Applications for High Resolution Healthcare Images: Present and Near Future

Neil Izenberg, M.D., FAAP
The Nemours Foundation

1. [redacted]
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Need to consider:

[redacted]

Nemours Center for Biomedical Communication

mayo

Thomas Jefferson University | Jefferson Medical College

Applications for High Resolution Medical Images: Present and Near Future

Desirable Characteristics

- *Resolution.* For a number of applications, the better the possible resolution, the greater the potential for diagnostic accuracy. We would want potentially high resolution, which is dialable, and open to improvement as technology evolves.

- *Image stability.* Must be free of quivering artifacts seen with current television technology. Along with resolution this characteristic should be objectively evaluated using standardized images looking for the ability to distinguish between fine parallel lines, etc.

- *Correct color.* Color is extremely important for medical diagnosis. Images can not "smear" or have color "averaged."; they must reflect reality, be accurate and self-correcting. This too can be objectively evaluated.

  Ultimately the ability to for the viewer to select for, or against, selected light/frequency patterns may be useful for certain diagnostic work.

- *Selectability.* Should allow for selectable trade-offs, such as dialable speed vs. resolution, etc.

- *Interoperability.* Imagery collected in various means and stored on various media must be usable together, and viewable (along with fine text) in an interactive environment.

- *Flexibility.* Whatever standards are adapted must take into account that new and improving methods of collecting and manipulating visual data will continue to develop in the years to come. Standards should be left as open and adaptable as possible - and not, in effect, hinder future advances in technologies and applications.

Neil Izenberg, M.D.
October 4, 1993

INTEROPERABILITY WITH FILM

The assets of a film studio are its library titles: whether feature films or television programing produced on film. The revenues generated by a film studio are maximized by distributing its assets in as wide a variety of markets as possible. Distribution by electronic means is a major source of revenue at present, and is expected to increase in share in the future. This is the case for both the domestic and international markets. It is for these reasons that the film production community cannot accept a trade of spatial resolution for higher picture repetition rates.

The Technology Council of the Motion Picture-Television Industry has issued a document calling for a digital mastering format for film: progressively scanned, 24 frames per second with a vertical resolution of greater than 1000 lines. This would serve the international market as it can now be seen to be developing. Europe will almost certainly adopt a standard greater than 1000 lines, Japan has already done so. Feature films for the Japanese market are in preparation for laser disc release now.

It should be noted that the export market for entertainment programing is an important one for Hollywood, even though it represents only 40% of its gross entertainment product. It is second only to aircraft in manufactured product for the United States, with a net positive balance of trade estimated at nearly two billion dollars per year.

The Technology Council is in the process of preparing a comprehensive list of user requirements but it has been recognized that a digital mastering format for film will have to be supported by a recording system with all the features currently in daily use at television studios, such as editors, time code generators et al. Such ancillary equipment will be necessary for the preparation of the digital masters themselves as well as derivative sub-masters as may be needed for electronic distribution.

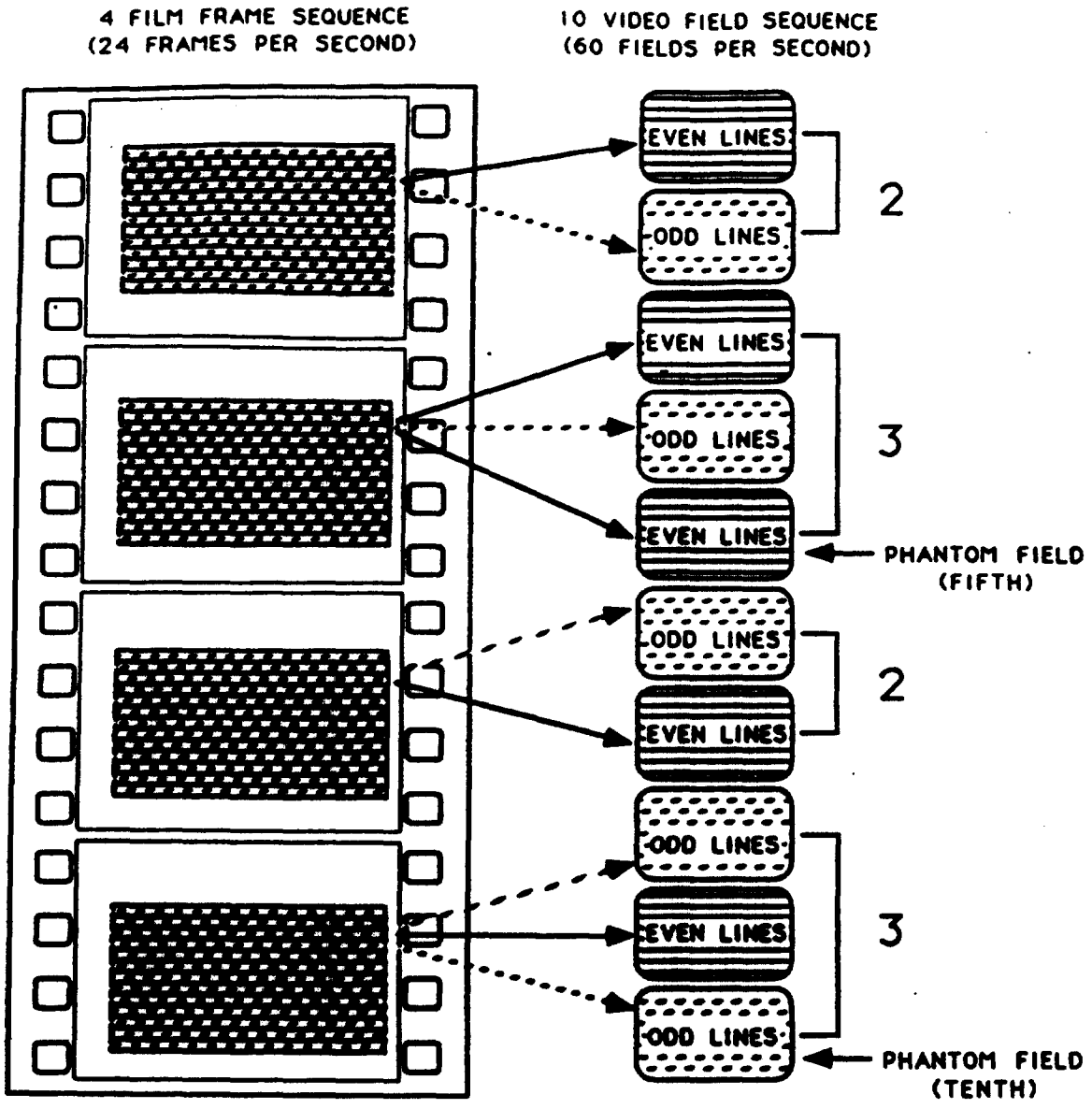
Sony Pictures Studios wishes to lend its support to the format with the highest spatial resolution under consideration, namely

1920X1080; and, in so doing to add its voice to the unanimity of the ACATS Technical Subgroup chaired by Dr. Flaherty and Dr. Dorros. We call upon television broadcasters to converge as well on this format to help reduce the cost of program preparation equipment which does not enjoy the economies of scale of the consumer marketplace.

