A VIDEO AND AUDIO STANDARD FOR THE DISTANCE LEARNING NETWORKS OF THE STATE OF NEBRASKA

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

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1.0 Authority

The Nebraska Information Technology Commission is empowered to *"...adopt minimum technical standards, guidelines, and architecture upon recommendation by the technical panel…"* LAW 86-1506 (6). In order to accomplish this, the Technical Panel is empowered to, *"Establish ad hoc technical advisory groups to study and make recommendations on specific topics…"* LAW 86-1506 (7).

This report is to document the recommendations of the Technical Standards Workgroup as authorized by the Technical Panel of the Nebraska Information Technology Commission. This document is to be used by the Education Council 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

As authorized above, the Technical Panel of the NITC commissioned a standards workgroup to study and make recommendations on synchronous distance learning video and audio standards. The report in hand is a result of that process.

The group met monthly for more than a year. Based on input from the Education Council of the NITC, a list of criteria was developed. The group identified video and audio protocols to be considered. Those that obviously would not in some way be an improvement over what is currently used in the state were eliminated. Next, a study was conducted on the remaining candidates based on the criteria. This process narrowed the field to two protocols: MPEG 2 and H.263. Some confusion has occurred on the part of many because the group at first identified H.263 as H.323. H.323 is a blanket protocol that encompasses several optional video and audio standards to be transported in an IP environment. Later it was decided to only specify the video and audio standard, as the charter directs, and to leave the network environment for the individual systems to decide. In this document, the standard will be referred to as H.263.

A test procedure was developed by the committee with the intent to allow system users to view more than one vendor hardware/software solution to be scrutinized in an apples-to-apples scenario. By using two vendors for each standard, the findings would not be skewed by the quality of a single vendor. The specific of the test is included below. By keeping the network constant a variable could be eliminated so that a true look at the protocol could result and not a test of an uncontrolled network.

This report is the result of all of these efforts. Upon review of this report, it is incumbent on both the Education Council and Technical Panel to recommend or to not recommend the conclusions. They may also make whatever remarks they choose to. Since this document is ultimately the work 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 actions to take.

3.0 Recommendation

It is the recommendation of the standards work group by unanimous vote that Nebraska adopt a dual standard. For higher data rate applications intending to use full-motion video MPEG 2 should be adopted. For those applications that do not have a need for full motion, H.263 video with G.722 audio should be adopted.

It was the intent of this group to designate a single standard. It is still the belief of this body that a single standard should be able to suffice. At issue is hardware availability.

MPEG 2 is specifically intended for applications that require high quality video. It minimizes the bandwidth required to achieve that goal. Therefore, its quality drops off rapidly as bandwidth drops below 2Mbps, especially at speeds below 1Mbps. Because of this, manufacturers assume that there is limited demand for low data rate MPEG 2 outside of desktop-to-desktop applications. Since educators have expressed needs beyond the desktop-to-desktop application, MPEG 2 could not be made to fit most of the lower bandwidth needs of the educational community.

In the case of H.263/G.722, most users of this standard do so in a low data rate teleconference application. For this reason, manufacturers have concentrated their efforts in that arena. H.263 CODEC's of high enough data rate to achieve full motion are difficult if not impossible to come by. The highest rate available in the two CODEC's tested was 1.9Mbps (E-1 rate), which is a European data rate not commonly supported in the U.S. This standard does, however, offer a very good solution in bandwidth savings and ubiquity of all educational applications that do not require full motion.

In this scenario, NET would need to continue its role as a gateway. Sites that now connect to both Neb*Sat Network 3 and/or NVCN that also have capacity into a pod would likewise act as a gateway. There is limited capacity on both NVCN and Network 3. This will become less of an issue with time as connectivity is increased around the state through efforts like the Nebraska Network initiative recently begun by the NITC and the NETCOM efforts of the DOC. Even if neither of these efforts offers an increase in connectivity, networks continue to grow on their own.

4.0 Chronology

4.1 From minutes of Tech Panel meeting September 12, 2000

FUTURE DIRECTION OF NEBRASKA TELECOMMUNICATIONS DISCUSSION - DENNIS LINSTER, CIO, WAYNE STATE COLLEGE

Mr. Linster brought several issues for discussion with the Technical Panel:

- The need for leadership in the state for a unified effort and vision for information technology and telecommunications.
- The need for adequate connectivity and equity in distance education, especially for out-state Nebraska communities and institutions. Currently, analogue systems make connectivity difficult and costly.

- The use of bandwidth and the need for more down links across the state for full motion video capabilities.
- The need of educational institution's for an immediate remedy and solutions to the connectivity issues. TINA study is a step in the right direction but it will take three years for implementation.

Mr. Linster's recommendation was to not fund any more analogue projects, as well as, not to appropriate further funding for Net3 due to bandwidth issues.
After discussion and feedback from the panel members, the following three actions were determined for follow-up:

- Network Architecture Work Group - refocus efforts on developing standards.
- TINA Study - Explore the opportunity for including current systems integration as part of the TINA directives.
- NITC - Mr. Winkle will address how to approach the fee base charge back issue with Lieutenant Governor Maurstad, Chair of the NITC.

Mr. Rolfes provided the group with information regarding the Southeast Learning Consortium's federally funded project to upgrade to a 100-megabit system. The Consortium will be addressing the Education Council at the September 15th meeting with their plans for the project. Mr. Winkle recommended that this project come before the Technical Panel for review and recommendations. Mr. Weir recommended that the Education Council submit written recommendations to the Technical Panel regarding educational resources and needs.
The panel thanked Mr. Linster for his input and discussion.

4.2 From minutes of the Education Council December 15, 2000

Mr. Beach reported that the Technical Panel has formed a Video Standards Work Group that he will be the chair. Mr. Beach is developing the charter and membership for the Work Group for approval by the Technical Panel at the January meeting. The first task of the Work Group would be a study of what standards already exist and are in place. Mr. Beach would like the Education Council's involvement.
At the last meeting, the Education Council also formed a Video Standards Work Group. Mr. Linster agreed to chair the group. Discussion followed on how the two groups can work together, changes in standards, migration and financial burden to institutions.

Dr. Hendrickson moved to have Dennis Linster serve as the Education Council representative on the Technical Panel's Video Standards Work Group. Mr. Bock seconded the motion. Discussion followed regarding K12 representation. Mr. Bock offered a friendly amendment to the original motion.

Dr. Hendrickson moved that the Education Council have both K12 and higher education representation on the Technical Panel's Video Standards Work Group. Mr. Bock seconded the motion. Roll call vote: Preusser-Yes, Tanderup-Yes, Wibbels-Yes, Ziegler-Yes, Bartels-Yes, Bock-Yes, Dietz-Yes, Hendrickson-Yes, Huck-Yes, and Johnson-Yes. Motion was carried.
Mr. Beach will take recommendations for members to serve on the Work Group.

4.3 From minutes of Technical Panel meeting January 9, 2001

Video Standards Work Group. Mr. Beach distributed a memorandum describing the membership, goals, implementation and proposed schedule time lines for the Work Group.
Mr. Schafer moved to approve the membership and goals of the Video Standards Work Group. Ms. Decker seconded the motion. Roll call vote: Beach-Yes, Decker-Yes, Horn-Yes, Schafer-Yes, and Weir-Yes. Motion was carried.

4.4 Document adopted by the Technical Panel on January 9, 2001

Memorandum – Technical Panel Action Requested

To: Technical Panel of the NITC

From: Michael F. Beach
Nebraska Educational Telecommunications

Subject: Network Standards Workgroup of the NITC Technical Panel

At the November 2000 meeting of the Technical Panel, I was asked to form and chair a new subcommittee of the Technical Panel. This workgroup was to determine the next video standard for the distance learning networks of the state of Nebraska. This document is the proposed basis for that workgroup. I am asking that the Technical Panel ratify the workgroup as outlined below.

Membership of Workgroup

The following individuals are recommended as workgroup members. Each has been contacted and has agreed to serve in this group if approved by the Technical Panel.

Michael Beach (Chair)
Assistant General Manager - Director of Engineering
Nebraska Educational Telecommunications
1800 N. 33rd St., Lincoln, NE 68503
Vox (402)472-9333 x348 Fax (402)471-8089
Email mbeach@unl.edu

Don Ferneding
Director
K-Nection
PO Box 6233, Omaha, NE 68106
Email dferneding@aol.com
Cell 402-657-0688

John Fiene
Assistant Vice Chancellor for Technology
University of Nebraska – Omaha
6001 Dodge St., Omaha, NE 68182
Vox (402)554-3670 Fax (402)554-3475
Email jfiene@mail.unomaha.edu

John Horvath
Director
Tri-Valley Distance Education Consortium
ESU-10 PO Box 850, Kearney, NE 68848
Vox (308)865-5664 x281 Fax (308)233-9066
Email jhorvath@esu10.org

Bob Huber
Assistant Director of Engineering for
Network Operations & Infrastructure Planning
Nebraska Educational Telecommunications
1800 N. 33rd St., Lincoln, NE 68503
Vox (402)472-9333 x205 Fax (402)471-8089
Email bhuber2@unl.edu

Gerry Hurley
Network Planner
Nebraska DAS, Division of Communications
Executive Building, 521 S. 14th St., Suite 300
Lincoln, NE 68508-2707
Vox (402)471-4960 Fax (402)471-3339
Email ghurley@doc.state.ne.us

Dennis Linster
Chief Information Officer
Wayne State College
1111 Main, Wayne, NE 68787
Vox (402)375-7286 Fax (402)375-7204
Email dlinster@wscgate.wsc.edu

Goals
The initial goal of the Standards Workgroup is to recommend a statewide standard for video / audio on state distance learning networks. The intent is to achieve interoperability of current systems, and to establish a standard for all constituents who will use the state distance learning networks in the future.

The second goal is to develop an implementation and migration strategy to allow for smooth transition of existing networks to the new standard.

Implementation
The workgroup will establish the specific process for accomplishing the goals. The process should include the following steps:

- Establish criteria on which to judge the possible competing standards.
- List all possible standards to be considered.
- Initially eliminate any system which will not improve efficiencies or meet current and projected needs.
- Conduct in-depth research and setup demonstrations and comparisons of remaining options.
- Draw conclusions based on criteria.
- Create a detailed report and give appropriate demonstrations to the Technical Panel and Education Council.
- Create a migration / implementation plan to include the following:
  How to integrate new systems using the new standard into the current system as they come on line.
  How to integrate existing systems into the new standard until replaced or upgraded.
  How to migrate when the existing system is upgraded to the new standard.
  Identify the financial impact and ways to minimize it.

Proposed Schedule

Due Date	Deliverable
Jan 2001	Present goals & participants to Tech Panel for approval.
Feb 2001	Engineering and economic criteria established and standards to be considered established.
Mar 2001	Less efficient standards eliminated and short list for detailed study determined.
Apr 2001	Individual spreadsheets on each standard and its status relating to established criteria. Select finalists.
May 2001	Demonstrations of finalists.
Jun 2001	Present findings to Technical Panel for approval. Give demonstrations.
Jul 2001	Create migration / implementation plan and present to Technical Panel for approval.

It is the intent of this workgroup to also keep the Education Council of the NITC informed on its progress.

4.5 Representation

Michael Beach represented the Technical Panel and was designated as work group chair by the Technical Panel. Bob Huber of NET and Gerry Hurley of DOC represented state agencies and were recommended by the chair. John Fiene and Dennis Linster were recommended by the Education Council and represented the University and State / Community colleges. Don Ferneding and John Horvath were recommended by the Education Council and represented the consortia using cable vendors and telephone vendors respectively.

4.6 Change in workgroup membership

John Horvath retired from his K-12 position in June 2001. From the minutes of the Education Council July 20, 2001.

