nature of any compatibility?

Installed base: How prolific is this standard already?

Life Cycle

a. What ability exists to upgrade to or from this protocol?

b. In this area we are looking for how interoperable the particular protocol is with older versions of itself and/or newer versions of itself. This is often more easily accomplished with protocols that are more software based then hardware based, though all protocols require both hardware and software. It is also helpful to understand if we are looking at something that is easy to obtain and more “off-the-shelf” or unique and custom.

5.3.5 AVAILABILITY

List of Manufacturers

Video & Audio Combinations

What is actually available in purchasable CODECs?

Maintenance & Control Options of Available CODECs

Serial, parallel, SNMP, etc.

Far End Camera Control

What standards are used by which CODECs?

Since it was decided to examine video and audio separately, this criteria is aimed to verify real-world availability of equipment using various combinations of video and audio standards.

5.3.6 RECOMMEND DEMONSTRATION

Yes or No

Finally, based on all the previous criteria, the work group was to decide which of the protocols should move beyond the criteria study and actually be physically tested by the group.

5.4 Criteria Study Results

Video Protocol	Advanced to Test / Demo
MPEG-2	Yes
MPEG 4 Part 2	No
H.263	Yes
H.264/MPEG 4 Part 10	Yes

Audio Protocol	Advanced to Test / Demo
MPEG 3	Yes
G.722	Yes
G.722.1	Yes
G.723	If available
G.728	Yes

5.4.1 VIDEO PROTOCOL RESULTS

MPEG-2

DISCUSSION

a. This protocol was originally designed as an improved algorithm to the MPEG-1 protocol. MPEG-2 is a form of compressed video, meaning not all the visual information is passed. The first new frame of video is passed. After that, only the part of the picture that changes is sent. On the far end, only the changed video is moved on the screen. The rest of the pixels on the screen simply repaint unchanged. The MPEG-2 audio is also encoded at a pre-selected sampling rate. This protocol is one of the two accepted in the original standard.

COSTS

a. Site-specific capital cost is specifically a CODEC. The CODEC could be as low cost as an MPEG card for a PC and software at less than $1,000 up to a $30,000 for an integrated quality system. Since this is currently a popular technology, many versions of hardware and software are available.

b. A hub is generally used for multi-site teleconferencing with MPEG-2. In existing systems, the hub is owned by the service provider and part of monthly costs. The cost of an MPEG-2 hub varies with size and features, but none of them are inexpensive.

c. Operational costs would include maintenance requirements. Since the cost of a CODEC is similar to the currently used CODECS in the system, no change in maintenance costs is expected. This is true as well related to technicians. If the current connectivity provider would permit purchase of bandwidth on a flexible use basis,

MPEG-2 would be the most expensive examined protocol since it requires the most bandwidth.

BANDWIDTH

a. MPEG-2 is probably not capable of achieving minimum quality as defined in the criteria. Below 2 Mbps the quality drops off quickly. At 2 Mbps the quality would be better than our defined minimum quality. To achieve full-motion quality requires 4Mbps per channel. Lip readable and ASL readable data rate is estimated to be around 2 Mbps.

b. Data rates seem to be available between 0.8Mbps and 15Mbps. The adjusting step size will vary from manufacturer to manufacturer. Bandwidth negotiation seems to depend on the kind of application. Typically, two-way systems require manual setting, though some can do automatic negotiation. Many switches that pass MPEG-2 will translate between data rates if required. One-way systems often employ statistical multiplexing. This means that the data rate varies automatically as motion in the video increases and decreases. The receiving half of a one-way system automatically tracks with the inbound data rate.

CONNECTIVITY

a. MPEG-2 is ubiquitous in that it can be delivered across most kinds of networks including IP, ATM, dedicated line, ISDN and VPN. It can be used in multicast, point-to-point, and teleconference applications (with an MCU). Dial up / dial out is a function of ISDN applications or access availability of outside IP networks. Exact latency was unknown to the committee at the time of the criteria study, but was determined as a part of the test procedure. This is true even though some users have MPEG-2 installed because the original systems use a 3-chip processor. New processors are using a single chip now.

COMPATIBILITY

a. Although MPEG-2 uses digital signal processing hardware, it is primarily a software driven protocol. There are no real incentives for backward compatibility. It is easier and more efficient to upgrade older MPEG-1 systems to the MPEG-2 standard. MPEG-2 is a commonly installed system. Upgrade to MPEG 4 Part 2 is not relevant since that protocol has not become widely adopted. Upgrade to MPEG 4 Part 10 (H.264) is really a complete replacement.

AVAILABILITY

a. MPEG-2 systems are available from a number of manufacturers, but most of those lines are considered mature in that manufacturers are not coming out with new lines of hardware. It is appears to be the most implemented protocol over the past few years. Recently implemented and existing systems are growing, but most newer systems are adopting H.264 and some MPEG-2 systems around the country are beginning to migrate to H.264. Older MPEG-2 uses its own audio encoding scheme. Newer models use MPEG 3 audio encoding. Both are compatible with each other. All CODECs are controllable by

a variety of methods. There is nothing about MPEG-2 that would preclude far end camera control though availability varies from manufacturer to manufacturer.

MPEG 4 PART 2

DISCUSSION

a. This protocol was on track to become the replacement for MPEG-2, but emphasis was shifted to MPEG 4 Part 10 when both the U.S. and international standards organizations focused on that system. Because of the proliferation and adoption of Part 10, this protocol has by and large ceased to be a viable option.

COSTS

This could not be determined since devices are not really available in this protocol.

BANDWIDTH

In theory this would have been an improvement over MPEG-2, but has since been superseded by MPEG 4 Part 10.

CONNECTIVITY

All network communications protocol would theoretically work with this system, but since there are not really devices available it is a mute point.

COMPATIBILITY

Transcoding with MPEG-2 is theoretically possible. The same is not true for H.26x.

AVAILABILITY

This is the most problematic issue for this protocol. There are a few companies toying with this system still, but on a small scale. We could not actually find a specific teleconference system using this standard.

H.263

DISCUSSION

This standard is part of a family of standards developed by the ITU for teleconferencing. They include the H.26x series for video, G.7xx for audio and T.1xx for data. H.263 video is one of the two current Nebraska standards. In the last standards process, audio and video were linked together. This time the committee decided to look at them separately. A specific discussion on bandwidth and audio selection is below.

COSTS

a. As with MPEG-2, the only real site cost is the CODEC. A PC card could run in the hundreds of dollars, but a typical dedicated system runs from $10,000 to $20,000.

b. A hub is generally used for multi-site teleconferencing as with MPEG-2. The cost of any hub is less of an issue than originally thought. It is assumed that the hub would be owned by the service vendor and the part of the monthly costs now paying for the original hub installed would continue to pay for any new installed hub(s). The cost of a hub varies with size and features. For NVCN and Neb*Sat Network 3 Accord hubs are already in place to accommodate this standard.

c. Operational costs would include maintenance requirements. In many of the contracts throughout the state, these costs are wrapped into the lease contract with the provider. For those entities that own their devices, the repair costs can reach into several thousand dollars per repair, but the need for repairs has proven to be rare. If the current vendor would permit purchase of bandwidth on an as needed basis, H.263 would lower costs as compared to MPEG-2. Since the state has now specified IP as the communications protocol, using a CODEC that requires less bandwidth can also allow greater amounts of bandwidth for other applications.

BANDWIDTH

a. H.263 is capable of the defined minimum quality. In fact it is designed for this kind of application. The protocol works down to about 128Kbps. In practice, full-motion quality is attained at T-1 and E-1 speeds and lip readable and usable for sign language at about 512Kbps.

b. Data rates are available from 0.128 to 1.92Mbps in steps that are multiples of 64Kbps. Negotiation between systems is automatic, but many CODECs auto shift from H.263 to H.264 as the bandwidth is lowered because it offers better performance at the lower rates. CODECs are not available in this protocol above 1.92Kbps. This is because above that data rate the picture quality doesn't really improve much and the quality is very good at this upper rate.

CONNECTIVITY

a. H.263 is typically used in the larger family of protocols defined in H.320 (ISDN dial up or dedicated line), H.321 (ATM) and H.323 (IP or VPN). It can be passed in the multicast mode but is specifically designed for the point-to-point and teleconference applications. Multiple site conferences require a hub (MCU), or doubling up on bandwidth by using multiple VPN links. Dial up / dial out is used in all 3 communications modes. Latency is defined in the test section of this document.

COMPATIBILITY

a. This standard as others uses both hardware and software. It is backward compatible with H.261 video through a transcoding switch mechanism like the Accord switch in place in the NVCN and Neb*Sat Network 3 systems. H.263 has been popular in the H.323 IP configuration as desktop teleconferencing rises in popularity. It has by and large replaced MPEG-2 in its proliferation. Since H.263 is a prolific ITU teleconference standard, forward compatibility to H.264 is similar to that of H.261 to H.263 in that a switch is to transcode.

AVAILABILITY

a. H.263 has been widely adopted in the low bandwidth teleconference arena. There are at least 6 manufacturers that we could find. Most all the CODECs can use a combination of G.7xx audio protocols. They generally offer a variety of internal or external / remote control. All H.263 CODECs use H.281 for far-end camera control when they include the option in their product.

H.264

DISCUSSION

a. This standard is part of a family of standards developed by the ITU for teleconferencing. They include the H.26x series for video, G.7xx for audio and T.1xx for data. H.264 is the only video protocol ever to be simultaneously adopted by the MPEG and IEEE organizations in the United States as well as the ITU/T internationally. This is a significant issue related to protocol licensing. Also, because of the worldwide adoption, this protocol is likely to be longer lived than other protocols have been. In the last standards process, audio and video were linked together. This time the committee decided to look at them separately. A specific discussion on bandwidth and audio selection is below.

COSTS

a. As with MPEG-2 and H.263, the only real unique site cost is the CODEC. A PC card could run in the hundreds of dollars, but a typical dedicated system runs from $10,000 to $20,000.

b. A hub is generally used for multi-site teleconferencing as with MPEG-2 and H.263. The cost of any hub is less of an issue than originally thought. It is assumed that the hub/switch would be owned by the service vendor and the part of the monthly costs now paying for the original hub installed would continue to pay for any new installed swtich(s). The cost of a hub varies with size and features. For NVCN and Neb*Sat Network 3 Accord switches are already in place to accommodate this standard.

c. Operational costs would include maintenance requirements. In many of the contracts throughout the state, these costs are wrapped into the lease contract with the provider. For those entities that own their devices, the repair costs can reach into several thousand dollars per repair, but the need for repairs has proven to be rare. If the current vendor would permit purchase of bandwidth on an as needed basis, H.264 would lower costs as compared to MPEG-2 and H.264. Since the state has now specified IP as the communications protocol, using a CODEC that requires less bandwidth can also allow greater amounts of bandwidth for other applications.