The technical merits and cost benefits of an interlace, high spatial resolution system for film is detailed in the accompanying diagram. As can be seen, a progressively scanned, 24 frame, digital master is inherent in the digital record. Moreover it should be noted that a clear migration path to a 60 frame per second, progressively scanned image of greater than 1000 lines is also inherent in this approach. In fact, should a receiver manufacturer wish to implement such a display for a film program , it could be delivered to the home by the Grand Alliance proposal and displayed even now.

William G. Connolly
Sony Pictures High Definition Center

TELECINE 3/2 PULLDOWN SEQUENCE



- THERE IS <u>NO TEMPORAL CHANGE</u> BETWEEN FIELDS" WHEN SCANNING A FILM FRAME
- CURRENTLY, LINES CONSTITUTING THE FILM FRAME ARE CLOCKED OUT ALTERNATELY
- THIS RESULTS IN AN IMAGE IDENTICAL TO A PROGRESSIVELY SCANNED IMAGE

NOTE: BY DROPPING EACH FIFTH PHANTOM VIDEO FIELD A 24 F.P.S. VIDEO SEQUENCE RESULTS

Be[illegible] [illegible]ision

~~29.97, 59.94 Frame Rates~~
- Awkward conversion

~~Interlace Scan~~
- Unnecessary complication
- Exacerbated artifacts
- "Interim" standards persist

~~Non-Square Pixels~~
- Inefficient image manip.

~~Quasi-Scalable Hierarchy~~
- Unrelated spatial and temporal formats

24, 30, 60 Frame Rates
- 25, 50, 75 as alternate

Progressive Scan
- Achievable now
- Facilitates image processing
- Market enabler

Square Pixels
- Efficient image manipulation

Scalable Hierarchy
- True future extensibility
- 1280x720, 1920x1080 to start

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HEWLETT PACKARD

4 October 1993

Mr. Robert L. Sanderson
Chairman

Mr. Michael Liebhold
Vice–Chairman

Joint Experts Group on Interoperability
Advisory Committee on Advanced Television Systems

Dear Sirs:

The following is in response to the Sept. 30 Interim Report from the Grand Alliance, entitled "Interoperability Aspects of the Grand Alliance HDTV System," and the accompanying slide set, both of which were distributed for review prior to the upcoming Interoperability Review meetings in Washington this week. Again, let me express my regrets at being unable to attend these meetings, but I am sure that Mr. Barry Bronson from HP Laboratories will do a better job than I could at this time in representing our positions.

The documents provided contain some very encouraging proposals, particularly in the areas of transport and compression interoperability. These proposals represent a significant step forward from those seen earlier, and certainly show serious consideration of these aspects of the future HDTV standard. However, there is at least one part of this report which is cause for serious concern, and that is what is being called here "picture layer interoperability."

As the GA report itself notes, what is being discussed is a transmission standard – not a production standard, and not a display standard. However, while it is true that production, transmission, and display are decoupled in a digital system. we cannot neglect the impact that standards in any of these areas will have on the other two. They are decoupled, but cannot be considered unrelated. This is especially true from the perspective of those of us in the computer industry, who may reasonably expect to provide systems which must exhibit interoperability with all three of these areas. Several papers have already been published which outline the concerns of our industry; among these, I would like to specifically mention "HDTV: Technical Issues of Special Importance to the Computer Industry" from Apple Computer's Advanced Technology Group, and "The Need for a Specific, Benchmarked Migration Path to an Interoperable ATV System," a white paper prepared by the Computer and Business Equipment Manufacturers Association (CBEMA). These papers do an excellent job of summarizing the general concerns of our industry.

I would like to concern myself here, though, with several very specific proposals in the areas of frame rates and spatial formats, and the arguments which have been presented for each. One of

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the most striking aspects of the GA report is the proposal to include a very large set of permissible formats and frame rates in the transmission standard. While the use of a hierarchy of related formats and rates has been one of the cornerstones of all recommendations for an interoperable system, this is not the approach being taken here. There are instead multiple unrelated formats and temporal rates, including both interlaced and progressively–scanned formats and rates based on both 60.00 Hz and 59.94 Hz rates. This is not in the interests of either interoperability or an acceptable international television standard, and there is no justification presented for many of these choices. In the following sections, I will address some of these issues separately and in greater detail.

1. The Choice of Frame Rates

The Grand Alliance is proposing that the transmission standard permit both 24, 30 and 60 Hz rates and the "NTSC–compatible" family of 23.97, 29.97. and 59.94 Hz. The reasons given for the use of the 59.94 Hz group are supposedly better compatibility with NTSC during the expected simulcast period, including both use of existing NTSC source and the display of NTSC transmissions on an HDTV receiver. This is a very unwieldy proposal, as it will be very difficult for a single set of hardware (as will be expected of the computer industry) to simultaneously support both sets to the necessary degree of accuracy. Further, there is really no compelling reason for choosing this path:

- Using 59.94 and related rates to maintain compatibility NTSC source is unnecessary for several reasons. First, the majority of prime–time programming – the source from which HDTV might be expected to draw most heavily from past material – is, by the GA report's own admission, originally shot on film, not NTSC video. Surely the use of this material by HDTV will best come from the use of the original film footage, at the 24 or 30 Hz modes already included in the GA proposal. What NTSC video remains unavailable in any but the NTSC format can simply be converted into 30 or 60 Hz HDTV by duplicating one field out of every 1000, something which can be done at scene cuts or other points in the original which will not result in a visible artifact. Requiring 59.94 Hz transmission, and supposedly therefore HDTV production at this rate, further does not do away with the problem of the final transition to 60 Hz. Instead, it makes it even more difficult, as we could reasonably expect that in the future we would also then have a sizable archive of 59.94 Hz HDTV material in addition to the existing NTSC stores.