John Horvath, Director of the Tri-Valley Distance Learning Consortium, retired from his position at ESU 10 and has also resigned from his duties with the NITC Technical Panel's Video Standards Work Group. A replacement must be found for the Work Group to finish the standards study and help with the development of the migration path.
The K-12 sector nominated John Stritt, the new Director for the Tri-Valley Distance Learning Consortium to replace John Horvath on the Video Standards Work Group.
Dr. Hendrickson moved to approve the K-12 sector nomination of John Stritt to replace John Horvath on the Video Standards Work Group. Dr. Berndt seconded the motion. Roll call vote: Koehler-Yes, LeDuc-Yes, King-Yes, Cunningham-Yes, Wibbels-Yes, Berndt-Yes, Dietz-Yes, Bose-Yes, Hendrickson-Yes, and Johnson-Yes. Motion was carried by unanimous vote.

5.0 The Decision Process

The workgroup tried to identify all the applicable standards to be considered. It was our goal to then determine which of those protocols identified represented technology that was in use or older than what we now use. In connection with this, we decided we were also not interested in technology that would be somehow less efficient than what we have today. After doing this, the remaining protocols were to be examined more closely.

We decided to conduct a study of the remaining protocol based on criteria. The criteria were developed with input from the members of the work group, the Education Council, and the Technical Panel.

5.1 Existing Protocols

There are 4 main protocols that we discovered existed in the state when we first began this process. These standards were those being used specifically for synchronous live delivery of two-way teleconference classes.

NTSC, commonly referred to as analog, was used by some K-12 consortia. In particular it was used by those pods, which received connectivity from cable system vendors. The STEP pod was also using analog delivered via a fiber optic system.

JPEG CODEC's have been implemented throughout many K-12 consortia. This network solution has been primarily supplied by telephone companies.

H.261/G.722 is used 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.

MPEG 1 was not in place in Nebraska when our project first started, but was in the process of installation as a part of the Southeast Nebraska Distance Learning Consortium. It has since been implemented there and may expand into other areas of the state.

H.263/G.722 has seen some implementation in the NVCN system, and in a few institutions of higher learning such as UNO and Wayne State College. This standard is being used in both the H.320 ISDN version and the H.323 IP version.

5.2 Initially Identified Protocols

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

5.3 Criteria Developed For the Follow Up Study

5.3.1 COSTS

Site

any uniquely required hardware/software
cost at site

Hub

if a hub such as an MCU is required hardware/software cost

Operational

maintenance requirements

technicians
connectivity bandwidth
scheduling personnel

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 vendor. The vendor 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.

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 vendor 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
Rate required for NVCN / Network 3 like quality

High quality
Rate required for full-motion quality

Lip readable
Rate required for language classes

ASL readable
Rate required for American Sign Language or any other sign language

Flexibility
Range available
Rate agile v. steps

Negotiation
Automatic / manual bandwidth negotiation between points

One of the messages that was loud and clear from the Education Council 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 idea, but the general sense among the consortia members was that full motion meant more or less what they have now. 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 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.

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 operate at the same speed. This might get 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.

5.3.3 CONNECTIVITY

Ubiquity

Supported delivery methods (IP, ATM, dedicated line, PVC, etc.)

Broadcast / multicast

One-to-many without interactivity

Point-to-point

Two interactive sites

Teleconference

Several interactive sites (MCU / Switch required?)

Dial up / dial out

The ability for an external site to connect into a conference and not have to be brought in

Latency

Amount of delay introduced by encoding process

When we speak of connectivity, we are 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 on. The kind of network then helps to understand what kind 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.

Latency is a very specific technical issue that effects 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. Latency is also introduced by a network, 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

Software standard or hardware standard

Backward compatibility

Nature of compatibility

Installed base

How prolific is this standard already?

Life Cycle

Ability to upgrade

In this area we are looking for how interoperable the particular protocol is with older version of itself and/or newer versions of itself. This is often more easily accomplished with protocol 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 RECOMMEND DEMO

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

Protocol	Advanced to Test / Demo
MPEG 1	No
MPEG 2	Yes
MPEG 4	No
MPEG 7	No
H.263/G.722	Yes
Wavelet	No

5.4.1 MPEG 1

5.4.1.1 DISCUSSION

This protocol was originally designed to allow primarily broadcast video to be digitized to save bandwidth and lower likelihood of signal degradation due to analog interference. MPEG 1 is a form of compressed video meaning not all the visual information is passed. The "missing" information is reconstructed at the far end of the network mathematically. Audio is also encoded at a pre-selected sampling rate.

5.4.1.2 COSTS

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. At issue for this system is that it is older technology. Companies producing new MPEG 1 CODECS are becoming increasingly difficult to find.

A hub is generally used for multi-site teleconferencing with MPEG 1. As with the CODEC, companies producing this technology are becoming harder to find. 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 committee was unable to find pricing on an MPEG 1 hub (MCU).

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 as related to technicians. If the current vendor would permit purchase of bandwidth on an as needed basis, MPEG 1 would theoretically lower costs as compared to both analog and JPEG systems, but would require more bandwidth than the H.261 systems in place.

5.4.1.3 BANDWIDTH

MPEG 1 is probably not capable of achieving minimum quality as defined in the criteria. Below 1.5Mbps the quality drops off quickly. At 1.5Mbps the quality would be better than our defined minimum quality. To achieve full-motion quality would probably require 8Mbps or more. Lip readable and ASL readable data rate is estimated to be around 3 or 4Mbps.

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. 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.

5.4.1.4 CONNECTIVITY

MPEG 1 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. Exact latency is unknown to the committee.

5.4.1.5 COMPATIBILITY

Although MPEG 1 uses digital signal processing hardware, it is primarily a software driven protocol. There is no real backward compatibility since it is the first MPEG standard. At one point MPEG 1 was a commonly installed system. With the introduction of more efficient compression systems it has become less common. MPEG 1 can typically be upgraded to MPEG 2 with a software installation.

5.4.2 MPEG 2

5.4.2.1 DISCUSSION

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. Audio is also encoded at a pre-selected sampling rate.

5.4.2.2 COSTS

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.

A hub is generally used for multi-site teleconferencing 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 an MPEG 2 hub varies with size and features.

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 as related to technicians. If the current vendor would permit purchase of bandwidth on an as needed basis, MPEG 2 would theoretically lower costs as compared to analog, JPEG and MPEG 1 systems, but would require more bandwidth than the H.261 systems in place.

5.4.2.3 BANDWIDTH

MPEG 2 is probably not capable of achieving minimum quality as defined in the criteria. Below 1Mbps the quality drops off quickly. At 1Mbps the quality would be better than our defined minimum quality. To achieve full-motion quality would probably require 4Mbps or more. Lip readable and ASL readable data rate is estimated to be around 1 or 2Mbps.

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.

5.4.2.4 CONNECTIVITY

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. Exact latency was unknown to the committee at the time of the criteria study, but was determined as a part of the test procedure.

5.4.2.5 COMPATIBILITY

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. MPEG 4 is the next version to come, but it is still in the early stages so there is really no viable MPEG upgrade yet.

5.4.3 MPEG 4

5.4.3.1 DISCUSSION

The video processes in MPEG 4 are not much different than MPEG 2. The goal of MPEG 4 is specifically to allow compressed video to be sent in an open IP network such as the Internet. Along with video and audio MPEG 4 also is designed to send digital “objects.” That could include a web page, a still photograph, a recorded audio file, etc. With MPEG 4 all the digital objects can be sent simultaneously.

5.4.3.2 COSTS

All costs for MPEG 4 are currently unknown. The protocol is mostly defined and some experimental systems are on the market, but it is by and large not a functionally implemented standard.

5.4.3.3 BANDWIDTH

Since the compression algorithms of MPEG 4 are similar to MPEG 2 one might assume that the same sort of bandwidth is required for the same quality. However, MPEG 4 is specifically designed for open circuit Internet-like networks so it is designed to be most efficient at lower data rates and lower quality.

5.4.3.4 CONNECTIVITY

MPEG 4 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. Exact latency is unknown to the committee.

5.4.3.5 COMPATIBILITY

Although MPEG 4 uses digital signal processing hardware, it is primarily a software driven protocol. The need for compatibility is yet to be understood since it is such a new standard. It could be assumed to be easier and more efficient to upgrade MPEG 2 systems to the MPEG 4 standard. MPEG 4 is the next version to come, but it is still in the early stages so there is really no viable MPEG upgrade yet.

5.4.4 MPEG 7

5.4.4.1 DISCUSSION

This protocol is not really a video and audio encoding system. MPEG 7 is designed to work with MPEG 4 as a search mechanism for “objects” to be sent such as live or stored motion or still video, audio clips, web pages, data files, etc. This standard is still under development and will not be considered further. The searching makes use of meta data that is imbedded within the objects.

5.4.5 H.263 / G.722

5.4.5.1 DISCUSSION

These standards are 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.261 video is the current NVCN and Neb*Sat Network 3 standard. Based on the Kansas test findings H.263 uses considerably less bandwidth for a comparable quality. A specific discussion on bandwidth and audio selection is below.

5.4.5.2 COSTS

As with MPEG 1 and 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 $8,000 to $12,000.

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.

Operational costs would include maintenance requirements. Since the cost of a CODEC less than the currently used CODECS in the system, lower maintenance costs are expected. This is true as well as related to technicians. If the current vendor would permit purchase of bandwidth on an as needed basis, H.263 would theoretically lower costs as compared to analog, JPEG, MPEG 1, MPEG 2 and H.261 systems.

5.4.5.3 BANDWIDTH

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. It would theoretically be of full-motion quality at 4.5Mbps, and would appear to be lip readable and usable for sign language at about 1.5Mbps.

Data rates are available from 0.128 to 2.048Mbps in steps that are multiples of 64Kbps. Negotiation between systems is automatic, but upper and/or lower limits on data rate are set manually.

G.722 audio encoding is a 48, 56 or 64Kbps system passing frequencies from 50Hz to 7KHz.

5.4.5.4 CONNECTIVITY

H.263 / G.722 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). Dial up / dial out is used in the H.320 ISDN mode. Latency is unknown to the committee without testing.

The group has been tasked with recommending a video and audio encoding standard. As stated above H.263 can be passed within H.320, H.321 or H.323. This document will not recommend the kind of network to pass the video over, however one of these will need to be selected for testing the standard.

5.4.5.5 COMPATIBILITY

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 is becoming more popular in the H.323 IP configuration as desktop teleconferencing rises in popularity. Though not as prolific as MPEG 2 yet, it is growing rapidly in use. Since H.263 is the latest ITU teleconference standard, we can only assume that forward compatibility will be similar to that of H.261 to H.263 in that a switch will be able to transcode.

5.4.6 WAVELET

5.4.6.1 DISCUSSION

The video processes in Wavelet are not much different than MPEG 4. The goal of Wavelet is mostly targeted for a low bandwidth teleconference application. It is specifically intended for a network such as the Internet. Wavelet is still in its early stages of development and implementation. This standard is still under development and will not be considered further.

6.0 Testing Procedure

6.1 Goals

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 in each finalist standard (MPEG-2 and H.323/H.263/G.722). Each will be tested at specific bandwidths. The environments will include IP, and IP over ATM.

6.2 Defined Qualities

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. 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 the quality now used by K-12 distance learning pods.

Since ultimately, educators will be using this system, we will use educators to assist in determining when the appropriate quality is achieved. Some teachers who use the current K-12 pod systems in the state will be invited to help determine when the minimum data rate is reached that still can be called full-motion. Language teachers who already use the distance learning networks will help determine when the picture is at a minimum level that is still appropriately lip readable. Users of ASL will do the same for ASL. Network 3 users will help determine when that minimum quality is reached. It is intended that all of these volunteers be present during the testing.

6.3 Other Bandwidth Issues

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.

6.4 Systems

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 and comparing codecs from V-Brick and Ahead Communications formerly GDC. For H.263 we are testing with Picturetel and Polycom CODECs.

6.5 Latency

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.

6.6 Settings

Since H.263/G.722 can be passed within H.320, H.321 or H.323, it has been decided to test both standards in IP and/or IP over ATM since this will introduce protocol stacking and put the standard to testing across a difficult network environment.

When testing, use standard setups each time, every time. The specific settings are given below. The setting yet-to-be-determined is the CIF setting in H.263. 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
Capture Resolution	CIF as determined in *CIF Test Procedure* section of this document
Audio	G.722 @ 56Kbps

6.7 Standard Video

In order to have exact comparison, the same videotape will be used for all tests. It has been dubbed onto a DigiBeta tape for quality.