BANDWIDTH

a. H.264 is capable of the defined minimum quality. In fact it is designed for this kind of application. The protocol works down to about 128Kbps. In practice, full-motion quality is attained at 768Kbps and lip readable and usable for sign language at about 384Kbps. These speeds are half of those required for the same quality in H.263 protocol.

b. Data rates are available from 0.128 to 1.92Mbps in steps that are multiples of 64Kbps. Negotiation between systems is automatic, but many CODECs auto shift from H.264 to H.263 as the bandwidth is raised. This is because less processing is required at higher data rates and the quality difference between H.263 and H.264 at T-1 speeds and higher is negligible. CODECs are not available in this protocol above 1.92Kbps. This is because above that data rate the picture quality doesn't really improve much and the quality is very good at this upper rate.

CONNECTIVITY

a. H.264 is typically used in the larger family of protocols defined in H.320 (ISDN dial up or dedicated line), H.321 (ATM) and H.323 (IP or VPN). It can be passed in the multicast mode but is specifically designed for the point-to-point and teleconference applications. Multiple site conferences require a hub (MCU), or doubling up on bandwidth by using multiple VPN links. Dial up / dial out is used in all 3 communications modes. Latency is defined in the test section of this document.

COMPATIBILITY

a. This standard as others uses both hardware and software. It is backward compatible with H.261 and H.263 video through a transcoding switch mechanism like the Accord switch in place in the NVCN and Neb*Sat Network 3 systems. H.264 has been used nearly exclusively in the H.323 IP configuration as desktop teleconferencing rises in popularity. It has by and large replaced MPEG-2 and is rapidly replacing H.263 in its proliferation. Since H.264 is a growing MPEG/IEEE/ITU teleconference standard, forward compatibility to future standards is more likely.

AVAILABILITY

a. H.264 is the newest serious protocol and its use is on the rise. It has been widely adopted in the low bandwidth teleconference arena. It seems to be riding side-by-side on many CODECs with H.263. Many devices use H.263 from 768Kbps up and H.264 below that rate. This is because H.264 gives roughly twice the quality of H.263 at lower rates. The trade off is it requires higher processing speeds. This means that current desktop systems in Nebraska will probably not have the processing speed necessary to adopt H.264 with just a software upgrade. The same is true with older H.263 CODECs, but the newer ones will only need software. There are at least 3 manufacturers that we could find. One more will be available in Fall 2004. Most all the CODECs can use a combination of G.7xx audio protocols. They generally offer a variety of internal or external / remote control. All H.264 CODECs use H.281 for far-end camera control when they included the option in their equipment.

5.4.2 AUDIO PROTOCOLS

MPEG 3

DISCUSSION

MPEG 3 is used in CODECs using MPEG-2 or MPEG 4 Part 2 video. When the MPEG members wanted to create a digital television (DTV) standard encoding system for the United States they began work on the MPEG 3 video and audio protocol. They eventually dropped changing MPEG-2 video so MPEG 3 is really just an audio protocol.

COSTS

There are no special costs associated with this protocol beyond those stated for video.

BANDWIDTH

MPEG 3 audio was a decided improvement over the original MPEG-2 protocol. Bandwidth was substantially reduced in the upgrade given equal quality. This protocol has such low bandwidth requirements that it has become the encoding standard of choice on the Internet for streaming audio. It is also popular for personal music storage devices known as MP3 players.

CONNECTIVITY

There are no special connectivity issues associated with this protocol beyond those stated for video.

COMPATIBILITY

MP3 audio is not compatible with other protocols

AVAILABILITY

MP3 is widely used in the asynchronous online world so it is quite prolific there. This means that MP3 software decoders are cheap and easy to come by, as are encoders. The same is not true in the teleconference synchronous video world however. The issues that apply to MPEG-2 video systems apply to MPEG 3 audio.

G.7xx

DISCUSSION

This entire series is a group of related audio protocols adopted by the ITU. They all act in more or less the same way and there are a variety of them available on different CODECs. The major way to tell them apart is by comparing the data rate required for each and the quality of the audio that is provided at that particular rate.

COSTS

There are no special costs associated with this protocol beyond those stated for video.

BANDWIDTH

The following spreadsheet gives detail for each protocol of this entire series.

ITU Standarc	Bitrate	Audio Fidelity	Notes	Applications
G. 711	64k	3.4 KHz	Voice Frequencies	Digital TelephoneT1/E1, Video Conferencing
G. 722	64/56/48k	7.0 KHz	Wideband	Wideband IP telephone, Video Conferencing
G. 722.1	32/24k	7.0/3.4 KHz	Wideband/Medium Bitrate	Wideband IP telephone, Internet Streaming, Video Conferencing Voice over Internet (VoIP)
G. 723.1	6.3/5.3k	3.4 KHz	Voice/Low Bitrate	Multimedia Low Bitrate, Video Conferencing
G. 728	16k	3.4 KHz	Voice/Low Bitrate	Voice over Packet Networks (VoIP Cable or DSL), Video Conferencing
G. 729A	8k	3.0 KHz	Voice/Low Bitrate	Voice over Internet (VoIP) Voice Mail, Multimedia Low Bitrate, Video Conferencing

In the case of G.722.1 and G.723.1 a latency or delay greater than 35 milliseconds. This could cause adjustment needs in CODECs to avoid lipsync issues.

CONNECTIVITY

There are no special connectivity issues associated with this protocol beyond those stated for video.

COMPATIBILITY

Though each specific G.7xx protocol is not specifically compatible with the other, they are widespread enough that most CODECs carry more than one of them. This makes it likely that any two H.26x series CODECs will be likely to share at least one of these protocols in common.

AVAILABILITY

As stated above, most of this series are very popular. Specifically, G.711 and G.722 are available on every H.26x CODEC we examined. G.722.1 and G.728 were also available on most, though the specific protocol used by the CODECs depended on the overall data rate and the systems switched by themselves automatically to the more efficient protocol as data rate was lowered.

6.0 USER PRIORITIES

a. In the first video standard document in 2002 we invited users of distance learning to come and view a series of video clips encoded at different rates using different encoding systems. Along with that process we asked them about their priorities concerning specific aspects of video and audio distance learning systems.

b. We used the same process for this document with one exception. The number of those actually able to come and view the video is relatively small so the priorities survey was filled out by a small sample of users. For this current process we decided to place the prioritization survey online and invite a larger group of system users to participate.

Actual survey taken online by participants throughout the state:

Distance Learning and Video Conferencing Video Standards Survey Form

Name

Email

Your specific identifying information will not be shared, it is to avoid counting responses more than once. You must fill out all of the survey or your responses will not be counted.

Institution Sector

☐ Public ☐ Private ☐ Other

Institution Type

☐ K-12 ☐ Community College ☐ 4-year College ☐ University ☐ Healthcare
☐ Other

Job Type

☐ Instructor ☐ Student ☐ Class/Meeting Coordinator ☐ Technical
☐ Other

Additional Expertise: (For Teachers Only) Select all that apply

☐ Language ☐ Sign-Language ☐ Music

Status: Select your teleconferencing usage

Experience with Teleconferencing Select

Current video system you use:

☐ Analog ☐ JPEG ☐ MPEG2 ☐ H.263 ☐ H.260 ☐ H.261 ☐ Don't know
☐ Other

Current audio system you use:

☐ Analog ☐ JPEG ☐ MPEG2 ☐ G.711 ☐ G.722 ☐ Don't know
☐ Other

Please rank the following teleconferencing characteristics in order of importance to you and your institution, 5 through 1. A '5' indicates the highest value, a '1' indicates lowest value. No two characteristics may be rated with the same value.

Bandwidth (refers to the data rate required to conduct the video conference, increased bandwidth means increased cost and increased quality): ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

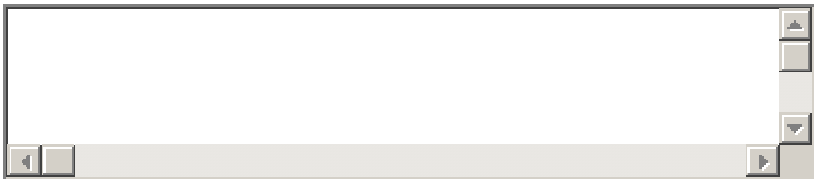
Latency (refers to the amount of time video and audio are delayed because of data processing, decreased latency means more real time conversation and less delay): ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Lipsync (refers to the synchronization of video and audio so that you see and hear events timed exactly in step): ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Picture quality (refers to the sharpness of the video, and the frame rate or smoothness of motion): ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Sound quality (refers to the clarity of the audio): ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Additional comments:

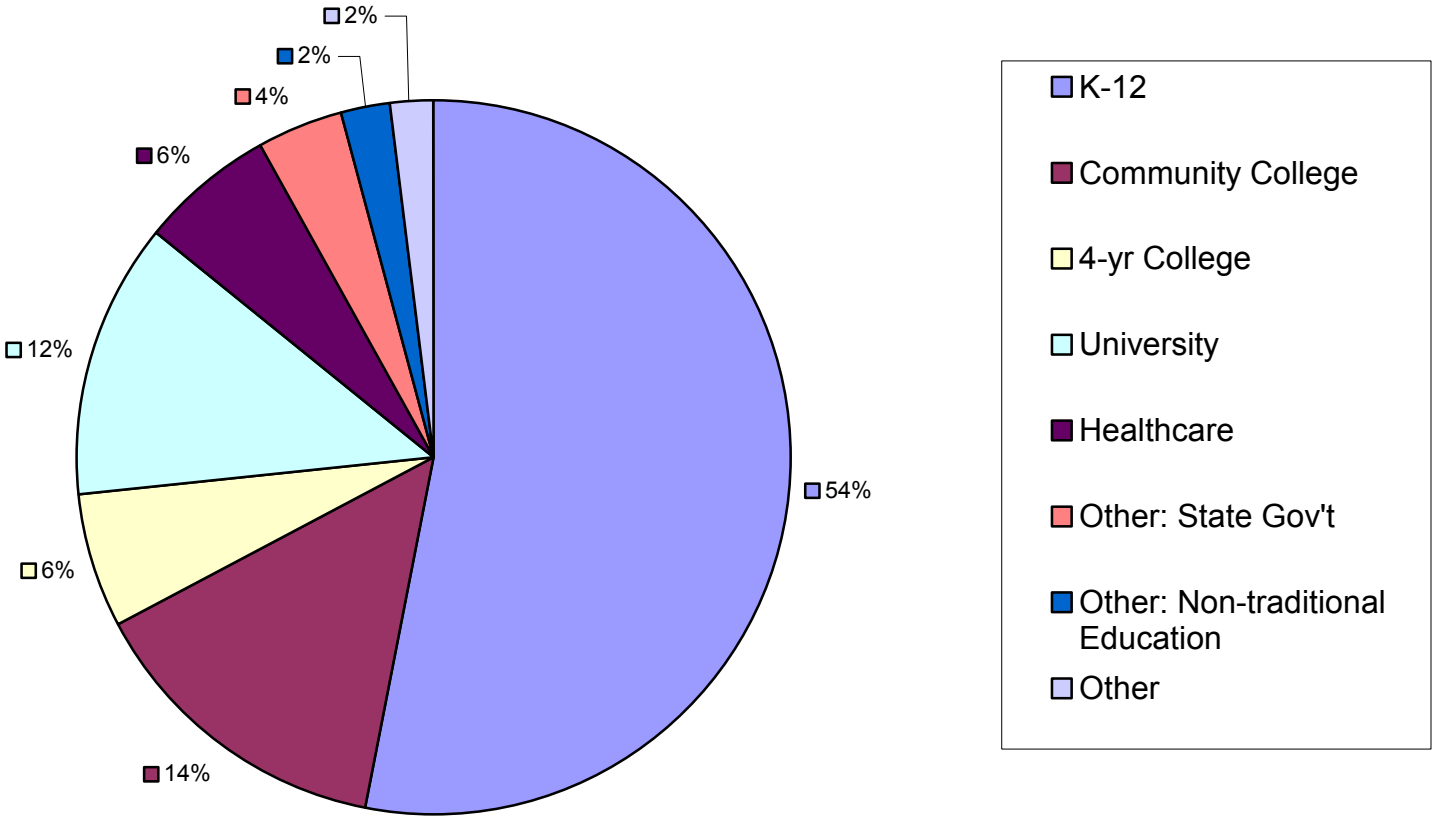


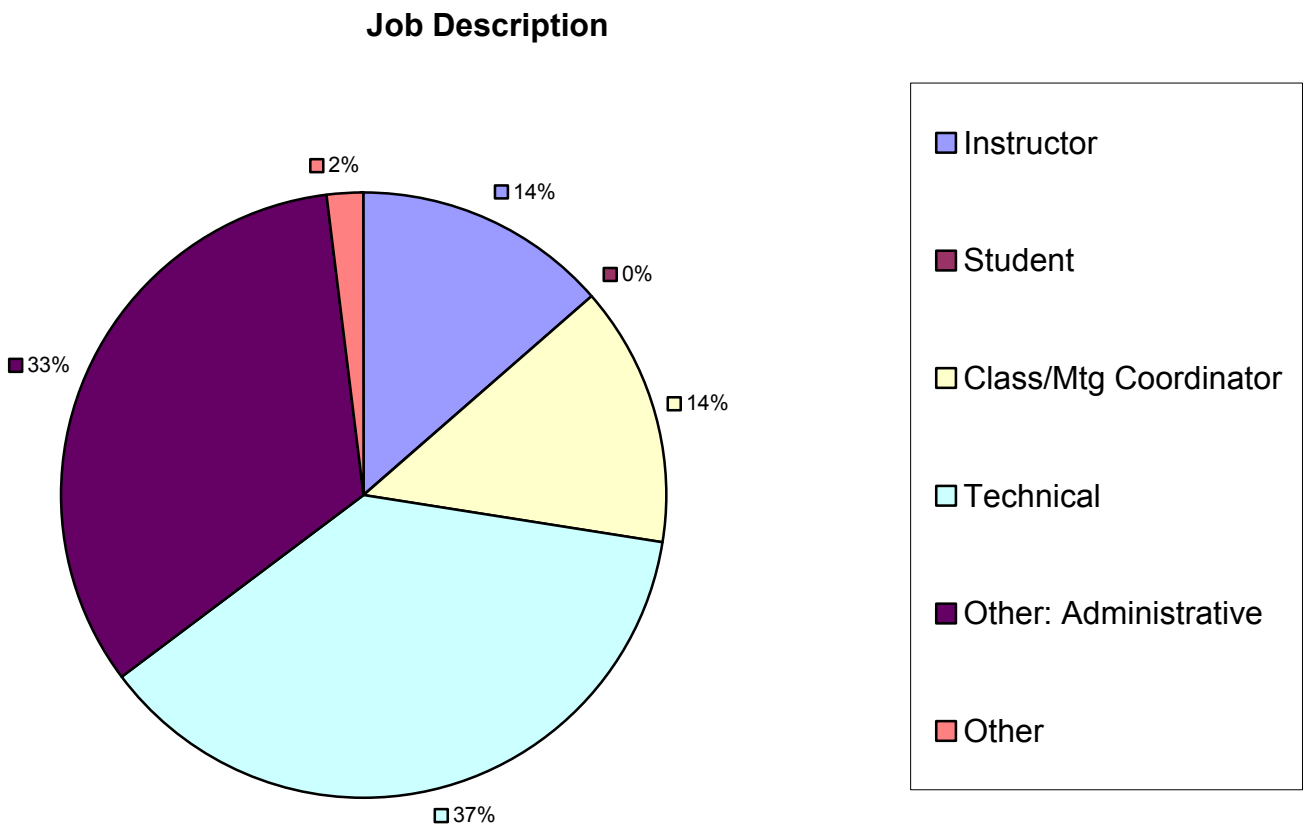
Submit the Survey

Survey Respondents

A total of 52 people filled out the online survey. Their self-reported make up is as follows:

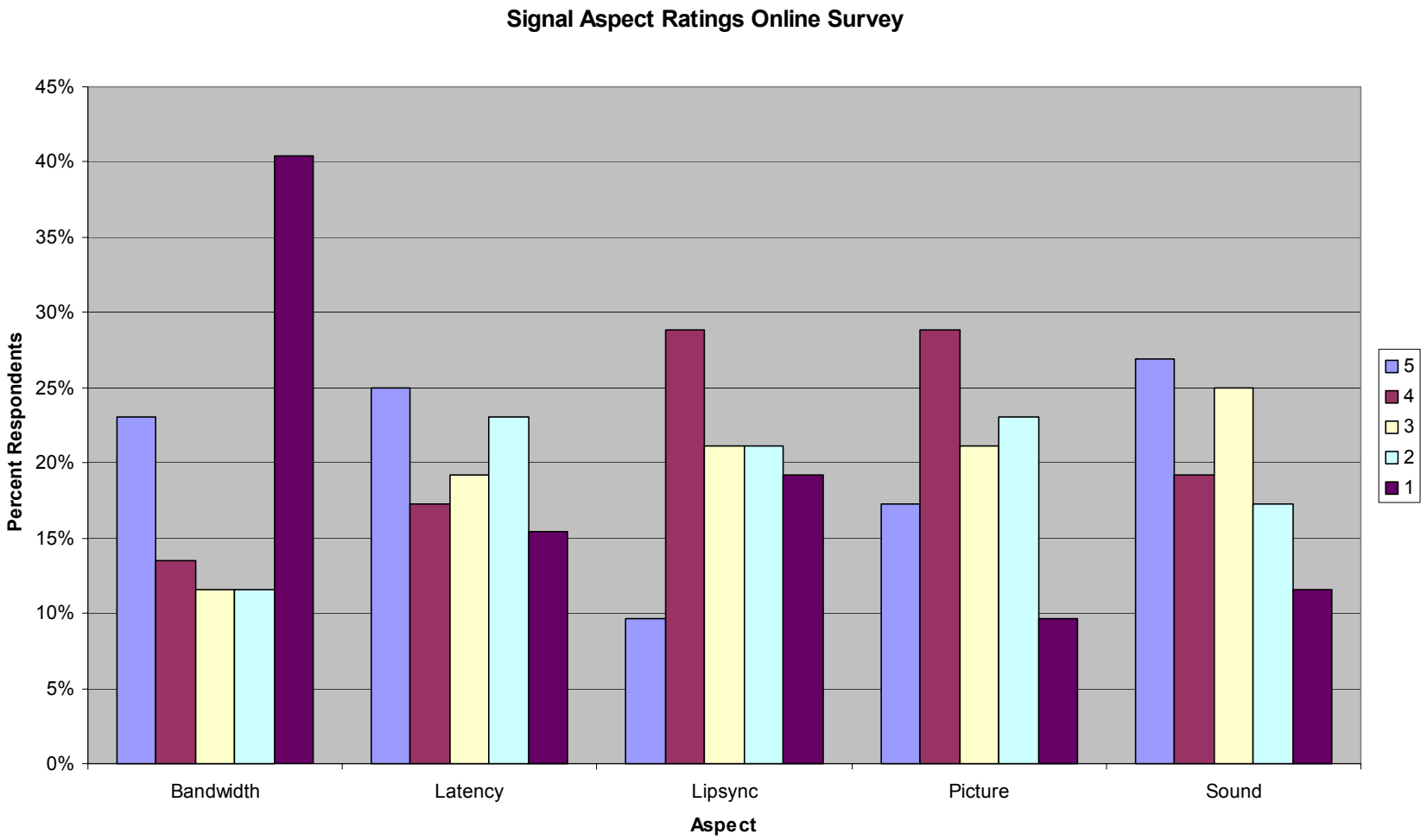
Community Representation





Three (3) respondents claimed specialty expertise in teaching language.

Survey Results



Comments from survey respondents

The following comments were submitted in the final text box of the survey. Each is followed by a response composed by the Video Standards Work Group, indicated in italics:

1. "Reliability of the system is the utmost priority!"

Reliability is clearly important, but it is not a function of the specific protocol. It is a function of a variety of issues such as network reliability, quality of the equipment used, correct application of QoS functions, amount of bandwidth provided on the network and simplicity of user interface to name a few.

2. "Of all the characteristics that are important the sound quality is the most important and picture quality would be next."

Opinions vary on this. That's why the survey was conducted.

3. "The State HHSS system is in the process of purchasing systems to integrate with the published standards. Greatest need is for emergency and unscheduled conferences across the entire State / telehealth network."

The Statewide Synchronous Video Work Group (not the same as those working on this project) are addressing the issues that surround user interaction and coordination. This need or ad hoc connectivity exists in all the user communities. The current system allows it within some aggregated groups, but not with all aggregated groups. Also, ad hoc connections are virtually non-existent currently from one aggregation group to another.

4. "Currently we are running H.261 and H.263 as well as G.711 and G.722. Soon will be also running H.264."

H.263 and G.722 are within the current state standard. H.261, H.264 and G.711 are not. If your plan is to run H.264 and that is the selected standard then that would be a wise choice. If H.264 is not selected you may incur additional expense in the future.

5. "We do not split the protocol between audio and video. We allow H323. As for importance to the above questions, I do not see how this will help you. We need a 5 on all of them for quality sake with the exception of latency (as long as the voice and picture stays in sync)."

H.323 is a communications protocol that specifies use of an IP-based network. Along with that protocol your CODEC also uses a video protocol and an audio protocol. Generally speaking, if a CODEC is using H.323 for communications it is also using an H.26x video protocol and a G.711 and/or G.72x audio protocol. Some CODECs make the decision automatically as to which of each of these to use when it communicates with the

CODEC on the other end of the circuit. This is called "handshaking." Others allow either automated or manual protocol selection.