- The use of 59.94 Hz also does not simplify either HDTV receiver design or the display of NTSC transmissions on HDTV receivers (or vice–versa, via an external converter feeding an existing NTSC receiver). Per the GA report, the HDTV receiver would now be expected to handle both the 24/30/60 family of rates and 23.97/29/97/59.94 – which cannot help but complicate the design, particularly in the area of maintaining accurate timing, over a single–family solution. Given the fact that the HDTV receiver must include a large frame buffer and circuitry for performing spatial and simple rate conversions, and much better solution would be to simply allow the receiver to perform the deinterlacing and field duplication mentioned above. Conversely, a converter for the display of HDTV transmissions on an NTSC receiver will essentially be the "front end" of an HDTV receiver, and can therefore reasonably be expected to perform a frame drop to display 60 Hz source at 59.94. (It must already have the needed memory, etc., as it will have to handle the 24 and 30 fps modes of HDTV.) Actually, such a conversion may not be needed – the majority of current NTSC receivers will likely work quite well with HDTV converted to a 60.00 Hz NTSC–like signal.

- The GA report implies that HDTV receiver standards and computer display standards will remain completed unrelated, owing to a supposed need for the HDTV receiver display to

operate at a line rate which is some multiple of the current NTSC rate, and due to the belief that the computer display industry does not have any suitable display standards anyway. Both of these are in error. Taking the latter first: it is certainly true that in the past, there were no true standards in the computer–display industry, and the timings which were in use were not selected for compatibility or interoperability. This is rapidly changing; the computer industry has recognized the need for compatible standard timings, and has developed such standards. The Video Electronics Standards Association (VESA) is a industry group to which I am currently HP's representative, and I can assure you that format and timing standards are a very important aspect of that group's activities. In fact, a set of standards for several related computer display formats (640 x 480, 800 x 600, 1024 x 768, and 1280 x 1024) were recently developed for 75.00 Hz refresh, specifically to address the need for display standards which were interoperable with existing and expected future video standards. One might even argue that the approach being taken here – developing standards for a set of related formats and rates – is exactly what is needed in HDTV.

Basing HDTV receivers on integer multiples of the NTSC line rate is unnecessary; as discussed above, there are other ways to achieve NTSC compatibility without tying the receiver to this past standard. For true interoperability, we might instead propose that the HDTV display standards be developed in cooperation with computer–display groups such as VESA and similar groups from other concerned industries.

- The GA report also completely ignores the issue of acceptability of this proposal as a worldwide standard. Surely, if any of the arguments regarding NTSC compatibility are valid, they will remain valid when considering the potential use of such a standard in areas currently using the 50 Hz PAL or SECAM standards. In keeping the 59.94 Hz rate family, the GA has taken a major step away from such worldwide acceptance.

2. The Choice of Spatial and Scanning Formats

The GA report present a bewildering array of spatial and scanning options: the expected 1280 x 720 and 1920 x 1080, plus 1440 x 1080 and 1728 x 960. All but the 1280 x 720 format are being considered for initial use as 2:1 interlaced. It is true that the final selection of the 1000+ line format, according to this report, has not yet been made. However, several aspects of the formats being considered are of great concern:

- The 1440 x 1080 and 1728 x 960 formats should be viewed as unacceptable for several reasons. First, neither of these is simply related to either of the other two, while 1280 x 720 and 1920 x 1080 have a very usable 2:3 relationship. Further, the pixel aspect ratio of the 1440 x 1080 proposal is non–square, and has no compelling reason which would justify this step away from full interoperability. Both of these come from relationships to the NTSC format; 1728 x 960 by doubling the line count, and 1440 x 1080 by doubling the number of pixels in the horizontal dimension from a supposed 720 x 480 digitized version of NTSC. Neither of these features is necessary; as discussed above, maintaining an integer multiple of NTSC lines is not required, given the spatial conversion capabilities which must already be a part of any HDTV receiver or convertor. Further, the 720 x 480 digitization of NTSC (on which the 1440 format is based) is non–square, and represents a horizontal resolution which is beyond the capability of broadcast NTSC. It would be better from an interoperability point of view to assume that NTSC is digitized as 640 x 480, which is square and which is already in widespread use as a standard display format

- All of the >1000 line formats are discussed in terms of their use in an interlaced scanning mode at the time HDTV is first introduced. Interlaced operation is certainly not desirable from

the standpoint of maximizing interoperability, and has no compelling reason which would justify even its initial use. The arguments presented in favor of interlaced formats have to do with the impracticality of full-rate progressive scan cameras and displays. However, none of these arguments justify the use of an interlaced transmission standard, as follows.

An interlaced transmission would supposedly allow a high-resolution, high-end receiver which would de-interlace the transmitted image for display. It is also argued that the interlaced transmission would permit a less expensive receiver using interlaced display. However:

1. The interlaced transmission has ALREADY given up vertical resolution which cannot be restored simply by deinterlacing in the receiver. In the case of an interlaced receiver, the effective vertical resolution will be comparable to that obtained with the proposed 720-line progressive-scan display, but with poorer motion rendition and the usual interlace artifacts.

2. Even if the full 1920 x 1080 resolution COULD be restored in the receiver, there will be no display capable of adequately displaying the resulting image. Horizontal sweep rate issues aside, there simply isn't going to be any tube suitable for such display in consumer equipment. It is important to note that in comparisons between proposed 720-line progressive and ~1000-line interlaced receivers, the CRT and video amplifier is assumed the same for each, and would not be capable of the full 1920 x 1080 resolution in any case. If a low-cost consumer receiver is desired, we might consider the possibility of a 720-line interlaced set; interlaced display is always simple to achieve from a progressive transmission, and such a display would be even less expensive than the 1000-line interlaced units proposed so far. A 720-line interlaced receiver would not, as some have claimed, have any problems in dealing with an NTSC transmission. Again, given the memory, etc., which is already required of such a receiver, reception of NTSC at 240 active lines per field will be readily achieved by a 1.5:1 upconversion to the 360-active-line fields used in the interlaced HDTV receiver.

3. If we grant that both the sweep rate cost and tube issues could be solved simply by throwing enough money at them (I am willing to consider this as a VERY high-end receiver), this would still be expected to represent a very small share of the market for the foreseeable future - certainly not reason enough to take the interoperability hit that permitting interlaced transmission would cause. We must also note that, at expected display sizes and viewing distances, the image quality of a true 1000+ line display (if one were available) would not be significantly better than that of a 720-line display.

4. There is already a 1920 x 1080 x 24 film mode proposed, and a 1280 x 720 progressively scanned receiver would have to be capable of displaying transmissions using this mode. Therefore, the ability to handle 1920 x 1080 information is already a part of the system. I have heard no arguments which suggest that a deinterlaced 1000-line interlaced transmission, displayed on what we might reasonably expect for a high-end consumer tube, is going to look significantly better than 1920 x 1080 x 24 feeding a 1280 x 720 x 60 progressive-scan display. Of course, the hypothetical high-end proscan receiver might reasonably be expected to be bought by the same people who are the market for laser disc, etc., today - those who want high-quality movies. 1920 x 1080 at either 24 or 30 fps with progressive scan would work very well with their 60 Hz (or even higher!) progressive displays, and such a receiver would certainly be capable of handling the 1280 x 720 x 60 progressive transmission expected for sports and other motion-critical programming.