1. 1:00 min — Color bars with tone

2. 2:00 min — Class segment of **Advance Manufacturing Process**. Recorded Live to Digital Beta tape.

3. 2:00 min — Segment from **Interactive Spanish**. Recorded from Beta SP master.

4. 2:20 min — Segment from **Sign Language Crash Course I.** Recorded from VHS tape.

5. 2:00 min — Segment from **Piano Masters Class**. Recorded Live to Digital Beta tape.

6. 2:20 min — Segment from **Reading Rainbow**. Recorded from master 1 inch analog tape.

7. 1:00 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.

9. 2:00 min Random White Noise Test: 5 seconds of video white noise with no audio, followed by 1 frame of video black with 1 frame of audio tone.

6.8 General Test Procedure

6.8.1 MPEG-2

Follow this procedure using the V-Brick set of codecs and the Ahead set of codecs.

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

2. Using the videotape 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.

6.8.2 H.263

Follow this procedure using the Picturetel set of CODEC's and the Polycom set of codecs.

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

2. Using the videotape 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. Conduct this procedure incorporating the requirements of the *CIF Test Procedure* section of this document.

6.9 CIF Test Procedure

The CIF (Common Intermediate Format) in H.263 refers to the setting in this protocol that determines resolution. The two versions we are interested in comparing is FCIF (full CIF) and 4CIF (4x the pixels of FCIF). Specifically, FCIF delivers a raster of 352 x 288, and the 4CIF raster is 702 x 576. There are higher and lower CIF settings, but these two are the ones just higher than and just lower than digital standard definition video at 640 x 480. It is understood that 4CIF will not work below 768Kbps. It is also understood that to reach minimum quality as described in the *Defined Qualities* section of this document, the systems tested will go below 768Kbps. Therefore, there are only two possible CIF configuration outcomes of the testing that can result: FCIF for all data rate settings, or FCIF for data rates below 768Kbps, and 4CIF for data rates at or above 768Kbps. The selection will be determined based on following the *Establish a Baseline* procedure below for each of these options and selecting the option with the lower data rates.

6.10 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 tape matching to the respective CODEC 1 inputs. Connect the other audio output to the channel 1 input of a storage or digital oscilloscope. Playback the videotape after bars/tone/resolution. (about 2 minutes into the tape).

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.

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.

6.11 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 a set 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 order of vendor system and data rate should be varied with each group showing, and the viewers should not be told which encode standard or data rate they are viewing. Randomly mix in a showing of the raw tape without telling the volunteers so we can see how prejudice may skew the results of the test.

6.12 Network Performance Test Procedure

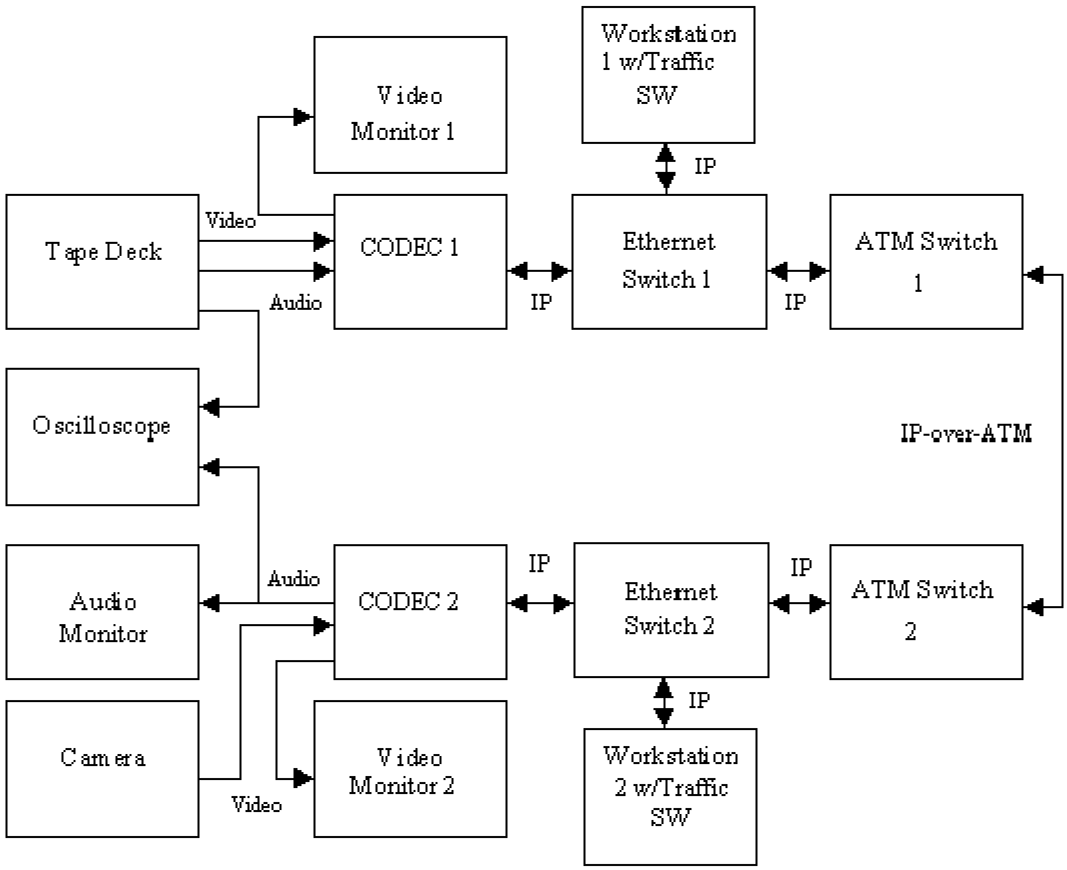
Establish a baseline of the network system once the system is set up as depicted in the *General Setup Diagram* section of this document. Test the network with the CODECs unconnected from the system. Then test it again with the CODECs connected.

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.

6.13 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 ATM switches, ethernet switches, etc. 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



6.14 Test Sheets

To be filled out by the volunteers follows:

Nebraska Information Technology Commission

Distance Learning and Video Conferencing Video Standards Evaluation Form

Session:	Wed AM	☐	Wed PM	☐	Thurs AM	☐	Thurs PM	☐
Institution:	K-12:	☐	College:	☐	State:	☐	Other:	☐
Type:	Instructor:	☐	Student:	☐	Coordinator:	☐	Technical:	☐
Expertise:	Language:	☐	ASL:	☐	Music:	☐	________:	☐
Status:	Current:	☐	Future:	☐	Past:	☐		
Experience:	0 to 2 yr:	☐	2 to 5 yrs:	☐	5 to 10 yrs:	☐	10 to 20 yrs:	☐
System:	Digital :	☐	Analog:	☐	NVCN/Net3:	☐	Other:	☐

Rate Value (Highest = 5 to Lowest = 1) Circle One

Bandwidth:1 2 3 4 5   Latency:1 2 3 4 5   Lipsync:1 2 3 4 5   Picture:1 2 3 4 5   Sound:1 2 3 4 5

Additional Comments: ____

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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:	☐

7.0 Test Results

7.1 Schedule

The test procedure described earlier in this document was followed and volunteers came to NET on October 3 and 4, 2001. Those who attended are listed below. The random rotation of the CODEC's is also listed below.

Wed AM:

CODEC
A1: MPEG B at 5.3 mbps
A2: MPEG B at 3.5 mbps
A3: MPEG B at 2.0 mbps
A4: MPEG B at 1.0 mbps
B1: H.263 A at 1.920 mbps
B2: H.263 A at 1.536 mbps
B3: H.263 A at .768 mbps
B4: H.263 A at .384 mbps
C1: MPEG A at 5.3 mbps
C2: MPEG A at 3.5 mbps
C3: MPEG A at 2.0 mbps
C4: MPEG A at 1.0 mbps
D1: Tape replay (Control)
D2: H.263 B at .768 mbps
D3: H.263 B at .512 mbps
D4: H.263 B at .384 mbps

Wed PM

CODEC
A1: Tape replay (Control)
A2: H.263 B at .768 mbps
A3: H.263 B at .512 mbps
A4: H.263 B at .384 mbps
B1: MPEG A at 5.3 mbps
B2: MPEG A at 3.5 mbps
B3: MPEG A at 2.0 mbps
B4: MPEG A at 1.0 mbps
C1: MPEG B at 5.3 mbps
C2: MPEG B at 3.5 mbps
C3: MPEG B at 2.0 mbps
C4: MPEG B at 1.0 mbps
D1: H.263 A at 1.920 mbps
D2: H.263 A at 1.536 mbps

D3: H.263 A at .768 mbps
D4: H.263 A at .384 mbps

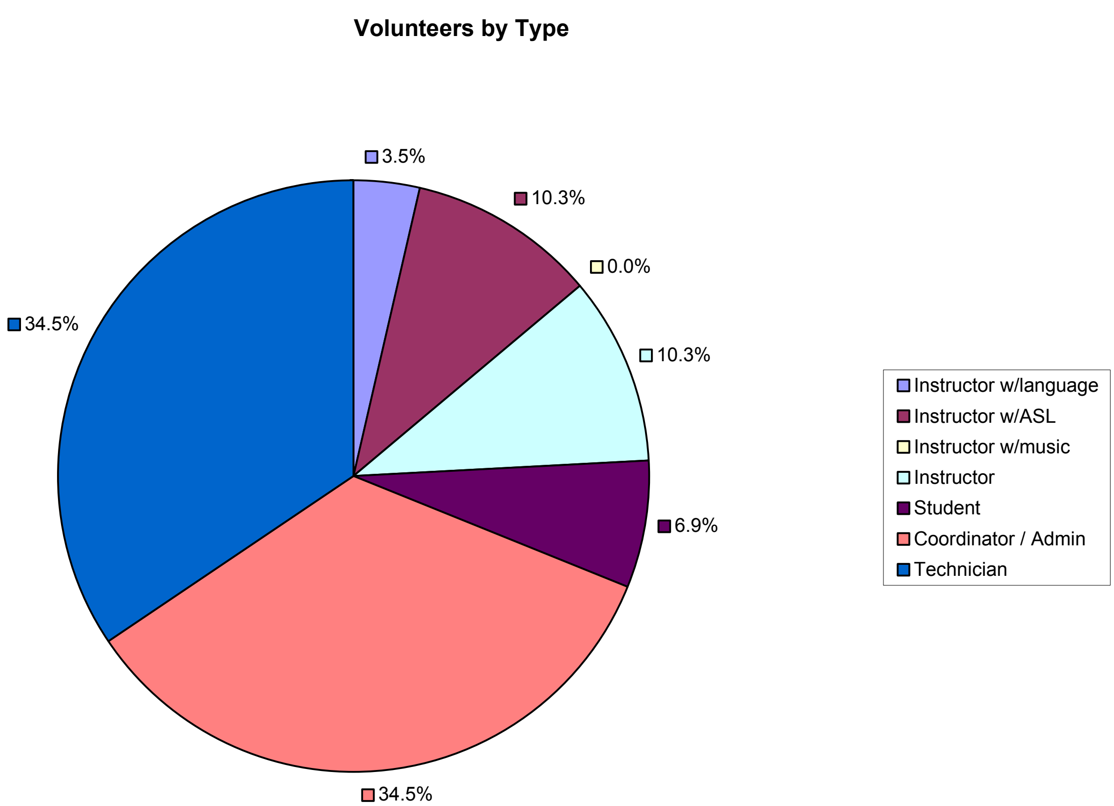
Thurs AM:
CODEC
A1: MPEG A at 5.3 mbps
A2: MPEG A at 3.5 mbps
A3: MPEG A at 2.0 mbps
A4: MPEG A at 1.0 mbps
B1: H.263 B at .768 mbps
B2: H.263 B at .512 mbps
B3: H.263 B at .384 mbps
D1: Tape replay (Control)
C1: H.263 A at 1.920 mbps
C2: H.263 A at 1.536 mbps
C3: H.263 A at .768 mbps
C4: H.263 A at .384 mbps
D1: MPEG B at 5.3 mbps
D2: MPEG B at 3.5 mbps
D3: MPEG B at 2.0 mbps
D4: MPEG B at 1.0 mbps