It is true that all of the issues we asked prioritization of. This is a given. Nobody is indicating anything else. However, each CODEC device design is based on decisions made by the manufacturer as to what to give up as bandwidth goes down. The prioritization can help hardware purchasers to research the specific devices with some information to influence their decisions.

6. "I'd rate all the characteristics as very important."

Again agreed. However, another way to think about this when one is forced to make a decision, multiple aspects must be considered and balanced. Obviously quality is important, but if the bandwidth required to provide "high quality" is beyond the budget, one option is to purchase less bandwidth if it can produce "good enough quality." So if a protocol requires less bandwidth to produce "good enough quality" then it may be more useful to users. Such a set up might also be thought of if one wants to increase the number of connections without having to increase the purchased bandwidth.

7. "We will be upgrading our VTEL system to IP this summer at Central CC."

IP is a communications protocol that has already been specified by the NITC. This document will define video and audio protocols as well. Any purchased CODEC must conform to all three standards, not just the communications standard.

8. "Usable quality with most efficient use of bandwidth possible."

Agreed, but quality is in the eye of the beholder. Such a subjective specification is difficult for engineers to deign to. That is why the process of this standard included a subjective quality test. The video viewing portion of this document helps the panel to understand what the largest number of users would consider "good enough" for their purposes. It also helps the panel to understand the opposite or what is not "good enough." Once this protocol standard is set it is incumbent on network designers to apportion enough bandwidth to meet the subjective quality needs of their constituents. They will also have to decide if and how to implement QoS norms for the network.

9. "I'm not sure how increased bandwidth would specifically affect the other four areas which is why I rated it at a two. I rated sound quality and lip-sync high (3 and 4) because I am a language teacher. A visual arts teacher might rate picture quality higher. A good quality teleconferencing system seems important if we are going to replace real-life teachers who can look over our students' shoulders with a teacher who may be miles away and is trying to make a connection with students."

The writer's prioritization and understanding of why others might prioritize differently goes to the heart of the discussions this survey is intended to inform. As to the relation of bandwidth to the other issues, those who pay the bills would want less bandwidth

requirement because increased bandwidth means increased cost. Those who wish to increase the number of classes (sessions) would prefer a protocol that uses less bandwidth because one could pass more traffic (signals) through the same network.

10. "In the world of H.323, we may use a variety of audio and video algorithms. The ranking section of the survey threw me for a bit of a loop. I understand latency, lipsynch, picture and sound quality. But I was unsure what the bandwidth was referring to. Sure, I'd love lots of bandwidth... but I also know that H.264 video produces just fine results at less than 256Kbps. I guess I want better compression schemes that use less bandwidth. The most important aspect, I've found, is the human element - is it easy to use, requiring little to no technical support, and is there a support mechanism for the entire network - a place that has the funds to provide all of the tech support needed (this will likely be a full time job for several folks with the number of endpoints the Network Nebraska will be deploying). Please feel free to bring me into discussions as I am currently supporting UNL's H.323 efforts."

The bandwidth issue is explained in the response to the preceding comment. The user interface and technical support issues have nothing to do with the specific protocol used, but are important network design and hardware/software selection issues.

11. "Sound quality and the ability to get the Video/audio to and from the remote student without latency is imperative!!! We need to have enough bandwidth to be able to transmit our classes to other UNMC campus sites, other colleges and universities and finally to students' homes. Being unable to note the descriptors with similar classifications of importance seems as an unfair or bias. We feel that sound, latency and transmission quality go hand in hand not one over the other. I feel your bias on the characteristics destroys any meaningful discussion of videoconferencing."

As stated above, all the prioritized factors are important. In some applications there can be no compromise in quality. Designers of such applications would take the attitude of the writer, and would spend the money required to sustain sufficient bandwidth to provide what the user would consider to be "high quality." Other system users don't have the same stringent need. This is why any protocol selected must be flexible enough to provide all levels of quality and the network provider can decide how to design the network to meet the user's quality needs.

12. "K-12 schools are accustomed to excellent video quality. MPEG-4 meets this requirement, but equipment is costly. I recommended MPEG-2 over 5 years ago because it is a digital standard. Costs for MPEG-2 encoders have come down, and seem to give the minimum compression and video quality required."

The writer does not specify which MPEG 4 being referenced. Part 2 is not widely adopted and has been essentially replaced by Part 10 (a.k.a. H.264). MPEG-2 is certainly a digital standard. All the protocols being examined are digital. The word CODEC means coder/decoder. This device takes an outbound analog video and audio signal and digitizes (encodes) it. Then it takes the inbound digital signal and turns it back

into analog video and audio (decodes). The video and audio protocols are the rules the device uses to digitize and un-digitize. As with MPEG-2, the cost of all CODEC equipment continues to come down. This is the nature of electronics in general.

13. "The larger the group using the conferencing and the longer the session is to take place shows the greater need for synchronization. Lower contacts as far as size of group or length of connection may require less synchronization."

Synchronization in this case refers to video and audio synchronization. When they are "in sync" the audio and video arrive at the destination at the same time. When they are not the audio may arrive either before or after the video. The number of users online might only affect synchronization by increasing the number of processors (chips) involved by increasing the amount of equipment used in the conference. The more processors the more likely for delay of one signal or both. If both are delayed we refer to that as latency. If one is delayed longer than the other then synchronization is adversely affected.

14. "I have to say that the above ranking of teleconferencing characteristics "in order of importance to you" does not allow for the fact that ALL of these things are of equal importance. If our network is built correctly, we need sufficient bandwidth to allow for not only the applications of today, but also for those, which will be coming tomorrow. At the K-12 level, we need picture quality and sound quality good enough to hold the attention of a typical five-year-old. Lip-sync and latency are so closely related, how do we choose between one needed for a French or Spanish language class and the other which must be as close to perfect as we can get it for Music classes? Sorry, but I would hate to see this ranking quoted anywhere in public, because it sends a message I do not believe is correct."

Again, it is agreed that all are important, but if there are potential limitations anywhere in the system then a balance must be struck by network designers.

15. "We're currently paying for large bandwidth. Any reduction in bandwidth and cost will benefit us."

Understood.

16. "Seems to work fine most of the time. Would like any new information to help me if there are new developments. I cannot submit the survey because of something about the lip-sync category?????"

The writer's survey did work and the panel received their input. The final result of the process is a published document and actions taken by the NITC. All will be published and available on the NITC website; http://www.nitc.state.ne.us. The writer is encouraged to stay abreast of the proceedings and contact any of the participants for more information.

7.0 Testing Procedure

7.1 Goal

a. The goal of this testing procedure is to obtain data based on the criteria established by the standards workgroup. The data obtained is intended to assist in forming a recommendation for adoption of a video and audio standard for the synchronous distance learning networks of the State of Nebraska. This data will be obtained by testing hardware from multiple venders. H.264 will be compared to the current standards of H.263 and MPEG-2. G.722 will be compared to all G.7xx protocols available on the CODECs obtained for the test. Each will be tested at specific bandwidths. The communication protocol will be IP. Since it is understood that MPEG-2 has high quality video but uses high bandwidth, we only compared technical issues of MPEG-2 and not quality. This means the bench testing procedures described below were conducted on MPEG-2, but not the subjective viewing. H.263 and H.264 were directly compared in the subjective viewing test.

7.2 Defined Qualities

a. As a part of the criteria developed by the standards committee, four quality levels were designated. These quality levels were decided on after consultation with members of the Education Council of the NITC. They include: minimum, lip readable, ASL readable, and full-motion. Minimum refers to video and audio that is comparable to the current NVCN and NebSat Network 3 quality. Since those networks have improved since the last test this means the quality bar has been raised. Lip readable means, for language classes, a student can see the shapes formed by the teacher's mouth as words are said. ASL readable means that information can be reasonably passed using sign language. Full-motion means whatever the viewer considers to be "good enough" for distance learning.

b. Since ultimately, educators will be using this system, we used educators to assist in determining when the appropriate quality is achieved. Members of the SSVWG were invited to help rate the video and audio as various rates and encoding schemes were used in the test.

7.3 Other Bandwidth Issues

a. Several other bandwidth-related issues are to be documented in the testing: flexibility and negotiation. Flexibility refers to the data rate range available (highest/lowest), and rate agility (what data rate settings are available?). Negotiation refers to how two systems of differing data rates talk to each other. Specifically, we are interested in knowing if the machines figure out what data rates to use automatically, if a human being needs to manually set them, or if some third device needs to do that negotiation.

7.4 Systems

a. We are specifically testing more than one vendor's products. This is to avoid having the results skewed by the hardware of a particular vendor. Specifically, for MPEG-2 we are testing Ahead Communications. For H.263/H.264/G.72x we are testing with BNI, Polycom, Sony, and Tandberg.

7.5 Latency

a. During the test procedures, latency will be documented. This refers to the amount of delay introduced by the encoding process. Generally speaking, the lower the bandwidth, the greater the processing required and the greater the latency. Latency test procedures are described below. A general drawing is provided in the *General Setup Drawings* section of this document.

7.6 Settings

a. When testing, use standard setups each time, every time. The specific settings are given below. The CIF setting in H.263/264 is FCIF. This is a result of the 2002 standard process. The procedure below will assist in determining what the outcome of that decision will be.

MPEG-2 Settings:	
Communications	Full Duplex
GOP structure	15
Frames	IPBB
Encoding	4:2:0

H.323 Settings:	
Video	H.263/H.264
Capture Resolution	FCIF
Audio	Set to G.722 at highest rate available Allow the CODEC to auto-select if it chooses to

7.7 Standard Video

In order to have exact comparison, the same videotape was used for all tests. It played from a DVD. Viewers watched segments 2 through 6.

1. 1:02 min Color bars with tone

2. 1:05 min Class segment of **Advance Manufacturing Process**. Recorded Live to Digital Beta tape.

3. 0:59 min Segment from **Interactive Spanish**. Recorded from Beta SP master.

4. 1:25 min Segment from **Sign Language Crash Course I.** Recorded from VHS tape.

5. 1:00 min Segment from **Piano Masters Class**. Recorded Live to Digital Beta tape.

6. 1:21 min Segment from **Reading Rainbow**. Recorded from master 1 inch analog tape.

7. 1:30 min Multiburst with silence.

8. 2:00 min Latency & Lipsync Test: repeating 1 frame white square with 1 frame tone with 5 sec black between.

7.8 General Test Procedure

MPEG-2

Follow this procedure using the Ahead set of CODECs.

1. Set up the equipment as depicted in the *General Setup Diagram* section of this document.

2. Measure latency per the *Latency Test Procedure* portion of this document.

H.263/H.264

Follow this procedure using each set of CODEC's.