Arguments for an interlaced transmission format based on the need for interlaced cameras are also in error. The GA report assumes that the HDTV receiver will be capable of handling all proposed formats; this implies that, for a 720–line progressive–scan display, a simple, economical, and effective method of deinterlacing such a transmission will be available. However, if such a technique is available, then it more properly belongs at the point of program origination, prior to encoding and transmission, in order to keep the overall system cost down and to maximize performance. If deinterlacing cannot be achieved with high quality at a sufficiently low cost for use in consumer receivers, then it most certainly belongs in the production area -- not in the consumer display. In either case, the transmission standard remains fully progressive for the best interoperability, and the task of the consumer receiver/display is simplified for lower cost. There is simply no justification whatsoever for the use of interlacing in the transmission standard.

3. The Need for a Scalable Hierarchy of Formats and Rates

Many sources, most notably the report from the SMPTE Task Force on Digital Image Architectures (published in Sept., 1992), have called for the establishment of a hierarchy of related formats and rates which would provide for easy scaling and conversion among its members. Adopting such a strategy of considering the format and rate set as a whole is, in my opinion, essential to meeting the goals of interoperability, scalibility, and extensiblity for the HDTV standard. The GA proposal fails to do this; not only are the formats and rates being considered often unrelated, but there is the implication that the initial HDTV transmissions will use an "interim" standard, to be later discarded in favor of the ultimate 1920 x 1080 x 60 goal. This is an unrealistic approach. We should assume that the initial transmissions will be made using a set of formats and rates which IS a part of an overall hierarchy, and that they will continue to be used even after the more difficult members of that hierarchy become practical to use. To design a system using the assumption of a temporary "interim" set of formats does nothing to enhance either interoperability or backwards/forwards compatibility. Indeed, as noted earlier, this makes the compatibility issues more difficult to deal with. It forces a second conversion to an unrelated "final" standard at a later date -- after considerable material may be expected to have been produced using the "interim" standard. We should therefore insist on an approach which is based on a complete hierarchy, with a clear path showing how all members of that hierarchy can be introduced and used.

The sensible hierarchy, based on what we know of the GA proposals so far, would seem to be at least the following (all progressively scanned):

24 fps: 1280 x 720, 1920 x 1080

30 fps: 1280 x 720, 1920 x 1080

60 fps: 1280 x 720 only (until 1920 x 1080 practical).

(I am disappointed that so far, there has been little discussion of lower–end formats (say, 640 x 360 or 854 x 480, depending on whether or not the 3:2 scaling of the above is kept), and/or the option for transmitting even higher resolution still imagery at reduced frame rates.)

As I said at the beginning of this letter, I am encouraged by many of the steps taken by the Grand Alliance in this proposal, and feel that we are definitely converging to a truly interoperable HDTV standard, one which will see widespread use in many industries around the world. But I would ask that this panel and the Alliance carefully consider these issues, and address them in a manner consistent with developing the best possible standard for all concerned.

Sincerely,

Bob Myers
User–Interface Hardware Lab
Advanced Systems Div.
Hewlett–Packard Co.

cc: Mr. Barry Bronson, HP Laboratories

Comments on Interoperability Aspects of the Grand Alliance HDTV System

Robert F. Sproull, VP & Fellow, representing Wayne E. Rosing, Exec. VP
Sun Microsystems Laboratories, Inc.

October 6, 1993

Interoperability of broadcast material with computers and workstations are most strongly influenced by the following requirements:

1. An all-digital implementation (PS-WP4 rec 1)
2. A well-designed layered communication architecture (PS-WP4 recs 2,4,5,8)
3. Compliance with international standards (PS-WP4 rec 10)
4. Progressive scan (PS-WP4 rec 3)
5. Square pixel aspect ratio (PS-WP4 rec 9)

With minor exceptions, the current GA proposal does an excellent job of meeting these requirements.

Data type independence. The success of this broadcast standard over a long period will require that the modulation and data transport layers be able to support a wide variety of data carriage. In addition to transmitting motion pictures, this broadcast standard will be used to transmit wholly different information types such as high-resolution static images representing magazines and newspapers; text data that is part of news feeds, consumer information, government publications; and many others. The burgeoning Internet and developing National Information Infrastructure exemplify the country's appetite for data transport.

To accommodate such a range of data types, the "packet type" field of the transport layer is used to label each type uniquely. It is essential that the assignment of packet types be administered so as to meet these diverse needs. These assignments should be controlled by a standards group, distinct from groups responsible for the format of the data types themselves.

While the method of administering packet type codes might appear unimportant, it is vital to the aggressive evolution of broadcast material. Product development cycles for digital decoders, algorithms, and equipment are short compared to those for modulation and broadcast equipment. Suitably decoupling the modulation and digital domains will permit rapid evolution of content and services within the broadcast framework.

Comments From Gary Demos
FCC ATV Interoperability Review Board Member
6 October 1993

Attachments: *8 Page List of Questions for G.A.*
Cooperation Between SMPTE and MPEG Systems (UniPack/MPEG-2 summary)
MPEG-2 Transport Stream Mapping and Adaptation Layer Fields for ATM
Use of adaptation_field_control reserved code (UniPack/MPEG-2 mapping)

My Major Concerns:

Interlace is not interoperable.

59.94 and 60.0 Hz are problematic, when 70+ Hz is required.

I don't believe the assertion that 59.94/60 Hz on 72/75/76 Hz display is acceptable.

We need a reference resolution for creation of N.I.I. content. I suggest 1280 x 720 prog.

Low latency is critical for N.I.I. interactive use. Only the AC leak can provide this.

Other Concerns:
Should an overlay plane definition be part of the ATV system?
Should an open text and graphics language (like SGML) be specified as part of ATV?
Multiscan is an unacceptable requirement for all receivers. Should only be premium units.
Interaction of the transport stream, universal header, encryption, and ATM needs testing

Suggestions:
The G.A. system should be made flexible in aspect ratio for movies (1.33, 1.85, 2.35).

By locking down 1280 and 1920 as horizontal resolutions, a variety of vertical resolutions, using square pixels, can be used to support a variet of aspect ratios.

1440 x 1080 should be replaced with 1280 x 1080 for compatibility with 1280 x 720.
- If non square pixels are going to be used, maintaining 1280 horizontal is preferrable

1920 x 1080 at 24 Hz is apparenly feasible now with the G.A. system.