Thurs PM
CODEC
A1: H.263 A at 1.920 mbps
A2: H.263 A at 1.536 mbps
A3: H.263 A at .768 mbps
A4: H.263 A at .384 mbps
B1: MPEG B at 5.3 mbps
B2: MPEG B at 3.5 mbps
B3: MPEG B at 2.0 mbps
B4: MPEG B at 1.0 mbps
C1: Tape replay (Control)
C2: H.263 B at .768 mbps
C3: H.263 B at .512 mbps
C4: H.263 B at .384 mbps
D1: MPEG A at 5.3 mbps
D2: MPEG A at 3.5 mbps
D3: MPEG A at 2.0 mbps
D4: MPEG A at 1.0 mbps

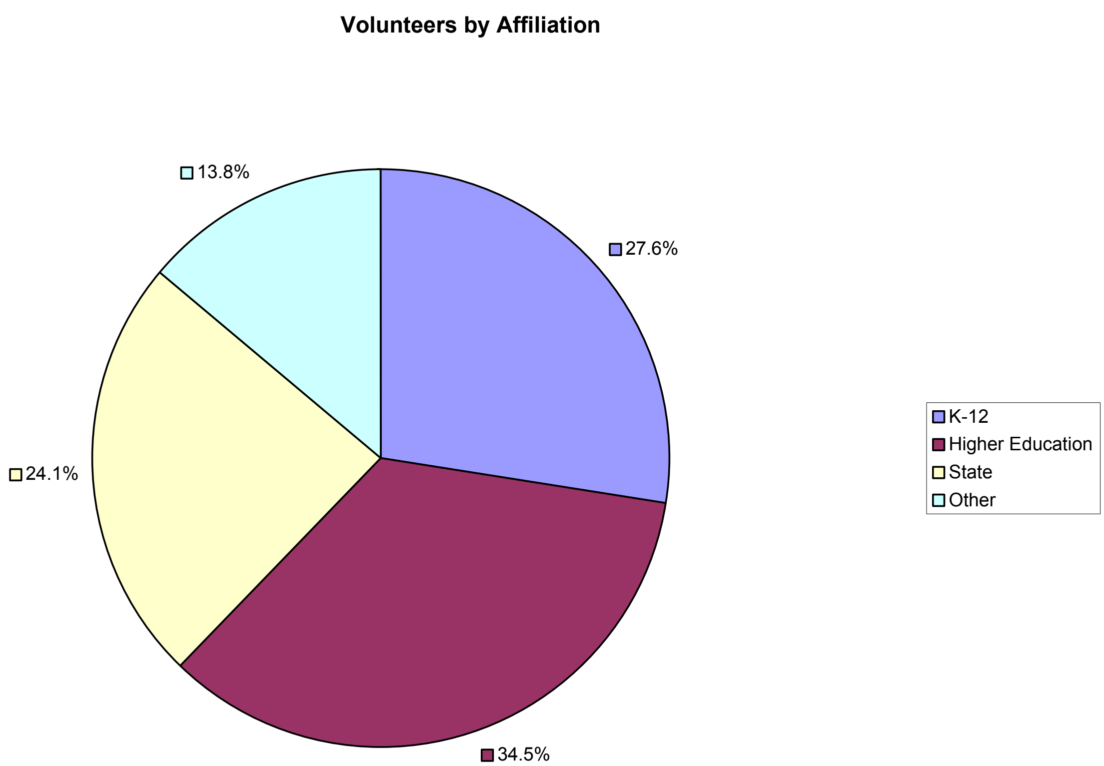
7.2 Volunteer Viewers

A total of 32 individuals volunteered to view the tape and pass through the testing procedure. The following chart depicts the composition of the group. None of the participants were asked to identify themselves on the sheet. Since they had no idea which specific CODEC they were viewing and that the order was changed in each session, it was important for the participant to mark which session they were in.

One Volunteer did not mark the session and their sheet had to be discounted. Some of the participants marked themselves in more than one category so it was decided to only count them in one category. In order to do this, a hierarchy or priority of descriptors was developed. Some assumptions had to be made to develop the priority. First, teachers use the system to benefit students. Teachers have the most experience with the quality specifically. Teachers with specialized training are the best judges of how those specialties (ASL, language, music) are used on the systems. System coordinators or administrators have more understanding of the quality needs than do technicians. As a result of these assumptions the priority was set as follows: instructor with a specialty, instructor, student, coordinator / administrator, technician. If a volunteer viewer marked themselves in more than one of these categories, they were credited for the highest applicable priority.



Some viewers marked themselves as affiliated with more than one type of institution as well. So a hierarchy was established for these as well. It was based on the quality requirements of the institutions of that sector as a whole. The priority is: K-12, higher education, state agency, other. A viewer that marked him or herself in more than one sector were counted in the sector with the highest place in this priority list.



7.3 Session Introduction

At the beginning of each session the following explanation of the test was given to the volunteer viewers:

Thank you for attending. I am Bob Huber, Assistant Director of Engineering for Network Operations with Nebraska Educational Telecommunications.

I would like to thank ADC for the ATM network equipment. Ahead Communications fermerly GDC, V-Brick, Polycom and Picture Tel for the CODECS and Qwest for their help in arranging the equipment loan. This evaluation would not be possible without their help.

You are here to aid in the selection of the NITC Video Standards for Distance Learning and Video Conferencing. The standards being considered are MPEG 2 and H.263. You will evaluate these two (2) protocols over the same network system. Concerns have been raised regarding field-testing. You are here to evaluate the Video Protocols NOT the network they will be delivered over. Network Quality of Service is a different matter. However, network issues will have a direct effect on the recommendation.

THE FORM

The form you will fill out has been constructed to ensure complete privacy. Please fill in the appropriate box. Session: Wed PM; Institution: K-12, College etc. Rate the importance of the items listed. If picture quality is your most important concern circle 5, if latency is the least important circle 1. **EXPLAIN Quality**

TEST TAPE

The Standards committee has assembled a test tape using real classroom equipment, instructor and students. Every test will use the same tape. Therefore, everyone will see the exact same test. Your expertise will focus on picture quality, sound quality and lip sync. The technical evaluation will use industry specific test signals and test equipment to determine exact technical measurements of; bandwidth, lip sync, latency, video resolution and audio frequency response. The tape was produced on a Digital Betacam system. It consists of; Advance Manufacturing Process (a Distance Learning class), Spanish language class, America Sign language class, Piano Masters class (a Distance Learning Class) and a segment from Reading Rainbow. Each section is about two (2) minutes in length, resulting in about a ten-minute test for each protocol and data rate. First you will be shown the test tape directly into a monitor. Then you will be shown four (4) deferent data rates for each system. You will not be told which system or data rate, just which line to fill in, A1, C3 etc.

SCORING

If what you see is full motion please fill in the full motion box. If you what you see less than full motion but it is acceptable for ASL please fill in the ASL box. If what you see is not acceptable fill in unacceptable. If what you hear is excellent please fill in the excellent box. If what you hear is good, fill in the good box. If what you hear is not acceptable please fill in the unacceptable box. **Remember**: please evaluate all five segments before filling in any of the boxes. If you wish to make additional comments please use the lined segment provided.