1. Set up the equipment as depicted in the *General Setup Diagram* section of this document.

2. Using the DVD described in the *Standard Video* section of this document, establish a baseline for the four qualities described in the *Defined Qualities* section of this document by following the procedures in the *Establish a Baseline* section of this document.

7.9 Latency Test Procedure

1. Using standard ping software, ping the system from Workstation 1 to Workstation 2 as depicted in the *General Setup Diagram* section of this document. Since ping time represents the round trip from Workstation 1 to 2 and back, log ½ the ping time as circuit-only time.

2. Attach the oscilloscope as depicted in the *General Setup Diagram* section of this document.

3. Setup a dual-trace storage or digital oscilloscope in dual-trace mode.

4. Attach one of the video and audio outputs of the source DVD player to the respective CODEC 1 inputs. Connect the other audio output to the channel 1 input of a storage or digital oscilloscope. Playback the video after bars/tone/resolution. (about 1 minute into the DVD).

5. Connect the CODEC 2 audio and video outputs to a video/audio monitor, verifying that the audio 'blip' coincides with the white video flash.

6. On the oscilloscope set the trigger source to channel 1 and setup for edge triggering on a positive going pulse. Set the input gain of channel 1 and 2 to 2 volts per division. Set the time division to 100ms per division to begin with. Set the level to trigger on the "blips" audio, while looking for a steady audio waveform on channel 1.

7. Bridge the CODEC 2 audio output to the channel 2 input of the oscilloscope or use a secondary output.

8. Store a 'picture' of the display.

9. Measure the time between the leading edge of channel 1 and channel 2. Log the CODEC-to-CODEC time.

10. Subtract the circuit-only time from the CODEC-to-CODEC time and log it.

7.10 Establish a Baseline

In order to make comparisons, a baseline must first be established. Procedure:

1. Set up the equipment as depicted in the *General Setup Diagram* section of this document.

2. Follow the *Network Performance Test Procedure* in this document and log the results.

3. From the CODEC manual or software, determine what data rate settings are available for the test. Note them on the test sheet.

4. From the CODEC manual or software, determine how bandwidth must be negotiated between the two CODEC. Note the available options on the test sheet.

5. Set up the CODECs per the *Settings* section of this document. Set them both at their highest common data rate. Set lipsync adjustments at this data rate to insure sound and video match. Document system setup with a complete listing of all hardware used and draw how they are interconnected. Document all software settings. There is no such thing as too much information.

6. With the quality volunteers listed in the *Defined Qualities* section above, show the video described in the *Standard Video* section of this document at set data rate steps to be determined once the hardware is available and the common data rates are known. Have the volunteers rate each version of the video using the document in the *Test Sheet* section of this document. The viewers should not be told which encode standard or data rate they are viewing.

7.11 Network Performance Test Procedure

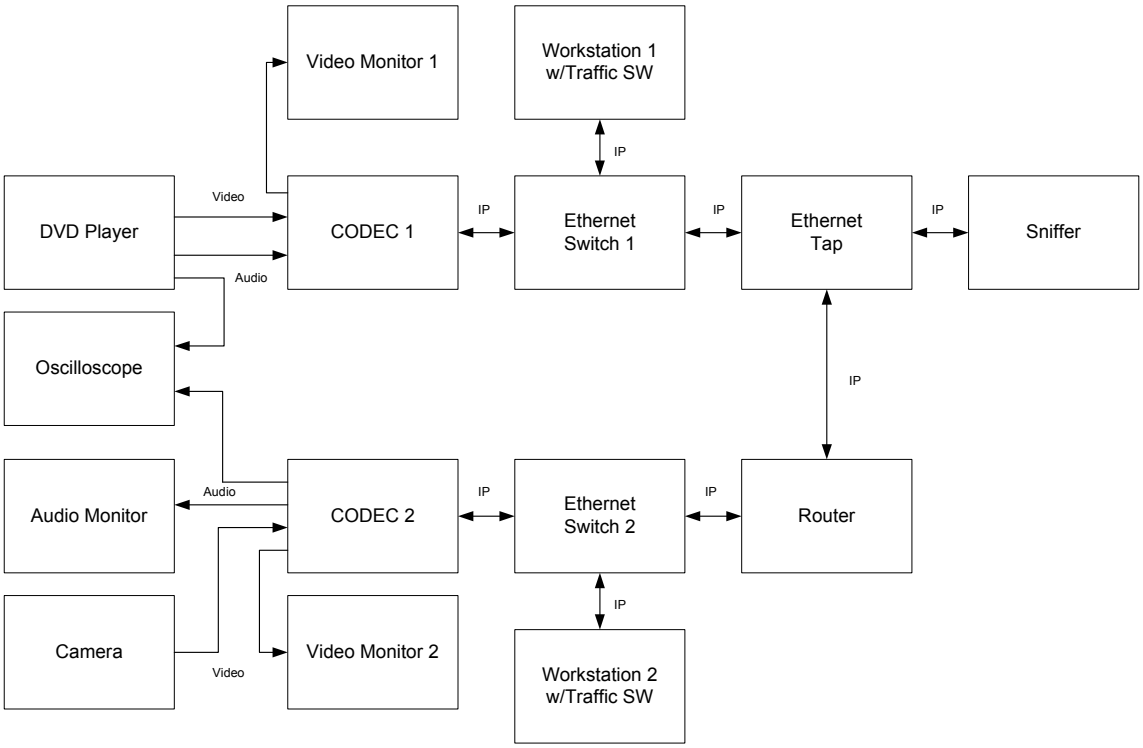
Establish a baseline of the network system once the system is set up as depicted in the *General Setup Diagram* section of this document. Test the network with the CODECs unconnected from the system. Then test it again with the CODECs connected.

Using file transfer software in the two system workstations, perform file transfers of a known size. Using network-monitoring software in the two system workstations, determine bandwidth utilization.

7.12 General Setup Diagram

These drawings are meant to be general in nature. When testing, specific drawings must be produced to show the systems as built. When making comparisons, it is essential that all systems be tested identically. The same hardware must be used for ALL tests conducted. The only equipment to be changed for each battery of data rate tests is the two CODECs in question.

STANDARD TEST SETUP



7.13 Test Sheets

To be filled out by the volunteers for each test repetition:

A1:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
A2:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
A3:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
A4:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
B1:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
B2:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
B3:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
B4:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
C1:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
C2:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
C3:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
C4:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
D1:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
D2:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
D3:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐
D4:	Full-Motion:	☐	ASL:	☐	Language:	☐	Minimum:	☐	Unacceptable: ☐
Audio	Very Good:	☐	Good:	☐	Acceptable:	☐	Poor	☐	Unacceptable: ☐

8.0 Test Results

8.1 Schedule

a. The test procedure described earlier in this document was followed and volunteers came to ESU-10 on May 26, 2004. Attendees were mostly members of the ESU NOC group and the SSVWG. The rotation of the CODEC's is also listed below.

A1: CODEC 1, H.263, G.722, 768Kbps
A2: CODEC 1, H.263, G.722, 384Kbps
A3: CODEC 1, H.263, G.722, 128Kbps
A4: CODEC 2, H.264, G.722, 1.92Mbps
B1: CODEC 2, H.264, G.722, 768Kbps
B2: CODEC 2, H.264, G.722, 384Kbps
B3: CODEC 2, H.264, G.728, 128Kbps
B4: CODEC 3, H.263, G.722, 1.92Mbps
C1: CODEC 3, H.263, G.722, 768Kbps
C2: CODEC 3, H.264, G.722, 384Kbps
C3: CODEC 3, H.264, G.722.1, 128Kbps
C4: CODEC 4, H.263, G.722, 768Kbps
D1: CODEC 4, H.263, G.722, 1.92Mbps
D2: CODEC 4, H.264, G.722, 384Kbps
D3: CODEC 4, H.264, G.722.1, 128Kbps

8.2 Volunteer Viewers

a. A total of 18 individuals volunteered to view the video and pass through the testing procedure. None of the participants were asked to identify themselves on the response form. Participants included members of the ESU NOC group and the SSVWG. Some viewers did not stay for the entire session. Their ratings were included for the portions of the test they participated in.

8.3 Specific Viewer Ratings

a. The following series of graphs depicts the results of the respondents' forms.

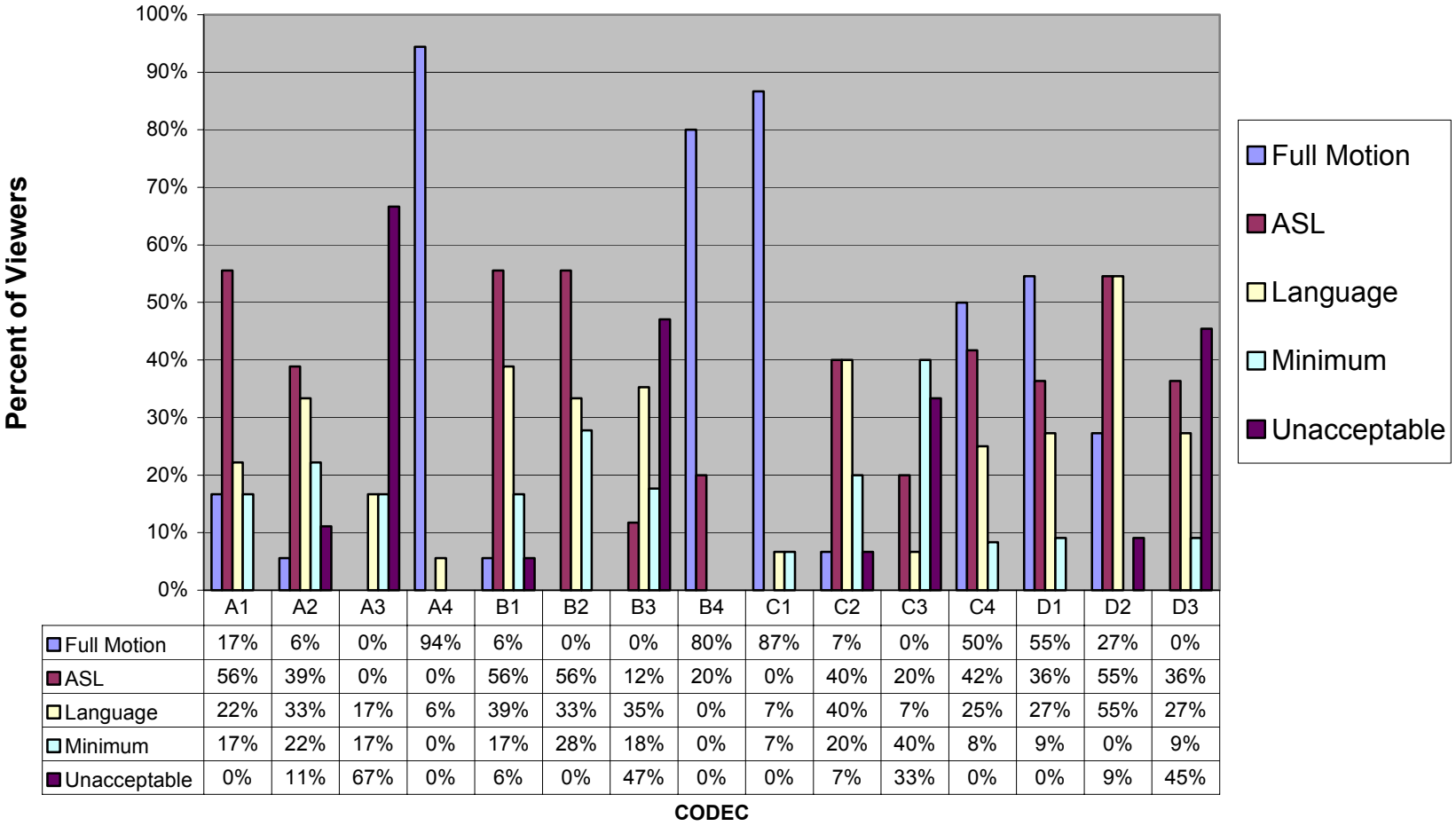
b. The H.263/H.264 picture is a bit more complicated. As a result of the 2002 testing FCIF was selected for H.263. G.722 audio was selected then as well it gives the greatest frequency response range at a low data rate. There is a disparity in the performance of one specific CODEC model used. CODEC 1 was not capable of H.264, or 1.92Mbps.