Use residuals to enhance from 1280 x 720 to 1920 x 1080.
- minimizing 1280 x 720 decoding costs.
- allowing 1280 x 720 displays to receive all ATV pictures.
- ensuring N.I.I. compatible progressive scan capability, compliant with reference.
- residuals can enhance picture further for 40 Mbit/sec cable systems.
- residuals can enhance picture for DVTR release using 50Mbits/second.

A high resolution still image mode (like Photo-CD) should be created and tested.

Conditional replenishment, is association with alpha blending should be part of ATV.

The G.A. should evaluate UniPack as a universal packet header candidate, since its definition is mostly worked out in the context of the the G.A./ MPEG-2 transport

Synchronize nationally to the 8kHz ATM/Sonet clock

Questions From Gary Demos
FCC ATV Interoperability Review Board Member

FCC ATV Interoperability Review, October 6,7 1993

Questions For The Grand Alliance

Computer Screen Text And Graphics Display

1. *How would you propose to handle non-band-limited image data? Such data is typically presented on computer screens as text, window borders, and graphics. Such data is typically raster-aligned and is usually created from a source format such as run-length coding, Adobe Postscript (tm), Apple Macintosh quickdraw (tm), X-Windows (for Unix), or Microsoft Windows (tm) (for PC DOS). Would you use overlay planes in the receiving device? If so, how many bit planes should be specified(2 or 4)? If no overlay planes are specified as part of the system, would you put this image data of text and graphics through your compression algorithm?*

2. *If overlay planes are selected as the preferred mode of sending text and graphics overlays, how would you propose that WP-2 test this capability?*

3. *Are the data areas in your system sufficiently robust, or could they be augmented with further error correction such they might contain graphics screen data as described above (in 1)? Postscript and other screen or printer formatting data types are extremely intolerant to errors. How could errors during screen display be handled if they were to occur? How should WP-2 test the sending of such graphic and text representational formats in the presence of anticipated impairments and errors?*

4. *What mechanism should be used to decide what screen presentation language formats should be supported by advanced television systems? Should the FCC decide using one or more non-proprietary data representations, or should proprietary and non-proprietary display data representations be supported? Example choices might be open standards such as Standard Generalized Markup Language (SGML) using Clear Text (ASCII) encoding (or Binary encoding), or alternatively Open Document Architecture (ODA). A Document Type Descriptor (DTD) for SGML could be easily defined for ATV use. What complexity would be associated with supporting more than one such format for interpretation to everydisplay? What graphics language and syntax should be used to support maps and other graphics?*

5. *Would you expect to see numerous fonts supported in every receiver? What would be the additional receiver display system complexity associated with a large number of fonts vs a few simple fonts? Should the fonts be standardized for every receiver? If so, should WP-2 test the set of fonts selected? Should WP-2 test graphics and text language compliance and functionality?*

6. *Jim Clark, the founder and Chairman of the Board of Silicon Graphics, says that we should plan for 3-D computer graphics in the receiving display. How do you think such 3-D graphics would be integrated with the advanced television picture? How would you expect to support 3-D graphics, and what data formats would you expect to use? Is the data area appropriate and sufficient for this purpose?*

7. *If 3-D graphics were to be used for a backgrounds, and advanced television were to be used for foregrounds, a transparency (or alpha) channel would be required in order to provide anti-aliased matte edges. How would you anticipate sending a partial image together with a transparency channel for such a 3-D and advanced television hybrid moving image? Could there be a mechanism for supporting multiple optional overlays using this technique (e.g. for maps). If such an image compositing capability is feasible with the G.A. system, how should WP-2 go about testing this capability?*

Flexibility Of System

1. *Is the G.A. system somewhat independent of scanning parameters, within limits? What do you estimate the range of such flexibility in scanning parameters might be?*

2. *Should WP-2 test the limits of flexibility of resolution and frame rate for the G.A. system? How should WP-2 go about performing such tests?*

Reference System

1. *Should there be a reference display that could be used to compose text, graphics, and other image material?*

2. *Should the reference display have the resolution of 1280 x 720? Would this be sufficient and suitable as the reference for all National Information Infrastructure (N.I.I.) uses? (Such uses might include education, medicine, collaborative work, library reference, scientific research, etc.)*

3. *If 1280 x 720 is used as the progressive scan and square pixel reference display for composing image material, would not the "1000" line format need to be at least as good in displaying these images as the reference? Would not the "1000" line format therefore need to be progressive scan, since interlace at this resolution would be unnacceptably inferior to the 1280 x 720 reference?*

4. *How would WP-2 test compliance with the display quality of the reference used to compose images, text, and graphics for interoperable uses?*

Receivers

1. *What is the concept of the G.A. concerning formats accepted by receivers? Is it anticipated that receivers will all need to be multi-scan-rate? Doesn't this cause a cost burden on every receiver, and preclude providing low cost receivers?*

2. *If 1280 x 720 progressive were to be the "reference system", would it be the intention of the G.A. to support all formats for direct and optimal display on 1280 x 720 single-scan-rate receivers? How could cost be optimized for any format conversions required in order for all G.A. transmitted formats to be optimally presented on 1280 x 720?*

3. *Would data rates and memory sizes be optimal if a 1280 x 720 signal were always present in the ATV signal, such that it could always be decoded directly?*

4. *For presentation of ATV images created using a reference 1280 x 720 system, do you anticipate that 480 line NTSC would have to zoom a factor of 3/2 using progressive scan NTSC (ITV), and a factor of 3 using normal interlaced NTSC, in order to read the text and graphics acceptably?*

Resolution Scalability

1. *Could your system be expanded to include resolution scalability in the compressed format?*

2. *It appears that receiver cost would be optimized at 1280 x 720 if the 1280 x 720 ATV signal were to be decoded directly (without conversion from higher resolution formats). Would this not be optimized if any higher resolution formats, such as 1920 x 1080, were coded as*

a residual on top of 1280 x 720? Would not the optimal quality and lowest cost be provided for a 1280 x 720-only display if the ATV signal is always present at this resolution, and the residual for 1920 x 1080 (or other higher resolution) could be ignored.