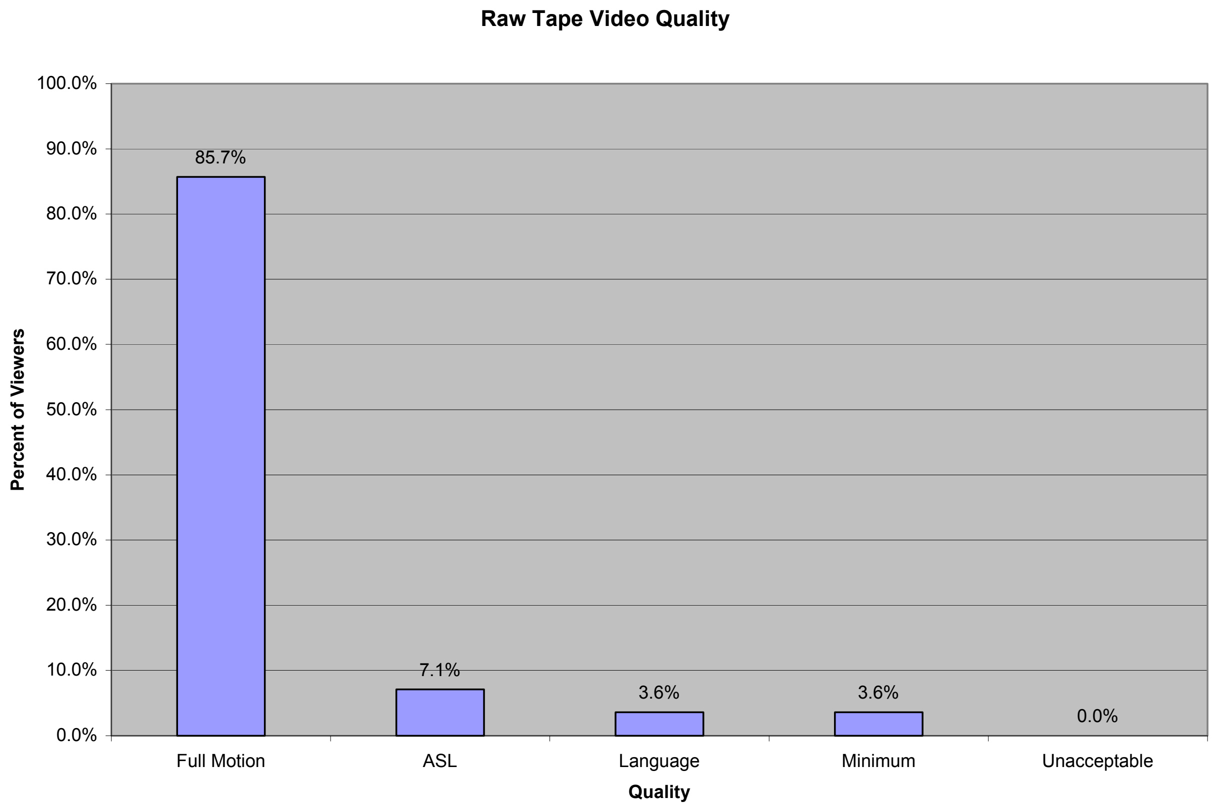
7.4 Specific Viewer Ratings

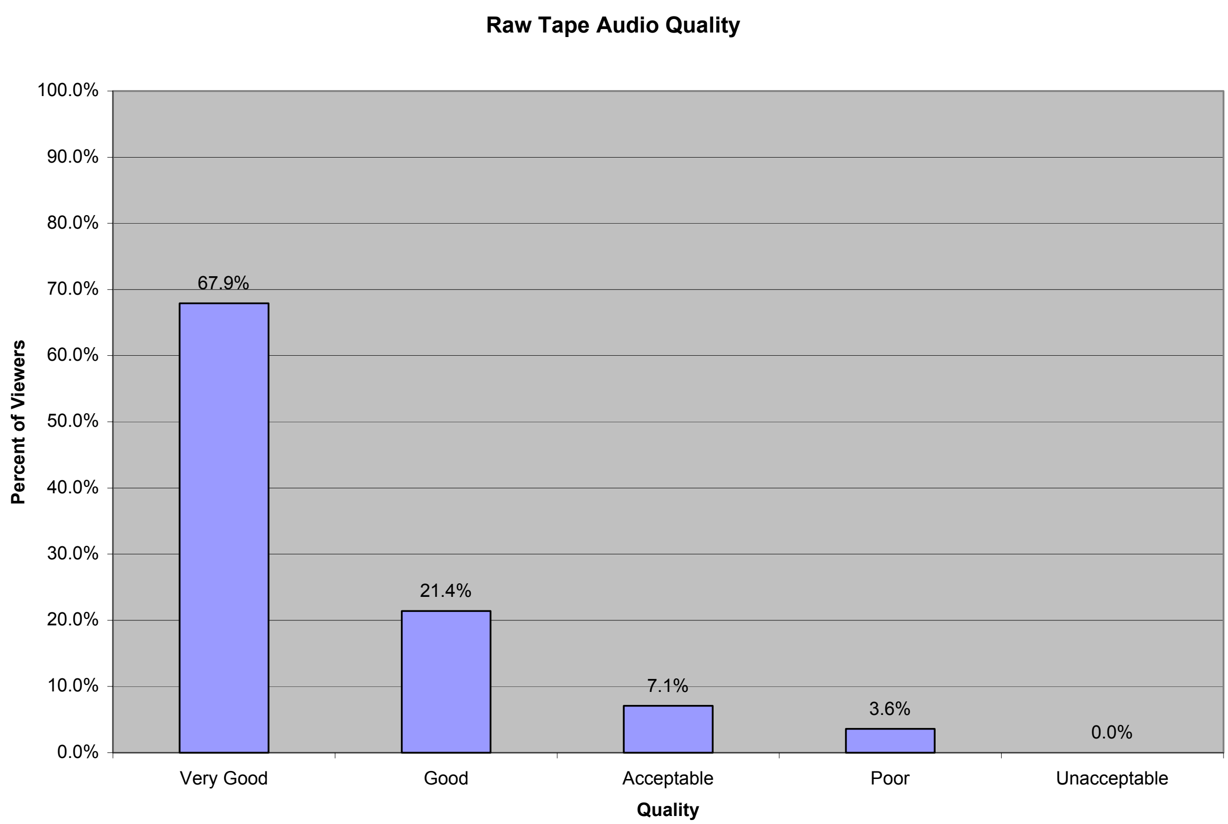
The following series of graphs depicts the results of the respondents sheets. The MPEG 2 CODEC's are shown separately, then an average of the two charts is shown. No attempt was made to show MPEG 2 below 1Mbps since the quality of this protocol drops off sharply below this rate. GOP 15 was selected as a result of system vendor recommendations.

The H.263 picture is a bit more complicated. As a result of the 4CIF vs. FCIF testing as described in the *Test Procedure* section of this document, FCIF was selected for H.263. G.722 audio was selected from the beginning because it gives the greatest frequency response range at a low data rate. Unfortunately, vendor CODEC's differ on available bandwidth settings in this standard. This is depicted in the charts below. No average chart could be developed for this standard because of this equipment limitation. There is an obvious disparity in the performance of the specific CODEC models used.

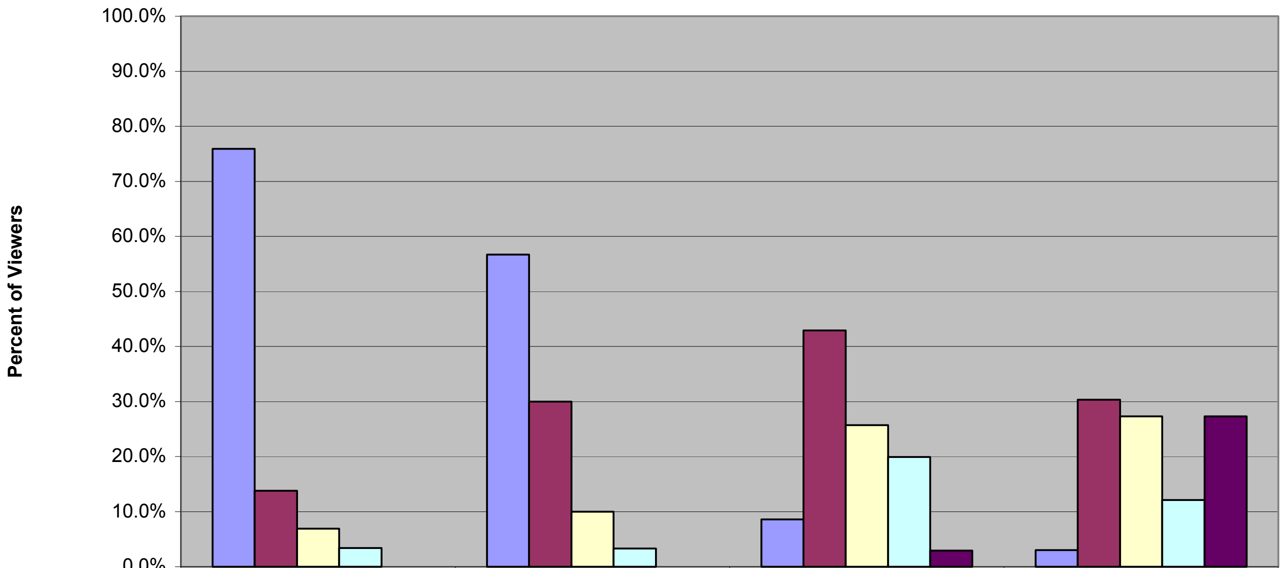
Some viewers marked more than one video quality. If a viewer marked the *full motion* box, it was assumed all other qualities were met and the vote was only counted in the full motion category. If full motion was not marked but either *ASL* or *Language* were marked, the vote was counted there. If full 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 then received credit where they marked, and no credit where they didn't mark.

Without viewer knowledge a "control" video was injected in the test. This was the raw videotape machine playing with no encoding by any CODEC. Some viewers marked this control video as less than full motion. This would indicate that they may have been unnecessarily harsh on the testing.


Raw Tape Video Quality
Percent of Viewers
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
85.7%
7.1%
3.6%
3.6%
0.0%
Full Motion
ASL
Language
Minimum
Unacceptable
Quality


Raw Tape Audio Quality
Percent of Viewers
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
67.9%
21.4%
7.1%
3.6%
0.0%
Very Good
Good
Acceptable
Poor
Unacceptable
Quality

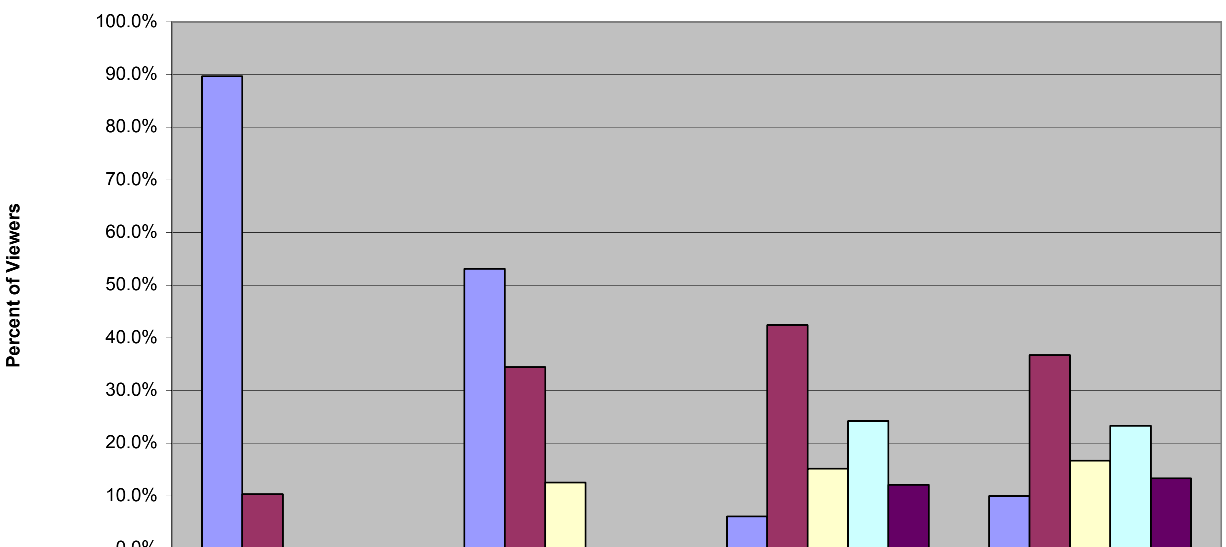
MPEG 2 CODEC "A" Video Quality



	5.3Mbps	3.5Mbps	2Mbps	1Mbps
Full Motion	75.9%	56.7%	8.6%	3.0%
ASL	13.8%	30.0%	42.9%	30.3%
Language	6.9%	10.0%	25.7%	27.3%
Minimum	3.4%	3.3%	19.9%	12.1%
Unacceptable	0.0%	0.0%	2.9%	27.3%

Data Rate

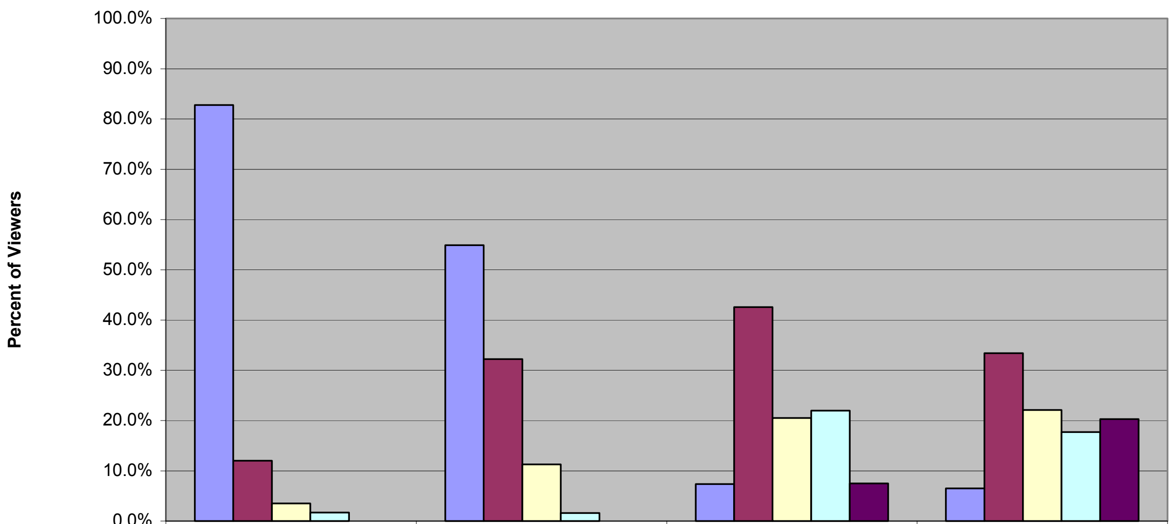
MPEG 2 CODEC "B" Video Quality



	5.3Mbps	3.5Mbps	2Mbps	1Mbps
Full Motion	89.7%	53.1%	6.1%	10.0%
ASL	10.3%	34.4%	42.4%	36.7%
Language	0.0%	12.5%	15.2%	16.7%
Minimum	0.0%	0.0%	24.2%	23.3%
Unacceptable	0.0%	0.0%	12.1%	13.3%

Data Rate

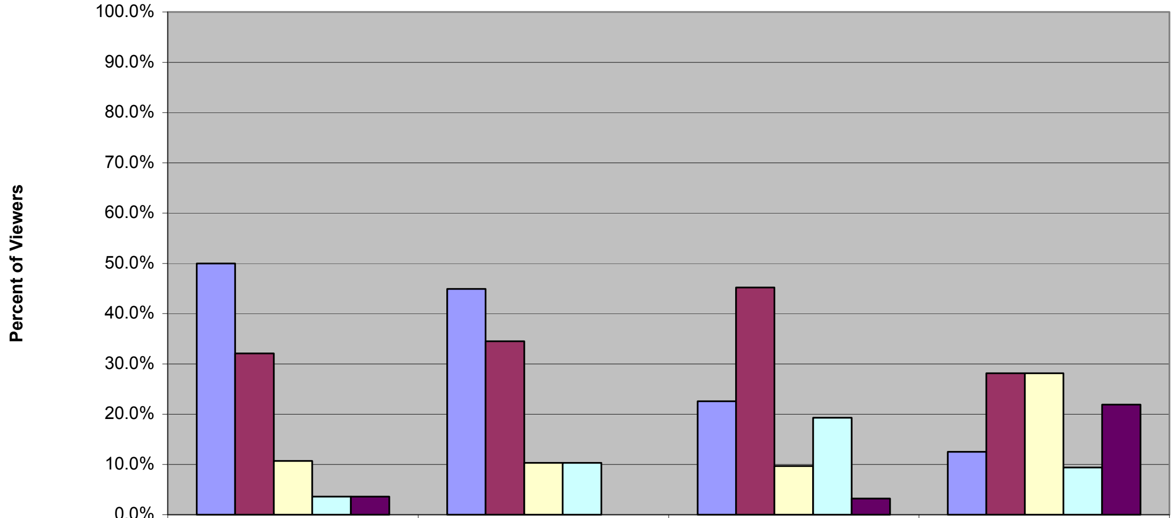
MPEG-2 Video Quality Average



	5.3Mbps	3.5Mbps	2Mbps	1Mbps
Full Motion	82.8%	54.9%	7.4%	6.5%
ASL	12.0%	32.2%	42.6%	33.4%
Language	3.5%	11.3%	20.5%	22.1%
Minimum	1.7%	1.6%	22.0%	17.7%
Unacceptable	0.0%	0.0%	7.5%	20.3%