c. Some viewers marked more than one video quality. If a viewer marked the *full motion* box, it was assumed all other qualities were met and the vote was only counted in the full motion category. If full motion was not marked but either *ASL* or *Language* was marked, the vote was counted there. If full motion was not marked and both ASL and Language

were marked, a vote was given to both of these categories since they are not necessarily mutually exclusive, nor does a vote in one category automatically mean a the video is of good enough quality for the other category. A vote for the *Minimum* category was only counted if no higher quality video box was checked. The same is true for the *Unacceptable* category. If some specific area was not voted on, no vote was added for that area. However, all votes actually marked on the page were counted. Viewers received credit where they marked, and no credit where they didn't mark.

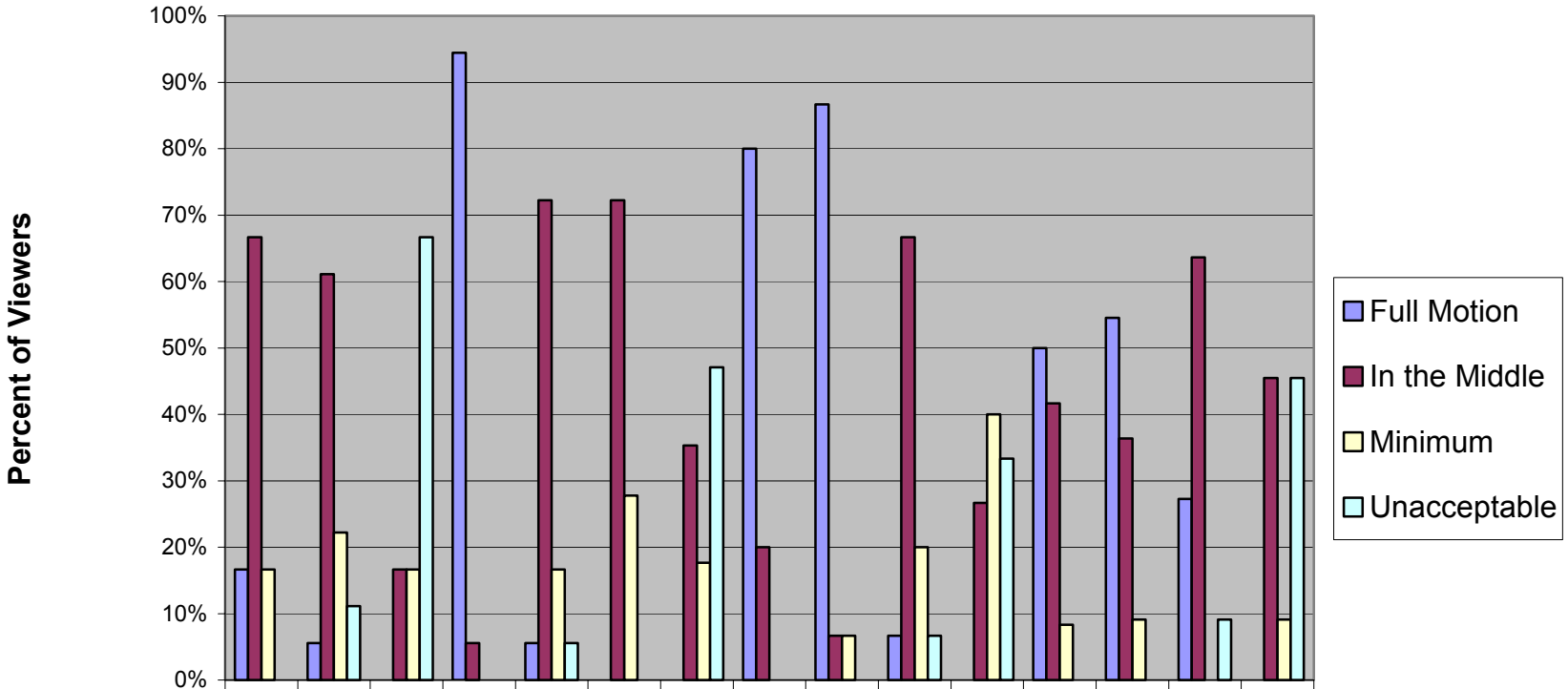
d. No "control" video was injected in the test as in 2002. To check bias this year a pattern was established with the first 3 CODECs. On the last CODEC the highest speed was moved in its position to see if assumptions were made.

Video Quality Rating



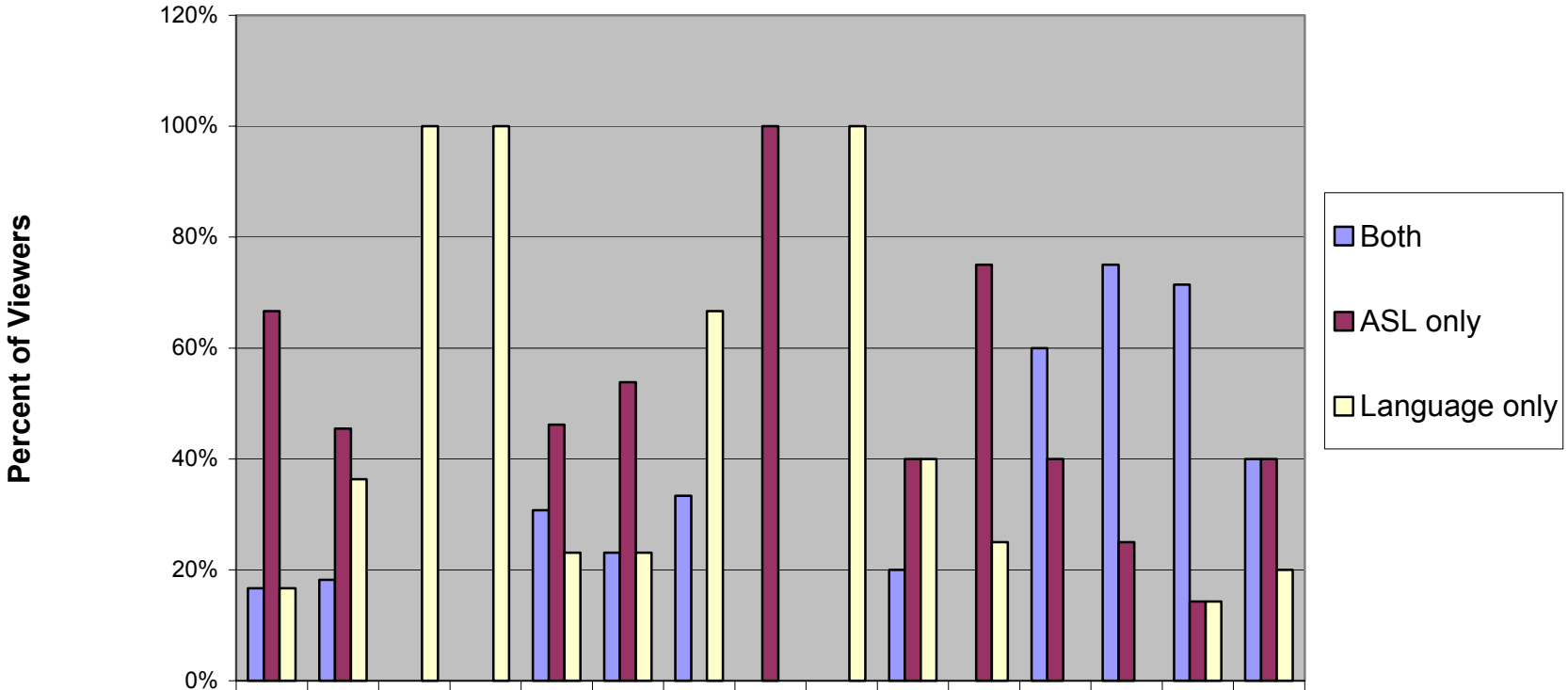
	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3
Full Motion	17%	6%	0%	94%	6%	0%	0%	80%	87%	7%	0%	50%	55%	27%	0%
ASL	56%	39%	0%	0%	56%	56%	12%	20%	0%	40%	20%	42%	36%	55%	36%
Language	22%	33%	17%	6%	39%	33%	35%	0%	7%	40%	7%	25%	27%	55%	27%
Minimum	17%	22%	17%	0%	17%	28%	18%	0%	7%	20%	40%	8%	9%	0%	9%
Unacceptable	0%	11%	67%	0%	6%	0%	47%	0%	0%	7%	33%	0%	0%	9%	45%

Video Quality



	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3
Full Motion	17%	6%	0%	94%	6%	0%	0%	80%	87%	7%	0%	50%	55%	27%	0%
In the Middle	67%	61%	17%	6%	72%	72%	35%	20%	7%	67%	27%	42%	36%	64%	45%
Minimum	17%	22%	17%	0%	17%	28%	18%	0%	7%	20%	40%	8%	9%	0%	9%
Unacceptable	0%	11%	67%	0%	6%	0%	47%	0%	0%	7%	33%	0%	0%	9%	45%