3. *Will the proposed G.A. system have a higher priority portion of the transmission, like the former ATRC and AT&T/Zenith proposals)? Could a reduced resolution format be decoded from the higher priority?*

4. *The G.A. has indicated that they are interested in being compatible to some degree with MPEG-2 transport and compression. How will this affect the desire by some to use MPEG-2 for multiple NTSC channels in one 6MHz band? Will it be possible to share a 6 MHz band between both MPEG-2 and ATV in the same modulation? What would be the proportional bit rates for such a shared channel? Would 5 Mbits/second be used for MPEG-2 and 15 Mbits/second be used for ATV, with 20 Mbits/second as rate of the 6 MHz modulation (after ECC)? Would it be more efficient to code wide-screen progressive-scan NTSC at 864 x 486 as part of a layered ATV signal, with residuals for 1280 x 720 and 1920 x 1080 resolution enhancements?*

5. *What is your estimate of the cost of a receiver for each year during the next decade for your full advanced television format?*

6. *Zenith has demonstrated 40 Mbits/second over a 6MHz channel on cable. If this doubled data rate were to be allocated for augmentation of the advanced television picture, could your system be expanded to offer higher resolution beyond the first 20 Mbit/sec advanced television format? Should WP-2 test the ability of the G.A. system to offer higher resolution using 40 Mbits/sec? Would the resolution best be enhanced by using a resolution-enhancing residual?*

7. *How important do you think square pixels and progressive scanning may be in creating resolution scalability?*

8. *How could your system be used to send a color still image to a color printer? Could the data area be used in conjunction with the main picture stream to provide this capability? What higher resolution could be achieved? What should WP-2 do to test high resolution still image transport using the G.A. system?*

Temporal Rate

1. *It is my understanding that the proposed G.A. system can provide a 24 frame per second image stream from motion pictures, such that a 72 Hz refresh display could be used. Is this correct?*

2. *Computer displays require a refresh rate which exceeds 70 Hz. How can your system be used or modified to allow presentation of advanced television on computer displays in the home or office? Would there be motion artifacts in such a presentation, and if so, how problematic is their appearance? How would you propose testing this for acceptability in the interoperability testing which will be performed under WP-2?*

3. *If both 59.94 and 60.0 Hz are found to be unworkable for these reasons, could your system be adapted to 72 or 75 Hz? How big of a modification would be required and what would be the expected performance?*

4. *If temporal rate compatibility with computer displays is deemed to be critical, can these temporal rate issues be tested with your system? How much time and effort might such testing take? Can we plan for operating the G.A. system at 72 /75 Hz in the WP-2 testing process in order to verify operation at these refresh rates.*

5. *It appears that there is a cost advantage from having the display rate be an integral multiple of the image update rate. For example, if the display rate is 72 Hz, then the image update rates of 72, 36, and 24 images per second are integral multiples (or 75, 37.5, 25). Use of integral rates allows double buffering. Use of non-integral rates, such as 24 frames per second for movies and 60 Hz for display, requires triple buffers to adjust for the non-integral rate relationship. Similarly, artifacts are minimized by integral relationships. Would there be a cost and performance advantage by restricting the ATV rates to 24, 36, and 72, or 25, 37.5 and 75?*

6. *The strong pressure to have ATV operate at 59.94 Hz and 60.0 Hz is coming primarily from those who favor entertainment-only and passive television-only uses. These have primarily been broadcasters, although others have also endorsed these numbers. Since NTSC, which is the source of this rate, is a low resolution medium, why is it being used to set the ATV rate? Isn't motion picture film, which operates at 24 frames per second, the more dominant force in selecting an appropriate ATV frame rate, since film represents our vast resource of existing high resolution materials. Is it proper that the broadcasters and other interests who are pressuring for 59.94 and/or 60.0 Hz carry so much weight that they are precluding an objective consideration of 72 or 75 Hz as the appropriate rate for ATV?*

7. *Zenith demonstrated 40 Mbits/second in a 6MHz band on cable. How best should the extra 20 Mbits/second be used? Zenith demonstrated a pair of 20Mbits/second ATV channels. Would some combination of enhanced resolution and improved temporal rate be another appropriate use of the factor of two increase in data rate available on Cable? Would this best be done by using a temporal rate enhancing residual as well as a resolution enhancing residual?*

Temporal Rate Scalability

1. *Could the use of motion vectors and compressed corrections, which is the G.A. proposal, be used to create a hierarchy of temporal decoding rates? For example, could 24, 36, and 72 Hz image update rates all be decoded directly from the same scalably compressed format? When is it estimated that motion vector technology will be useful for temporal rate conversion? Are estimates correct that this is at least ten years away?*

2. *Can your system be modified or adapted to update different regions of the image at different temporal rates? If your system already does this in a hidden fashion, is it possible to provide this "conditional replenishment" update capability more explicitly to more fully optimize image presentation?*

3. *Should conditional replenishment or variable screen update capabilities be tested by WP-2?*

4. *Can your system be adapted to provide higher resolution at 24 frames per second than for higher frame rates? In your opinion, would such higher resolution at 24 frames per second provide an enhanced viewing experience of movies over using the same resolution for 24 frame per second material as for the higher rates?*

5. *What should WP-2 be testing with respect to 24 frame per second material? The previous round of testing did not test this directly, but rather only tested 3/2 pulldown embedded in the signal. Should enhanced resolution at 24 frames per second be tested in WP-2?*

Channel Capacity Scalability

1. *During the next ten to twenty years, fiber communication will provide bandwidth to homes and offices in the hundreds or thousands of megabits. The proposed advanced television formats use approximately 20 Mbits/second. How should capacity of hundreds or thousands of megabits be best used? Can your system easily scale to use 40 or 80 Mbits/second? What format parameters would you improve? Examples include wider gamut colorimetry and dynamic range (more bits per pixel), wide screen aspect ratios, higher resolution,*

more sound channels, higher temporal rate, stereoscopic display, multiple screens, parallel information channels, etc.

2. *If greatly increased digital capacity were to be available in the future, could you adjust your system to use variable data rate in order to provide more constant image quality?*

3. *What should be tested in WP-2 with regard to the G.A. system's capability for utilizing 40 Mbits/sec or for using variable data rates between 20 and 40 Mbits/second?*

Channel Interoperability

1. *In the G.A. proposal, 188byte packets are used with a 184 byte payload. How would such packet schemes be related to such protocols as ATM which uses 53 byte packets with a 48 byte payload? How would packet priority be used with ATM or other such systems? How would packet dropping or errors be handled?*

2. *What does the G.A. think of the proposal to use one byte in each ATM cell which is divided into 4 bits of sequence number, 3 bits to form a 12 bit checksum with the three other cells, and 1 bit for an ECC code block flag? The sequence number identifies dropped packets, the checksum identifiers errored packets, and the ECC code flag allows low cost decoders to ignore error correction blocks.*

3. *What should be tested in WP-2 with respect to ATM transport of the G.A. data stream?*

Clock Synchronization

1. *A variety of applications will require synchomization of multiple ATV images, including collaborative work, video conferencing, and multiple ATV windows on the screen. How is this best achieved?*