Data Rate

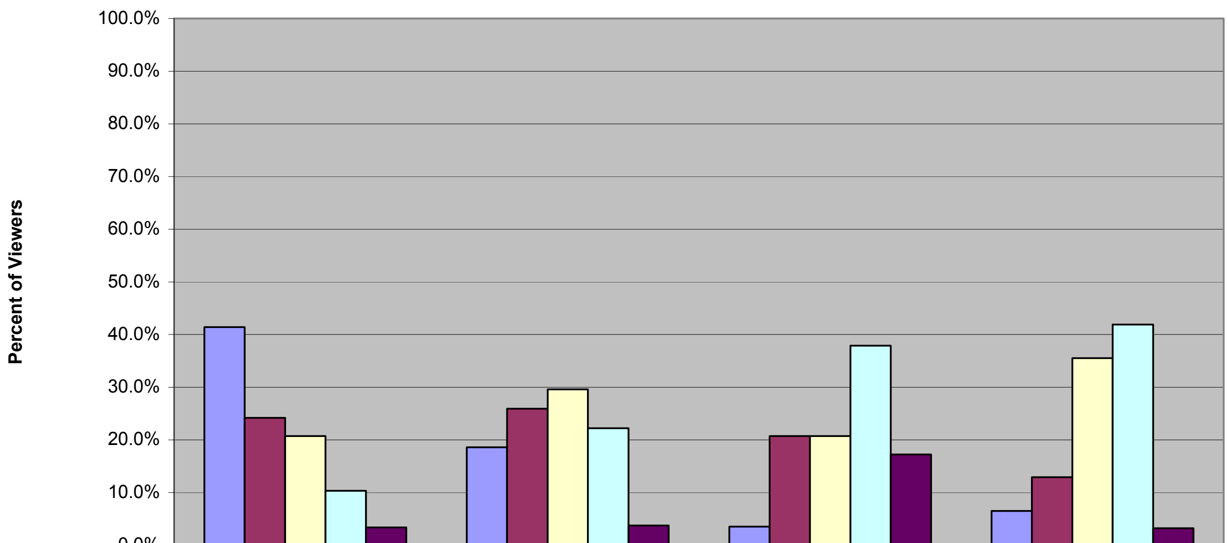
MPEG 2 CODEC "A" Audio Quality



	5.3Mbps	3.5Mbps	2Mbps	1Mbps
Very Good	50.0%	44.9%	22.6%	12.5%
Good	32.1%	34.5%	45.2%	28.1%
Acceptable	10.7%	10.3%	9.7%	28.1%
Poor	3.6%	10.3%	19.3%	9.4%
Unacceptable	3.6%	0.0%	3.2%	21.9%

Data Rate

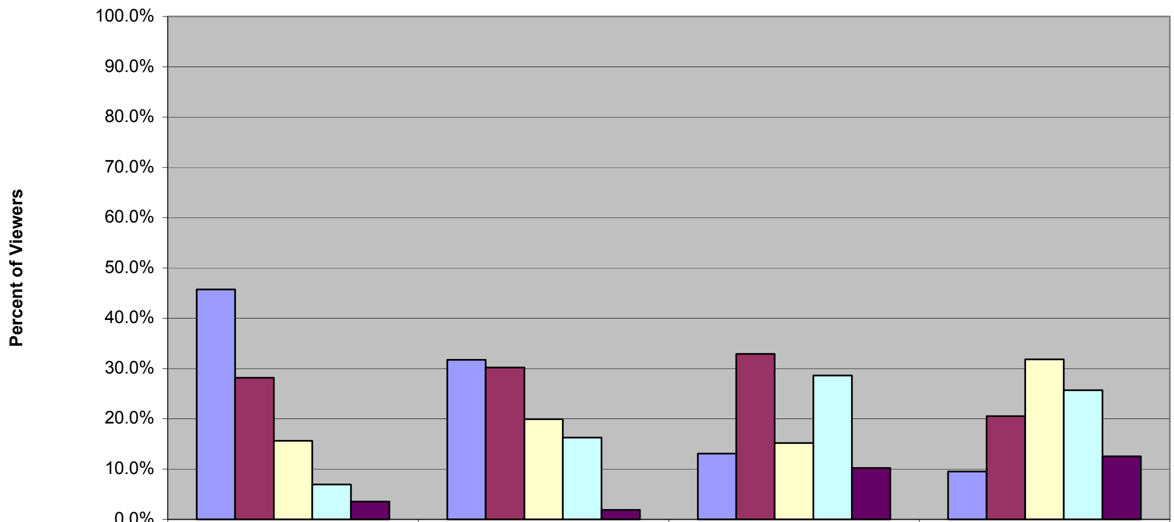
MPEG 2 CODEC "B" Audio Quality



	5.3Mbps	3.5Mbps	2Mbps	1Mbps
Very Good	41.4%	18.6%	3.5%	6.5%
Good	24.2%	25.9%	20.7%	12.9%
Acceptable	20.7%	29.6%	20.7%	35.5%
Poor	10.3%	22.2%	37.9%	41.9%
Unacceptable	3.4%	3.7%	17.2%	3.2%

Data Rate

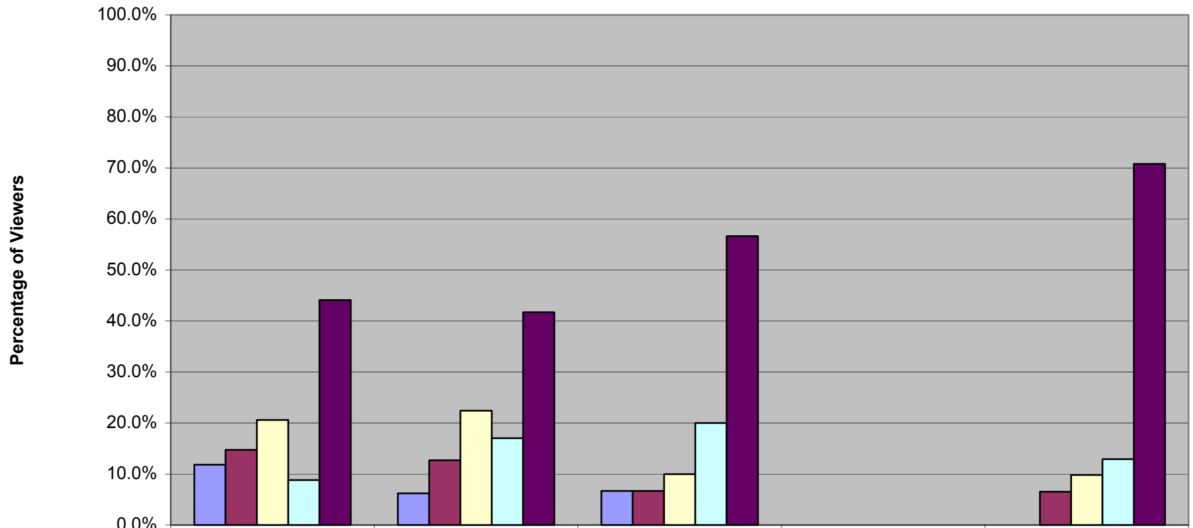
MPEG Audio Quality Average



	5.3Mbps	3.5Mbps	2Mbps	1Mbps
Very Good	45.7%	31.7%	13.1%	9.5%
Good	28.2%	30.2%	32.9%	20.5%
Acceptable	15.6%	19.9%	15.2%	31.8%
Poor	7.0%	16.3%	28.6%	25.7%
Unacceptable	3.5%	1.9%	10.2%	12.5%

Data Rate

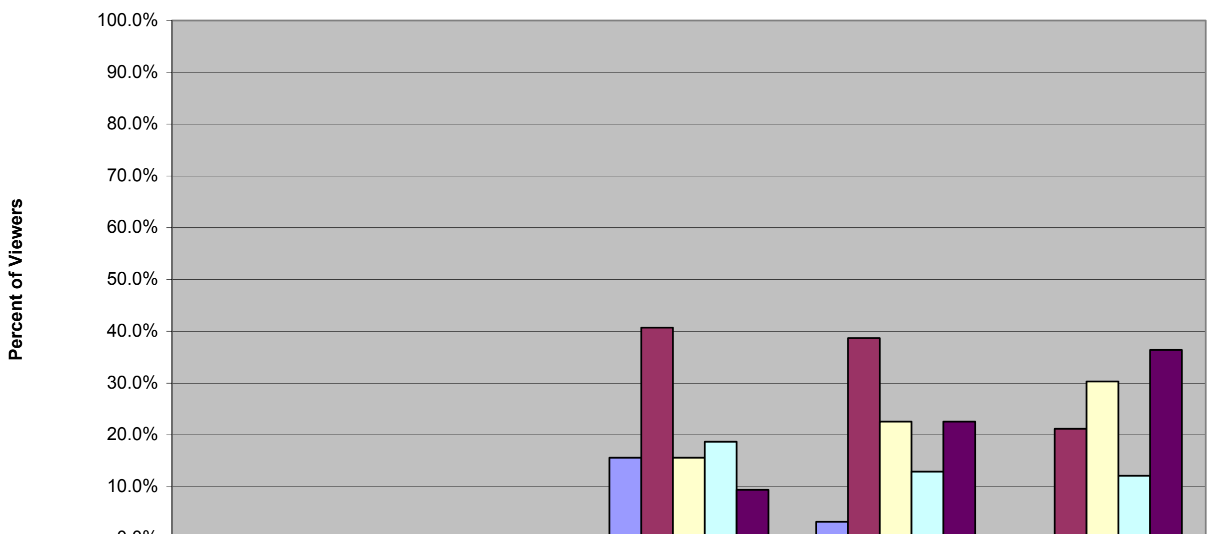
H.263 CODEC "A" Video Quality



	1.92Mbps	1.536 Mbps	.768Mbps	.512Mbps	.384Mbps
Full Motion	11.8%	6.2%	6.7%	0.0%	0.0%
ASL	14.7%	12.7%	6.7%	0.0%	6.5%
Language	20.6%	22.4%	10.0%	0.0%	9.8%
Minimum	8.8%	17.0%	20.0%	0.0%	12.9%
Unacceptable	44.1%	41.7%	56.6%	0.0%	70.8%