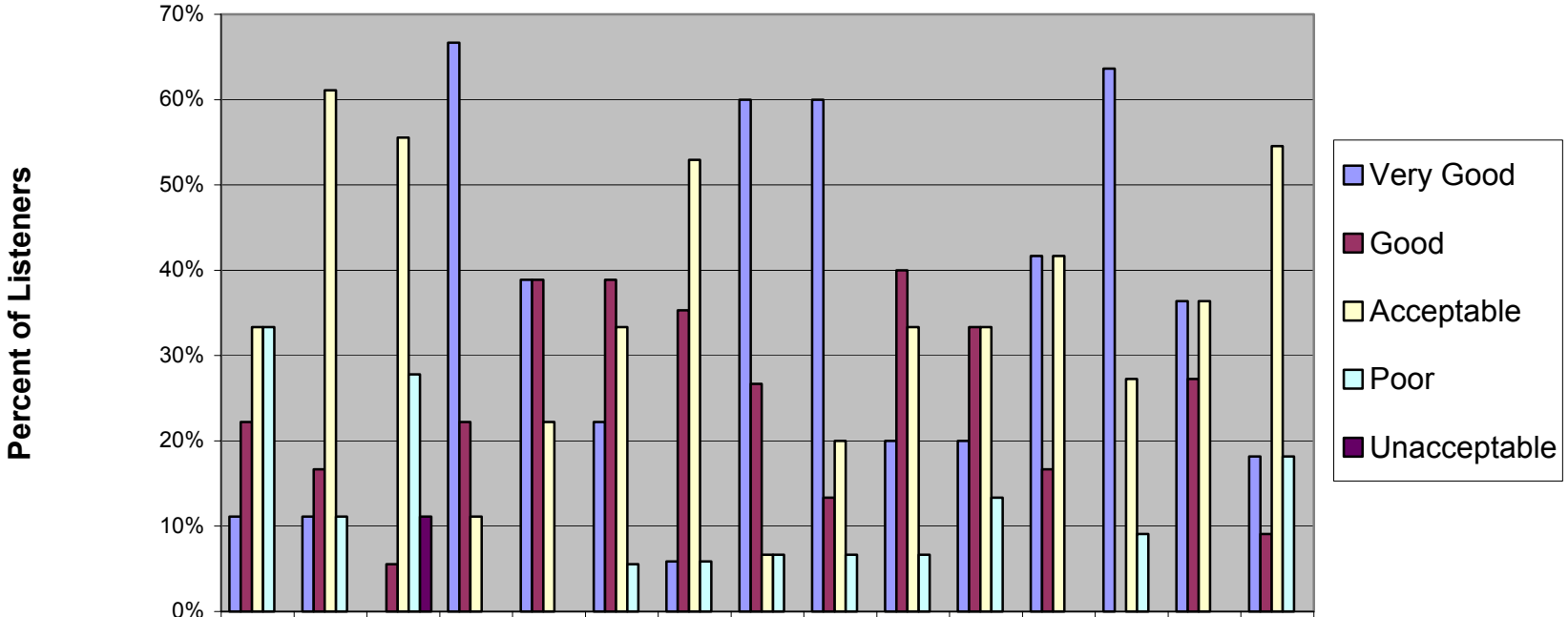
ASL / Language
(In the middle)



	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3
Both	17%	18%	0%	0%	31%	23%	33%	0%	0%	20%	0%	60%	75%	71%	40%
ASL only	67%	45%	0%	0%	46%	54%	0%	100%	0%	40%	75%	40%	25%	14%	40%
Language only	17%	36%	100%	100%	23%	23%	67%	0%	100%	40%	25%	0%	0%	14%	20%

CODEC

Audio Quality



	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3
Very Good	11%	11%	0%	67%	39%	22%	6%	60%	60%	20%	20%	42%	64%	36%	18%
Good	22%	17%	6%	22%	39%	39%	35%	27%	13%	40%	33%	17%	0%	27%	9%
Acceptable	33%	61%	56%	11%	22%	33%	53%	7%	20%	33%	33%	42%	27%	36%	55%
Poor	33%	11%	28%	0%	0%	6%	6%	7%	7%	7%	13%	0%	9%	0%	18%
Unacceptable	0%	0%	11%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

CODEC

8.4 Latency and Lip Sync

Per the criteria and test procedure, a detailed look was made at how much time was added to the signal transmission by processing (latency) within the CODEC. Synchronization between video and audio (lip sync) was also measured. CODEC 1,2, etc. are not identical to the same findings in the viewer subjective test depicted above. The findings follow:

CODEC	Data Rate	Latency	Lip Sync
Video Recorder	N/A	0 ms	0 ms
A MPEG-2	5.300 mbps	245 ms	55.1 ms
A MPEG-2	3.500 mbps	246 ms	50.7 ms
A MPEG-2	2.000 mbps	249 ms	50.5 ms
A MPEG-2	1.000 mbps	250 ms	82.5 ms
B H.263/G.722	1.92 Mb/s	207 ms	-9.3 ms
B H.263/G.722	1.54 Mb/s	207 ms	-3.5 ms
B H.263/G.722	768 Kb/s	240 ms	10.1 ms
B H.264/G.722	384 Kb/s	273 ms	-9.9 ms
B H.264/G.722.1	128 Kb/s	372 ms	-158.5 ms
C H.264/G.722	1.92 Mb/s	194 ms	-204.5 ms
C H.264/G.722	1.024 Mb/s	228 ms	-126.5 ms
C H.264/G.722	768 Kb/s	193 ms	-138.5 ms
C H.264/G.722	384 Kb/s	227 ms	-203.5 ms
C H.264/G.728	128 Kb/s	159 ms	135.5 ms

8.5 Audio Performance

A series of audio tones were sent through each CODEC pair. Each pair was left with any available audio settings at default. The results are as follows:

CODEC	TONE FREQUENCY (KHz)	TONE LEVEL IN (dB)	TONE LEVEL OUT (dB)
A G.722	.063	-10	-11.5
384Kbps	.125	-10	-11.4
	.250	-10	-11.5
	.400	-10	-11.3
	1	-10	-11.4
	2	-10	-11.3
	4	-10	-11.3
	8	-10	-14.5
	10	-10	-40
	12.5	-10	-51
	16	-10	-72

CODEC	TONE FREQUENCY (KHz)	TONE LEVEL IN (dB)	TONE LEVEL OUT (dB)
B G.722	.063	-10	-11.5
384Kbps	.125	-10	-11.5
	.250	-10	-12
	.400	-10	-11.4
	1	-10	-10.5
	2	-10	-11
	4	-10	-12.4
	8	-10	-15
	10	-10	-40
	12.5	-10	-73
	16	-10	-72

CODEC	TONE FREQUENCY (KHz)	TONE LEVEL IN (dB)	TONE LEVEL OUT (dB)
C G.722	.063	-10	-34.5
384Kbps	.125	-10	-33
	.250	-10	-9.5
	.400	-10	-9.4
	1	-10	-9.4
	2	-10	-9.7
	4	-10	-14
	8	-10	-58
	10	-10	-58
	12.5	-10	-58.1
	16	-10	-58.3

CODEC	TONE FREQUENCY (KHz)	TONE LEVEL IN (dB)	TONE LEVEL OUT (dB)
D G.722.1	.063	-10	-27
128Kbps	.125	-10	-14
	.250	-10	-17.5
	.400	-10	-12
	1	-10	-12
	2	-10	-12
	4	-10	-17
	8	-10	-45
	10	-10	-43
	12.5	-10	-43
	16	-10	-38

CODEC	TONE FREQUENCY (KHz)	TONE LEVEL IN (dB)	TONE LEVEL OUT (dB)
D G.722.1	.063	-10	-39
128Kbps	.125	-10	-32
	.250	-10	-24
	.400	-10	-10
	1	-10	-10
	2	-10	-12.5
	4	-10	-12
	8	-10	-40
	10	-10	-58
	12.5	-10	-58
	16	-10	-58

8.6 The Network

The IP network was set up per the test procedure. The specifics of the hardware were:

CODECS
Ahead Communications MAC–100
BNI Power Play
Polycom VS-4000
Sony PCS-P1
Tandberg 6000

DVD Player
Sony DVD Player DVP-NS725P

Video Monitors
Panasonic High Definition Plasma Display TH-50PHD6
Panasonic Color Television CT-20G8G

Ethernet Switches
Netgear FS108

IP Router
Cisco 2514

Traffic Injectors
Dell Optiplex Workstations with UDP Traffic Loader using Port-FTP

Network Sniffer
Dell Optiplex Workstation with Suse Linux 9.1 Professional

IP Tap
Net Optics 10/100 Ethernet Tap

Audio Test Equipment
Agilent Oscilloscope 546224A
Audio Precision System Two

Network throughput results are as follows:

CODEC	Bandwidth as set in software (Mbps)	Measured network bandwith (Mbps)
A H.263	1.92	1.983
	.768	.796
	.384	.405
	.128	.1335
B H.263	1.92	.884
	.768	.742
	.384	**.396**
	.128	**.143**
C H.264	1.92	**1.060**
	.768	.814
	.384	**.409**
	.128	**.146**

9.0 Protocol Implementation

a. As part of the original planning process, the work group identified some questions to be considered when forming an implementation plan.

- How will new systems using the new standard be integrated into the current system as they come on line?
- How will existing systems be integrated with the new standard until older systems are replaced or upgraded?
- How will existing systems be upgraded and migrated to the new standard?
- What is the overall financial impact and what are ways to minimize it?

b. The largest impact of this video/audio standards migration will be to K-12. It is the recommendation of this Work Group that the entire state upgrade as a group over a finite period of time. If this is not possible, then currently aggregated groups should upgrade one at a time or in clusters. If a statewide upgrade is possible, each contract would have to be renegotiated. Discussions of contract language options are underway within the SSVWG. If contract changes are not possible with some providers, then an existing aggregation group should upgrade when the current contract expires. Since LB833 allowed additional sites to be installed while adopting the existing standard of the aggregated group they joined, there is no need to consider individual site upgrades this time.

c. When the current consortia were originally built, each vendor had to install the CODEC and switching infrastructure to support the specific technology adopted at that time for that contract. The vendor charged an up front “engineering” fee, which helped to absorb some of the cost of that equipment and reduce the monthly amortized fee. Some portion of the on going monthly connectivity fee helped pay for the rest of that capital cost as well as the maintenance and other operational costs over the life of the contract. The Work Group recommends that when each aggregated group upgrades and takes on a new contract, the vendor can then follow this same methodology to cover its fiscal obligations.

d. An issue related to this concept are those sites who came on late in the contract period through LB822 who may not have paid their full share of the local CODEC and associated switch port costs. Also, two new consortium contracts have been written since the last standard was published adopting MPEG-2 technology and are just in the early stages of their contracts.

e. This plan eliminates the need for gateways in the system. A single gateway would be needed only when passing between systems with differing protocols. Each consortium could assess its need to share traffic with others until they have each migrated to the new standard. In the mean time some gateways already exist in the state and they would still be available as required until migration supersedes the need to gateway.

f. All entities requesting new funds for projects relating to synchronous distance learning must adopt these standards except as specified in this section. Existing systems asking for continuing State funds for installed synchronous distance learning networks must migrate to this standard at the time of their current contract renewal.