2. *The ATM/Sonet network will have a nation-wide 8kHz reference clock. Would it be a reasonable plan to lock all ATV sources to the nationwide 8kHz clock reference?*

3. *If no synchronization is provided, how much cost and quality degradation do you estimate for the picture and for the audio due to the required resampling?*

4. *Should WP-2 test synchronization of multiple ATV signals in a collaborative work simulation?*

5. *MPEG-2 and CCIR-601/656 have selected a 27 MHz data clock for use with a 13.5 MHz pixel clock. The 27 MHz clock is biased toward non-square pixel formats using 720 pixels in CCIR 601. This is highly problematic for interoperable computer applications which require square pixels and progressive scan. What is the plan for ATV clock rates?*

Data Encryption

1. *It may be desirable to encrypt the advanced television data in order to protect the image and sound from unauthorized viewing. Although the advanced television proposed systems are being tested in the presence of data errors, they are possibly not being tested in an encrypted form. What encryption algorithm for your system's data do you favor? How sensitive is such an algorithm to errors in the data? How would data errors affect the picture quality since the data errors occur in the encrypted data stream? How would networks such as ATM networks with potential packet reordering or dropping affect encrypted data?*

2. *What should be tested in WP-2 with respect to encryption and data errors?*

Latency

1. *Many applications of ATV will require interactive use. The most critical factor in interactive use of ATV will be the end-to-end delay. In the first G.A. presentation, it was indicated that the AC-Leak can achieve an end-to-end delay of 1/10 of a second, whereas the use of I-frames (as in MPEG and MPEG-2) results in an end-to-end delay of 1/2 second. Are these delay times, as presented previously by the G.A., correct?*

2. *Isn't this a crucial issue for ATV system architecture for such applications as video conferencing, collaborative work, interactive server-based games, and navigation of services? If so, isn't the need for the AC Leak a critical requirement?*

3. *Since the use of I-frames, in the style of MPEG-2, is said to cause a 1/2 second end-to-end delay, how much more delay is added by the use of B-frames? Aren't B-frames only useful for coding 24-frame per second movies?*

Interactive Two-Way Communication

1. *Current television delivery via terrestrial broadcast, satellite, and cable is predominantly one-way broadcast. When fiber systems come into existence, two way interactive communication will become feasible. How would you best make use of this two way or interactive communication capability with your advanced television system?*

2. *What is your estimate of the cost of an originating workstation for teleconferencing in your advanced television format over each of the next ten years?*

Storage Media

1. *How would you propose to format advanced television on video tape and video disk type devices? What would be the likely affect of media errors? How might fast forward and fast reverse be implemented?*

2. *Is it feasible to have scalable quality levels for media such as video tape and video disk? Could useful advanced television be presented at 5, 10, 25, 40, 50, or 80 Mbits/second to provide various cost/quality and play length levels? Would a layered residual compression format be optimal for providing this flexibility?*

Compression Efficiency Extensibility

1. *Digital image compression technology, upon which all of the digital HDTV proposals are based, is a rapidly advancing field. Technical developments in just the last two years have seen major new developments and improvements in compression quality and efficiency. This trend is likely to continue for many years. How can your use of data compression take into account rapid major advancements in compression techniques? Can you devise a method to extend your system by upgrading to new more efficient compression while not resulting in immediate obsolescence for those receiving displays using the currently proposed compression technique?*

2. *Do you anticipate that decompression chips in receiving displays will be programmable to some degree? How would you take advantage of such programmability?*

Use Of Header/Descriptor

1. *In the proposed advanced television system, the packet and error protection structure is such that these are placed at the outer most layer. One goal of the header/descriptor is to help identify unknown data streams. For this purpose, it was originally conceived that the header/descriptor would be the outer-most layer. How could your system accommodate the header/descriptor as an outer-most layer? If you intend for the header/descriptor to be an inner layer, how would you propose that it serve its universal identification function for data streams?*

2. *The proposed advanced television system allows acceptable transmission of picture data in the presence of data errors. Audio data and data within the data area may need to be almost error-free. The header/descriptor must also be interpreted without errors in order to function properly. Redundant transmission, error-correction-interleaving, and a separate transport header are possible mechanisms. How might your system expect to support the error-free header interpretation requirement?*

3. *In some of the proposals, data is grouped into packets which are prioritized. In all proposals, the data contains the separate elements of audio, picture brightness, color, motion vectors, data areas, etc. How would you propose to use the header/descriptor to identify each such data sub-area?*

4. *The UniPack universal header proposal to SMPTE from Apple has been developed to work within the MPEG-2 transport layer. The MPEG-2 transport layer is being considered for use by the G.A. Would the UniPack universal packet header proposal therefore be suitable for the header/descriptor needs of the G.A. system?*

Resolution Hierarchy

1. *The format of 1280 x 720 will use a production format of perhaps 1312 x 738 to allow extra border for image processing. A resolution hierarchy for the lower resolution image of 864 x 486 and 648 x 486 would be based upon the scaling fraction 2/3. Most scalable image resolution hierarchies have been based upon 1/2. Do you feel it is feasible to build a scalable resolution compression hierarchy based upon a 2/3 scaling relationship?*

2. *If a 2/3 relationship is created, 1280 x 720 would be stepped up to the next higher resolution of 1920 x 1080. Are there advantages to using this 3/2 relationship over using a 4/3 relationship to 1706 x 960?*

3. *It appears that 1920 x 1080 is desired by some, but difficult to achieve at high frame rates. Some have proposed a compromise to the horizontal resolution down to 1440. The use of 1440 does not appear to interoperate well with 1280 horizontal in the 1280 x 720 format. Would it be appropriate to consider 1280 x 1080 as an alternative to 1440 x 1080? Would 1280 x 1080 result in reduced cost for receivers which operate at both the 720 and 1080 line formats?*

4. *There are many who feel that horizontal resolutions such as 4096, 3072, 2048, 1536, 1024, 1280, and 640 are most desirable for digital display systems due to the match between these resolutions and digital chips and circuits. There is therefore some sentiment that television systems based upon the CCIR 601 horizontal resolution of 720, which include 1408, 1440, and 1920, are not appropriate for many industries. Could your system's use of 1440 or 1408 be adjusted to either of the nearby values of 2048,1536, or 1280? Square pixels would yield 2048 x 1152 and1536 x 864 as well as the familiar 1280 x 720.*

5. *There have been groups considering production formats for the ATV distribution formats of 1920 x 1080 and 1280 x 720. Can you explain the inconsistency between production formats under consideration for 1280 x 720, which provide extra room for processing (perhaps 1312 x 738), and production formats for 1920 x 1080, which do not appear to have any extra room for processing?*

Resolution For Movies

1. *Movies operate at 24 frames per second. Can the highest resolution under present consideration, 1920 x 1080, be supported at this frame rate using the G.A. system?*

2. *Since the largest overall refenue factor in television is the presentation of film material, shouldn't the greatest attention in the selection of ATV be focused on performance and*

resolution at 24 frames per second? It appears that only sports coverage requires the higher frame rates.