Data Rate

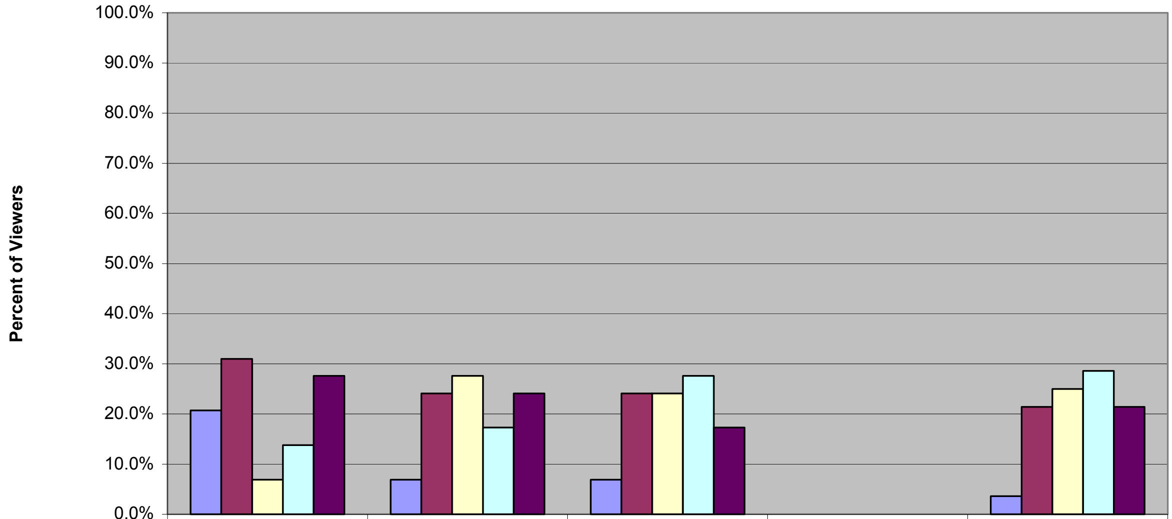
H.263 CODEC "B" Video Quality



	1.92Mbps	1.536 Mbps	.768Mbps	.512Mbps	.384Mbps
Full Motion	0.0%	0.0%	15.6%	3.2%	0.0%
ASL	0.0%	0.0%	40.7%	38.7%	21.2%
Language	0.0%	0.0%	15.6%	22.6%	30.3%
Minimum	0.0%	0.0%	18.7%	12.9%	12.1%
Unacceptable	0.0%	0.0%	9.4%	22.6%	36.4%

Data Rate

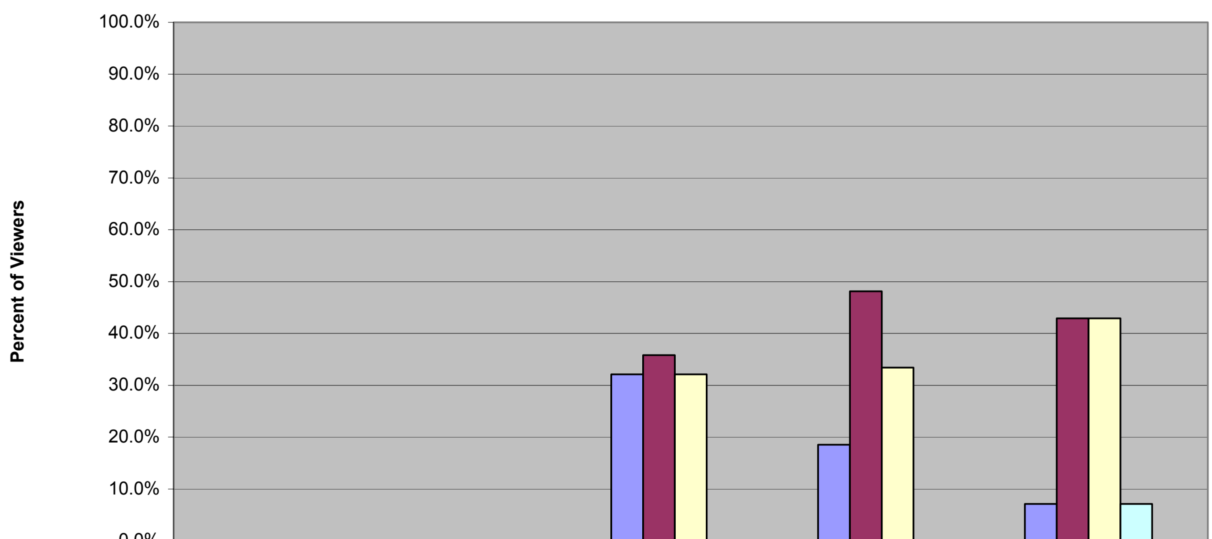
G.722 @ 56Kbps CODEC "A" Audio Quality



	1.92Mbps	1.536 Mbps	.768Mbps	.512Mbps	.384Mbps
Very Good	20.7%	6.9%	6.9%	0.0%	3.6%
Good	31.0%	24.1%	24.1%	0.0%	21.4%
Acceptable	6.9%	27.6%	24.1%	0.0%	25.0%
Poor	13.8%	17.3%	27.6%	0.0%	28.6%
Unacceptable	27.6%	24.1%	17.3%	0.0%	21.4%

Data Rate

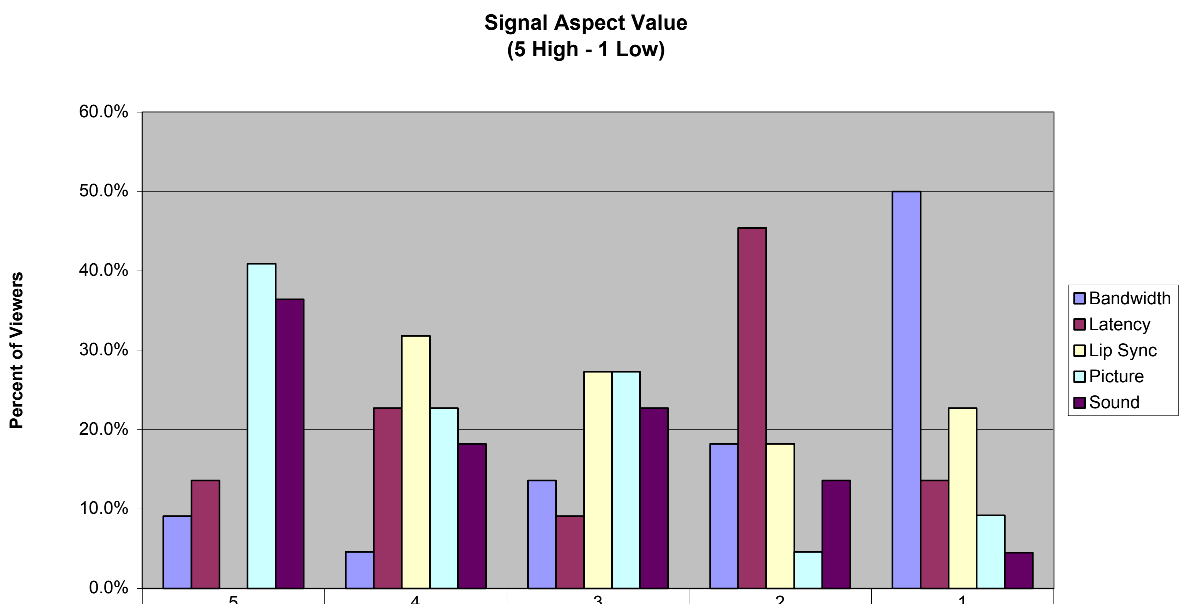
G.722 @ 56Kbps CODEC "B" Audio Quality



	1.92Mbps	1.536 Mbps	.768Mbps	.512Mbps	.384Mbps
Very Good	0.0%	0.0%	32.1%	18.5%	7.1%
Good	0.0%	0.0%	35.8%	48.1%	42.9%
Acceptable	0.0%	0.0%	32.1%	33.4%	42.9%
Poor	0.0%	0.0%	0.0%	0.0%	7.1%
Unacceptable	0.0%	0.0%	0.0%	0.0%	0.0%

Data Rate

Viewers were asked to rate a series of aspects about a generic system. They were to mark what they considered the most important aspect of the system through the least important aspect of the system. The scale was from 5 high to 1 low. The chart is below and is somewhat ambiguous. The only clear message in the chart is that the viewers care little for how much bandwidth is required to transport the signal, nor do they worry much about how much latency (time lag) the system introduces. Picture and sound quality seems to be most important to the respondents. Viewers that marked two aspects with the same value were discounted. Viewers who did not mark any value were discounted.



	5	4	3	2	1
Bandwidth	9.1%	4.6%	13.6%	18.2%	50.0%
Latency	13.6%	22.7%	9.1%	45.4%	13.6%
Lip Sync	0.0%	31.8%	27.3%	18.2%	22.7%
Picture	40.9%	22.7%	27.3%	4.6%	9.2%
Sound	36.4%	18.2%	22.7%	13.6%	4.5%

Signal Aspect

7.5 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. The findings follow:

CODEC	Data Rate	Latency	Lip Sync
Video Recorder	N/A	0 ms	0 ms
MPEG A	5.300 mbps	236 ms	0 ms
MPEG A	3.500 mbps	236 ms	0 ms
MPEG A	2.000 mbps	236 ms	0 ms
MPEG A	1.000 mbps	266 ms	0 ms
MPEG B	5.300 mbps	440 ms	47.6 ms
MPEG B	3.500 mbps	440 ms	72.0 ms
MPEG B	2.000 mbps	440 ms	72.0 ms
MPEG B	1.000 mbps	446 ms	46.0 ms
H.263 A	1.920 mbps	410 ms	72.4 ms avg
H.263 A	1.536 mbps	408 ms	72.8 ms avg
H.263 A	0.768 mbps	420 ms	72.8 ms avg
H.263 A	0.384 mbps	420 ms	72.8 ms avg
H.263 B	0.768 mbps	198 ms	42.8 ms
H.263 B	0.512 mbps	198 ms	42.8 ms
H.263 B	0.384 mbps	204 ms	44.0 ms

7.6 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)	DIFFERENCE (dB)
MPEG A	.063	-10	-9.5	+.5
	.125	-10	-9.5	+.5
	.250	-10	-9.5	+.5
	.400	-10	-9.7	+.3
	1	-10	-10.5	-.5
	2	-10	-11	-1
	4	-10	-11.2	-1.2
	8	-10	-11.5	-1.5
	10	-10	-11.5	-1.5
	12.5	-10	-11.6	-1.6
	16	-10	-11.8	-1.8

CODEC	TONE FREQUENCY (KHz)	TONE LEVEL IN (dB)	TONE LEVEL OUT (dB)	DIFFERENCE (dB)
MPEG B	.063	-10	-9.5	+.5
	.125	-10	-9.5	+.5
	.250	-10	-9.7	+.3
	.400	-10	-9.8	+.2
	1	-10	-10.7	-.7
	2	-10	-11.6	-1.6
	4	-10	-13.8	-3.8
	8	-10	-17.8	-7.8
	10	-10	-19.1	-9.1
	12.5	-10	-20	-10
	16	-10	-22.2	-12.2

CODEC	TONE FREQUENCY (KHz)	TONE LEVEL IN (dB)	TONE LEVEL OUT (dB)	DIFFERENCE (dB)
G.722 A	.063	-10	-27.15	-17.15
	.125	-10	-27.15	-17.15
	.250	-10	-27.68	-17.68
	.400	-10	-27.68	-17.68
	1	-10	-28.24	-18.24
	2	-10	-28.24	-18.24
	4	-10	-29.48	-19.48
	8	-10	-51.76	-41.76
	10	-10	-51.76	-41.76
	12.5	-10	-51.76	-41.76
	16	-10	-51.76	-41.76

CODEC	TONE FREQUENCY (KHz)	TONE LEVEL IN (dB)	TONE LEVEL OUT (dB)	DIFFERENCE (dB)
G.722 B	.063	-10	-14.4	-4.4
	.125	-10	-25.3	-15.3
	.250	-10	-25.3	-15.3
	.400	-10	-25.7	-15.7
	1	-10	-26.6	-16.6
	2	-10	-27.1	-17.1
	4	-10	-28.8	-18.8
	8	-10	-51.7	-41.7
	10	-10	-51.7	-41.7
	12.5	-10	-51.7	-41.7
	16	-10	-51.7	-41.7

7.7 The Network

The IP/ATM network was set up per the test procedure. The specifics of the hardware are as follows:

CODECS
Ahead Communications MAC–500
Polycom VS 3.23
PictureTel 900 Series
VBrick 6200

Tape Deck
Sony Digital Betacam DVW–500

Video Monitors
Sony PVM 1354Q
Toshiba CF2662

ATM Switch
ADC Access Concentrator

Ethernet Hub
D-Link DSH8+

Ethernet Switch
Link Sys EZXS 55W 2.20

Test Oscilloscope
Hewlett Packard 54601A

Audio Amplifier
UBL 6215

Speakers
Boston CR6

The MPEG 2 CODEC A could not be run through the Ethernet Switch because it had a fiber optic output. This CODEC was connected directly to the ATM Switch. Because of this, network throughput could not be determined on this particular CODEC. The rest of the network throughput results are as follows:

CODEC	Bandwidth as set in software (Mbps)	Measured network bandwith (Mbps)
MPEG A	N/A see above	N/A see above
MPEG B	5.3	**6.9**
	3.5	**5.5**
	2	**4.4**
	1	**4.3**
H.263/G.722 A	.192	**0.6**
	.1536	**0.5**
	.768	**0.3**
	.384	**0.18**
H.263/G.722 B	.768	**0.81**
	.512	**0.54**
	.384	**0.4**

8.0 Protocol Implementation

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

> How to integrate new systems using the new standard into the current system as they come on line.
>
> How to integrate existing systems into the new standard until replaced or upgraded.
>
> How to migrate when the existing system is upgraded to the new standard.
>
> Identify the financial impact and ways to minimize it.