10.0 Public Comment and Responses

a. The proposed standards process as published by the NITC allows for a 30-day public comment period. After the comment period, this section will be amended to attempt to reply to all the public comments received.

11.0 Glossary

1 Inch Analog Tape
A format of analog videotape used in many television broadcast facilities.

4:2:0
Numbers that correspond to sampling rates of the luminance and color-difference signals in video.

Algorithm
A logical expression that solves a complex problem to a mathematical formula or a program's instructions. Used as keys to logarithmic manipulations of data for encryption.

Analog
Any system that represents a wave in one medium with a wave in a different medium. (light waves turned to video, audio waves turned to electrical waves, etc.)

ASL
American Sign Language

ATM
Asynchronous Transfer Mode – A high speed cell switching network technology that handles data and real-time voice and video. ATM is defined in the Broadband ISDN (BISDN) standard and provides bandwidth on demand by charging customers for the amount of data they send.

Backward Compatibility
The ability to work with earlier versions.

Bandwidth
In digital applications, this term refers to the speed at which data is transmitted. It is usually expressed in terms of bits per second. It is often used interchangeably with the term data rate.

Beta SP
A format of analog videotape used in many television broadcast facilities.

Bridge
In this document this term refers to an audio bridge. This means that more than one audio device is connected simultaneously to a single audio port (input or output) of a single device.

Broadcast

This describes signals sent from one location to an unlimited or large number of locations.

Carrier

A wave that has defined characteristics on which intelligence is passed.

CIF

Common Image Format – This parameter defines the size of the picture raster by the number of pixels.

Sub-QCIF (below quarter CIF)	128 x 96
QCIF	176 x 144
CIF (a.k.a. FCIF – Full CIF)	352 x 288
4CIF (4 x CIF)	702 x 576
16CIF (16 x CIF)	1408 x 1152

Closed Network

In the sense used in this document, this term refers to a network that has no traffic passing on it beyond the distance learning video, audio, and data.

CODEC

Stands for Encoder / Decoder or Coder / Decoder. This device changes outbound analog video and audio into data and inbound data into analog video and audio. It is a device that attaches directly to the video and audio source (the classroom).

Color Bars

A set of defined and calibrated colors that are generated in a video system for test purposes.

Data Rate

This is the amount of digital information that a system can process and/or transmit. It is usually expressed in terms of bits per second. It is often used interchangeably with the term bandwidth.

dB

Decibels – It is a comparative logarithmic measure of signal strength. A measure must be compared to some reference.

Decode

The process of changing a digital stream into an analog wave.

DigiBeta

A format of digital videotape used in many television broadcast facilities.

Digital

Referring to communications procedures, techniques, and equipment by which information is encoded as either a binary one or zero.

DOC

The Division of Communications with the Nebraska State Department of Administrative Services.

Dual Trace

On an oscilloscope, a mode that displays two separate wave inputs simultaneously.

Edge Triggering

On an oscilloscope, a mode that causes the device to mark and measure at the leading edge of a rising signal.

Encode

The process of changing an analog wave into a digital stream.

ESU

Educational Service Unit

ESU NOC

Educational Service Unit Network Operations Committee. A group of network technicians in the state who are responsible for most of the K-12 data networks in Nebraska.

Fiber Optic

A system that transmits information on a wave of light along glass or plastic.

Frame

A single still image within a video stream.

Frequency

A measure of how often a wave passes a single point in a given amount of time. Usually expressed in Hertz (Hz).

Frequency Response

In audio devices, this term refers to the span from the highest audio frequency to the lowest frequency the device is capable of processing.

Full Duplex

A two-way circuit that allows for continuous transmission in both directions simultaneously.

G.7xx

A family of audio protocols with varying specifications as developed by the ITU. Examples include:

Standard	Req'd Bandwidth	Frequency Response
ITU-TG.711	56/64Kbps	50Hz – 3.4KHz
ITU-TG.722	48/56/64Kbps	50Hz – 7KHz
ITU-TG.728	16Kbps	50Hz – 3.4KHz

Gain

Signal increase or loss across a device, network, wire, etc. Gain can be measured through any number of links in a network chain and usually expressed in dB.

Gateway

As used in this document, this term refers to a device or system that allows a system using one protocol standard to communicate with a system using a different protocol standard.

GOP

Group of Pictures – In the MPEG-2 standard, a given GOP determines how the algorithms will structure the I, P and B frames in the encoding process.

H.2xx

A family of video protocols with varying specifications as developed by the ITU. Examples include H.261 and H.263. They are differentiated by the specific algorithms used to encode and decode video.

H.3xx

A family of communications protocols with varying specifications as developed by the ITU. Each of these protocols have multiple options of video, audio and data protocols defined within them. Examples include:

H.320 for transportation on an ISDN network
H.321 for transportation on an ATM network
H.323 for transportation on an IP network

Hub

As used in this document, a device, system or location that acts as a central connection point for multiple location.

Hz

Hertz – Named after the scientist that defined the concept. It is a measurement of wave frequency expressed in cycles per second.

IP

Internet Protocol

IPBB

Defined types of video frames.

I – Intraframes – Defines video in terms of the motion within the immediate video at hand.

P – Forward Prediction frames – Defines video in terms of the predicted motion in the video yet to come based on the motion in the immediate video at hand.

B – Buffer frames or Backward Prediction frames – Defines video in terms of the motion in the video already passed compared with the current interpolated video to predict the motion in the video yet to come.

ISDN

Integrated Services Digital Network – An international telecommunications standard for transmission over digital lines running 64Kbps. ISDN uses 64Kbps circuit switched channels, called B channels, or "bearer" channels, and a separate D channel, or "delta" channel, for control signals.

ITU

The International Telecommunications Union – A telecommunications policy and standards defining body with representatives of participating countries including the United States.

JPEG

The Joint Picture Experts Group – An association that has defined standards for digitizing of still pictures. The JPEG video standard is an extension of the still picture standard in that it simply defines a succession of JPEG encoded still pictures to create video. This standard is known as Motion JPEG.

Kbps

Kilobits Per Second – Thousands of bits per second.

KHz

Kilohertz – Thousands of cycles per second.

Latency

The amount of time added to pass a signal through a device or system as a result of the processing and transport that occurs within the device or system.

LB833

Legislative Bill 833 – A law enacted by the Nebraska State Legislature that funds distance learning classrooms around the state.

Mbps

Megabits Per Second – Millions of bits per second.

MCU

Multi-Conferencing Unit – A device that connects two or more of its ports into a teleconference. Whatever remote location is connected to each port can then participate in a multi-site teleconference.

Meta Data

Information (data) that describes or enhances information within the main data stream. Closed captioning with a digital video stream is an example of Meta Data. The properties information in a computer file is another example.

MHz

Megahertz – Millions of cycles per second.

MPEG

Motion Picture Experts Group – A body that defines protocols for digitally encoding video and audio. Some of the protocols defined by this group include:

MPEG-1 – Designed to compress the data required to pass analog video and audio.
MPEG-2 – An improvement in efficiency over the algorithms of MPEG-1
MPEG 4 – Designed to incorporate voice, video and data as objects that can be transported interchangeably.
MPEG 7 – A meta data system used as a search engine for other MPEG files.

ms

Milliseconds – Thousandths of a second.

Multiburst

A test signal consisting of a white flag and six modulated frequencies superimposed upon standard synchronizing and blanking signals. The modulated frequencies are: 0.5 Mhz, 1.5 Mhz, 2.0 Mhz, 3.0 Mhz, 3.5 Mhz and 4.1 Mhz.

Neb*Sat

The Nebraska Satellite system – A general term used to describe all the services delivered by the Nebraska Educational Telecommunications Commission (NETC).

NET

Nebraska Educational Telecommunications – A term that describes the staff organization of the NETC.

NETCOM

The Nebraska Telecommunications Network – A proposed system in which all taxing entities in the state could purchase their data connectivity through a single prime contractor.

Network 3

The low bandwidth, satellite delivered, teleconference network operated by NET.

NITC

The Nebraska Information Technology Commission – The entity in the state tasked with review of, and strategic direction for, information technology for the Legislature and Governor.

NTSC

National Television Standards Committee – A group who defined the analog standards for video and audio as well as over-the-air broadcast. The standard itself is also referred to as NTSC.

NVCN

The Nebraska Video Conference Network – A network of the DOC and operated by NET. It is a low bandwidth, terrestrially delivered, teleconference network.

Open Network

For the purposes of this document, this term refers to a network that allows many types of digital traffic to pass on the same system without any quality of service controls for video and audio.

Oscilloscope

A device that measures and displays the characteristics of an analog waveform.

PC Card

A printed circuit board that can be "plugged" into the mother board in a PC computer.

Pod

A term often used to refer to a consortium of K-12 and higher education entities that share classes over some video-based technology system.

Point-to-point

A network with only 2 endpoints.

Port

An input and/or output connection on an electronic device.

Protected Network

For the purposes of this document, this term refers to a network that allows many types of digital traffic to pass on the same system but uses quality of service controls for video and audio.

Protocol

Rules covering the transmission of data.

Raster

The visible part of a display screen. It is usually defined in terms of how many pixels it is high by how many across the screen.

Signal Level

The "strength" of a given waveform. It is usually measured in dB.

Site

For purposes of this document, a site is an endpoint in a network (such as a classroom).

SSVWG

Statewide Synchronous Video Work Group – a work group of the NITC Technical Panel.

STEP

Sandhills Technology Education Project – The name of one of the K-12 consortia in Nebraska.

Switch

A device used to direct packets in a switched network.

Teleconference

A meeting held at two or more locations linked by means of technology.

Throughput

The volume of data that are passing or can pass over a given network. It is usually expressed in bits per second.

Tone

Steady audio at a given frequency.

Transcode

For purposes of this document, this term means to change a digital stream from one protocol to another.

Trigger

To cause an oscilloscope to measure and mark a specific wave point.

TINA

Telecommunications Infrastructure Needs Assessment – A study commissioned by the DOC with Federal Engineering of Virginia to determine the telecommunications capacity used and needed by taxing entities in the State of Nebraska for purposes of formulating NETCOM.

UNK

The University of Nebraska at Kearney

UNL

The University of Nebraska at Lincoln

UNO

The University of Nebraska at Omaha.

VHS

A consumer grade videotape machine.

VPN

Virtual Private Network – A system that passes many kinds of data, but allows for bandwidth to be reserved for specific purposes between specific locations. Other data on the same system but not in the VPN bandwidth competes with all other data for the remaining available bandwidth outside the VPN. VPN systems generally employ IP traffic schemes.

Wavelet

A video and audio encoding protocol currently in development stage.

White Noise

Constantly present random video and audio. In video is often referred to as snow. In audio it may be known as static or hiss.