3. *Using a rate of 24 frames per second, Jae Lim has indicated that his formerly proposed system can convey information at resolutions up to 2560 x 1440. Will the G.A. system retain this capability?*

4. *How much resolution and format aspect ratio flexibility is available for 24 frame per second movie material? Could the G.A. system support 2048 x 870 (2.35:1 aspect ratio), 2048 x 1108 (1.85:1), and/or 2048 x 1536 (1.33 :1)?*

16:9 Aspect Ratio

1. *There have been many who have pointed out problems created by the choice of a 16:9 aspect ratio. These problems include the absence of use in existing film production of this aspect ratio, as well as difficulties in constructing digital display circuits which fall more naturally on factor of two boundaries. Would your system easily accommodate a change to a 2:1 aspect ratio?*

2. *If a 2:1 aspect ratio were alternatively selected for ATV, what resolutions would you favor? Are 1280 x 640, 1440 x 720, 1536 x 768, 1920 x 960, or 2048 x 1024 among the possible choices?*

3. *Would it be desirable to send original material in its original aspect ratio, and require that the receiving device handling the blanking of the border areas? For example, 1.33,1.85, and 2.35 material would be sent at these original aspect ratios. Would it then be possible to have a variety of receiver displays in the market which support a variety of aspect ratios, as chosen by the consumer?*

4. *If multiple aspect ratios in the transmitted /distributed image format were to be used,,would it be better to fix the horizontal values or the vertical values of the material? For example, should 1.33, 1.85, and 2.35 aspect ratios all have a common horizontal resolution (perhaps 1280, 1920, or 2048), or should they have a common vertical value (perhaps 720, or 1024)? Is it correct that digital circuitry is more optimal if the horizontal value is kept constant when supporting multiple aspect ratios?*

Issues With Interlace

1. *How would you present non-band-limited image data on the interlaced display? Would the image presentation be limited to text and graphics in which horizontal features span at least two or four lines? Would this be done by magnifying existing text and graphics by a factor of two?*

2. *Can interlace at 960 or 1080 lines be able to display text and graphics with quality equal to or exceeding a 1280 x 720 reference? Since this appears unlikely, should consideration of an interlaced format be abandoned?*

3. *If you had to revise the interlaced format to have square pixels and be progressively scanned, what format would you favor? Does the G.A. favor 1706 x 960 or 1920 x 1080 as eventually being feasible at high frame rates using progressive scan?*

4. *There are many who feel that horizontal resolutions such as 4096, 3072, 2048, 1536, 1024, 1280, and 640 are most desirable for digital display systems due to the match between these resolutions and digital chips and circuits. There is therefore some sentiment that television systems based upon the CCIR 601 horizontal resolution of 720, which include 1408, 1440, and 1920, are not appropriate for many industries. Could your system's use of 1440 or 1408 be adjusted to either of the nearby values of 2048,1536, or 1280? Square pixels would yield 2048 x 1152 and1536 x 864 as well as the familiar 1280 x 720.*

5. *Why is interlace being considered in the G.A. system? 1280 x 720 is both progressive scan and square pixels at high frame rates suitable for sports. Why is this not completely sufficient for coverage of sports, which is the primary need for high frame rates?*

6. *The desire for high resolution is satisfied at 1920 x 1080 (or other nearby resolution), which appears achievable at 24 frames per second. The desire for rapid frame rate coverage for sports is achieved by using 1280 x 720. What need is there for 1920 x 1080 (or other nearby resolution) using interlace, since the needs and desires of the system appear to be met without the use of an interlaced format?*

(end)

Source:	Joseph Stampleman, Apple Computer
Distribution:	MPEG Systems group
Date:	May 13, 1993
Subject:	Cooperation between SMPTE and MPEG Systems

Introduction

Apple Computer is submitting to SMPTE a universal video header format proposal called "UniPack" which is being distributed along with this document. Our goal is not to try convince MPEG-2 to adopt this video format. Our primary goal is to propose UniPack as an example of a more flexible, feature-rich data format that meets the long-term goals of the SMPTE header work. Once all of the SMPTE proposals have been reconciled, we hope that the result will indeed be a data syntax that, while being more complex, will provide a larger feature set.

However, we don't think of a SMPTE universal header format necessarily as a mutually exclusive alternative to the MPEG-2 transport layer (although it can be used in that way). Our reason for bringing this work directly to the attention to MPEG-2 is that we believe it may be possible for a universal header to coexist with an MPEG-2 transport. Such a stream would therefore be readable by both a dedicated MPEG player and by a SMPTE-savvy one. MPEG-2 stream would benefit by being able to use the SMPTE headers. The purpose of this document is to describe how the two formats might coexist, and to suggest how MPEG-2 might best provide hooks for use of such a header.

We welcome comments on both UniPack and on how a SMPTE universal header might coexist with the MPEG2 transport layer.

UniPack Summary

A UniPack stream is a group of successive packets. There are several different types of packets. All packets include a length field. All packets contain a header that identifies the packet type, information that accompanies all headers of that type, and a checksum. Some packets contain a "directory" (see below) that precedes a payload. Most packets contain a payload. All of these data structures (header, directories, payloads) are quadword aligned.

The nature of all data items in UniPack is identified by a 64-bit identifier that denotes the standard that's being used. For example, the identifier might declare that the operative standards body is ISO, and within that, MPEG, and then within that, MPEG-2 video. Similarly, the identifier might declare ANSI, and within that, Apple, and then within that, any format that Apple chooses to support. These 64-bit identifiers do not need to be transmitted repeatedly- they can be "defaulted" - or inferred - from previous declarations within that channel. UniPack channels correspond roughly to MPEG programs. In this way, the meaning of identifiers within UniPack can be tailored to support a wide variety of uses, and can be so defined by registered users of the standard.

Some packets contain directories. These define a map of what sorts of data are contained in the packet's payload. This mapping then permits the stream to

match payload information with associated data such as error correction or encryption information. For example, heavily error protected executable code could be downloaded. In general, the use of the universal header provides the possiblity of accessing a wide variety of algorithms and syntaxes that are rigorously registered and so can be unambiguosly labeled. Apple believes that any system using the SMPTE header should be limited only by hardware and software, and not by the flexibilty of the bitstream specification.