The largest impact of this migration will be to the K-12 pods. In the case of these pods it is the recommendation that each pod upgrade as a whole group. They should do so when the current contract expires. All new sites that come on prior to that date should adopt the current technology used by the pod they will join. Any new pods coming on line should adopt the new standard.

When the pods were originally built, each vendor had to install the CODEC and switching infrastructure to support the specific technology adopted at that time for that pod. The vendor charged an up front "engineering" fee, which helped to absorb some of the cost of that equipment. Some portion of the on going monthly connectivity fee helps to pay for the rest of that capital cost as well as the maintenance and other operational costs over the life of the contract. Our suggestion is that when the pod upgrades as it takes on a new contract, the vendor can then follow this same methodology to cover its fiscal obligations. Though the cost of the new equipment will be different to some degree than the originally installed equipment, taken over the life of the contract, it should be a virtual wash.

An issue related to this concept are those sites who came on late in the contract who may not have paid their full share of the local CODEC and associated switch port costs yet. These will be relatively small in number, and the scale of loss per site will be minimal if any. Such loss the vendor may have could be spread out over the life of next contract.

This plan eliminates the need for many gateways in the system. A single gateway would be needed only when passing between pods, not at multiple sites within a single pod. Each consortium could assess its need to share traffic with other pods 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 precludes the need.

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.

9.0 Next Step

This effort was intended to allow the distance learning networks of the state to interact with each other in an efficient way. The efforts of the NETCOM process may or may not produce a cost mechanism that will allow for increased connectivity to rural locations throughout the state. Even if it doesn't a basic network does exist in the form of many tenuously connected networks, and other independent "island" networks. The work group believes there is a piece missing to link the two in the form of a network protocol solution. As it turns out the NITC has set in motion the very process that this group recommends: to form a new work group tasked with tackling the issue of a communications protocol and managed network connection in the state. The following was adopted by the NITC:

The NITC directs the chairs of the Education Council, State Government Council, and Technical Panel to explore the concept of a Nebraska Education Network and recommend by January 2002 a method for evaluating the feasibility of such a network. The report to the NITC shall be in the form of a charter that includes:

1. *Draft goals and objectives of a shared network;*
2. *Basic requirements of such a network;*
3. *Critical success factors and other issues that should be addressed;*
4. *Description of the potential relationship of the network to NETCOM;*
5. *Potential participants and other stakeholders;*
6. *Scope, outcomes and timeline for the evaluation.*

The standards work group supports this effort and feels it to be the next logical step in creating efficiencies in the distance learning networks in Nebraska.

10.0 Public Comment and Responses

The proposed standards process was published by the NITC to allow for a 30-day public comment period. The following is an attempt to address the issues raised by public comments received. They are in no particular order and the wording is generalized when multiple comments were made that relate to the same topic.

1. H.323 (H.263) is not capable of full-motion quality.

The quality of the video and audio with both MPEG 2 and H.263 is a function of the bandwidth applied to it. Neither standard will be full-motion if bandwidth is too low. Both could be full-motion with enough bandwidth applied.

2. The test should be conducted on a “real” circuit and not in a “clinical” setting.

The concern for this seems to arise from the belief that somehow the standard would be demonstrated better on an external network. There are several problems with this. A “real” network is not defined. There are many different types of networks that exist throughout the current systems of the state. Each is different in its characteristics and would give differing results. Likewise, the established networks could not be manipulated to show how changing parameters could change the video quality. Availability is also at issue. A network does not simply consist of a CODEC at each end of some wires. There are numerous devices that will exist along the connection from point A to point B. Each of these devices would have to be able to switch the standard being tested. Such networks are difficult at best to fine in the state. Likewise, no system in the state exists that could pass BOTH standards over the same equipment making the test by fair and identical for a true comparison. The result is that if we tested the over two different networks, we would see the results of the specific network attached and not the video and audio standard. ALL of the information obtained from such a test would be suspect.

The intention of the test as demonstrated was to show qualities at various throughputs to allow future network planners to make requirements on connectivity vendors to allow the quality the required for the application. By the information given in this document, a system planner at an educational institution can tell the vendor they intend to use the designated standard and require a specific throughput for each channel of video to be used. This information would not have been available if the CODEC had been attached to an uncontrolled network.

It is important to remember that the actual display is a function of the classroom hardware purchased, the quality of CODEC purchased, and the options allowed in the network switching devices. All of these are separate issues from the protocol standard selected.

3. Video tested should not just include talking heads.

Agreed. A variety of video and audio was used during the test. In fact the test included some very active video from a Reading Rainbow segment that went beyond most uses of the current system in terms of video activity.

4. We need a system that will perform at least as well as our current system.

Agreed. The purpose of this entire process is to find a protocol that will allow for the desired quality with a more efficient use of bandwidth. The test results and recommendation permit those system users to determine for themselves what quality will suit their needs. The protocol will not restrict the quality decision, but will facilitate it.

5. Besides bandwidth savings, there is no real incentive to change.

This is not true. JPEG and other systems currently in use will not continue to have hardware availability forever. In fact many of the systems currently in use are either being phased out by manufacturers or are available in a proprietary way only. This will begin to increase costs of both maintenance and future purchases. By moving to a newer more prolific standard, costs can be maintained or even reduced.

6. Can we participate in the test?

All distance learning education related professionals in our state as could best be ascertained were invited to participate in the test. If anyone did not receive an invitation it was not due to a lack of trying on the part of the committee. The NITC was extremely helpful in our efforts to be inclusive.

7. Check out what Kansas did.

We did examine the results of the Kansas study. There methodology was different from ours. The results in the end were the same. The most useful information to the committee found in the Kansas study was that H.263 video uses significantly less bandwidth than H.261 video. We knew this, but the Kansas report put some specific data to that assumption.

8. H.263 will not work for 1 send and 3 receive.

This is not true. The number of connections coming and going is not a function of the protocol or the CODEC. It is a function of the network design. Both MPEG 2 and H.263 can be configured in the 1 send and 3 receive model.

9. Increasing the bandwidth of H.263 to make the quality as good as the current classrooms may increase connection costs.

Not true. In fact, H.263 would use less bandwidth to achieve full-motion than the currently used encoding schemes (analog, JPEG, MPEG 1, H.261).

10. MPEG 1 uses less bandwidth than MPEG 2.

As with many technical assumptions, this depends on how you look at it. To achieve full-motion quality, MPEG 2 uses less bandwidth than MPEG 1. Both drop off in quality rapidly as lower bandwidths are approached. The issue is how much quality is a system willing to accept. If bandwidth is more important to a user, H.263 can satisfy its connection needs at the lower bandwidths much more efficiently than can MPEG 1. If a user must have full-motion quality, MPEG 2 offers this at more efficient bandwidth rates than MPEG 1. In either case, MPEG 1 is not the answer.

11. If a site is on the NVCN system, how would it gateway in?

The NVCN system will be easily updated from H.261 to H.263. The only issue up until now has been the transport mechanism. The switches recently installed in the NVCN system will allow easy passage of both H.261 and H.263 in both the H.320 (ISDN) and H.323 (IP) modes. This switch will act as the gateway. The NVCN switches are already connected to NET, this is how the current gateway works. As a CODEC in the NVCN system is updated to operate at H.263, the gateway functions will not change from the current method. Those sites that rely on these connections currently will continue to be connected in this way.

12. A live source is better than a tape source.

The word "better" is not defined. If one means that a live video source is of higher quality, then the tape shows a worse case scenario and taxes the system even more. That would make the tape a harsher test of the protocol, which is probably preferable. If one means that a live source is preferred, at issue is the ability to tax the system with high motion. This is only really achievable through a videotape of some kind unless the live video was of some scene such as flowing water or passing automobile traffic. Neither of these would be likely controlled or achievable in a classroom setting. On the tape used, various sports footage was used.

13. H.323 (H.263) degrades over distance.

ALL signals (digital or analog) degrade over distance. Proper network design takes this phenomenon into account. The degrading of the signal is not a function of protocol but of bandwidth throughput. If a data stream is not passed along a network with sufficient carrier strength, the result is excessive loss. It is incumbent on the network provider to guarantee a defined minimum throughput. Based on that defined throughput, the provider must design the network with sufficient signal levels to achieve it.

14. Why does the decision have to be made so soon that a live test couldn't happen?

As explained in #2 above the live test would not have made a positive difference to the outcome of the testing. Another consideration is that the Legislature has required those receiving state funds under LB833 to adopt the new standard as recommended by the NITC migration plan in the final version of this document. At issue are both these state funds and federal matching E-Rate funds. The correct decision must be made in time for systems to take full advantage of these funding sources.

15. H.323 (H.263) would not guarantee video quality because of other IP traffic.

If a system chose to pass H.263 in an IP (H.323) environment they have a second decision to make. They could simply put this on an open network that carries other traffic. In this scenario, there would be no guarantee of video and audio quality. They could put this traffic on a closed or protected network in which case there would be no conflicting traffic to hinder the video or audio. Finally they could use a different form of H.263 such as H.320 (ISDN) or H.321 (ATM). In either of these cases the video and audio quality would also be protected.

On another note, these issues are not unique to H.263. If a system uses MPEG 2, the issue and solutions are exactly the same.

16. IP based systems are vulnerable to viruses.

Agreed. As stated before, either of these protocols can be transported in an IP environment or in a non-IP environment. If a system adopts an IP environment, they can protect their systems in the same way they can guarantee video and audio quality above in #15. IP in and of itself does not make the vulnerability. Access determines the degree of vulnerability.

17. Music should be included in the test.

Agreed. The committee had not thought of this issue. Thanks to this comment a music segment was added to the test.

18. NITC will pick only one standard. They should consider more than one.

Agreed. Though not originally considered, the study and test results bore out this conclusion. Ultimately, hardware availability played a major part in the decision to offer a dual standard.

19. State funds should be permitted to invest in enhancing existing systems.

The word "enhancing" is not clearly defined. If by this word it is meant that existing protocols should be improved on in some way with state funds, we disagree. If what is meant is that a consortium should be able to continue to grow indefinitely on the existing standard we also disagree. If what is meant is that a consortium should be able to persist on the currently used protocol until the contract is to be renewed we agree. We also agree that a new site joining an old pod should adopt the standard in use in that pod until the pod-wide contract runs out and the system as a whole upgrades (see the implementation section of this document).

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.

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 know as Motion JPEG.

Kbps

Kilo Bits Per Second – Thousands of bits per second.

KHz

Kilo Hertz – 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

Mega Bits 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

Mega Hertz – 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

Mili Seconds – Thousandths of a second.

Multiburst

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. This concept is still in the formulation process.

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 technology issues 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
In this document the term refers to a consortium of K-12 entities that share classes over some technology based 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).

STEP
Sandhills Technology Education Project – The name of one of the K-12 pods 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 Analysis – A study commissioned by the DOC to determine the telecommunications capacity used and needed by taxing entities in the State of Nebraska for purposes of formulating NETCOM.

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.