3. *Do you plan to build a receiver with B frame capability from the beginning of the service in order to accommodate B frame features when it is introduced in an encoder in the future?*

   If it is decided to include B frames, all receivers need to be built with B frame capability.

## VCR ISSUES

1. *Is progressive refresh exactly same technique used in the original DigiCipher system, or are there changes/ Does new proposal have 4 panels with vertical seams? Would horizontal seams be better, especially for VCR trick play?*

   Progressive refresh will be different from the technique used in the original DigiCipher system. There will be no vertical or horizontal seams.

2. *VCR trick play must be anticipated. Will the system make easy random access with rapid image acquisition? Will editing of compressed image data streams be possible? Will system mark data in bit stream to aid trick play processing? and prioritize data?*

   The system will be designed to support easy random access and editing of compressed image data streams. The issue of data marking and prioritization for VCR trick mode is being considered.

3. *Did not address VCR performance especially for "trick modes" that consumers expect. (Page of discussion).*

   Various consumer VCR manufacturers are working on trick modes with compressed data. The resulting image quality of fast forward and fast reverse will be comparable to VHS.

## MISCELLANEOUS QUESTIONS

1. *Using square pixels for 1050, total pixels/pict is 20% more than previous systems. Will this result in increased static (or dynamic) horizontal resolution system performance or is pixel map internal to coder adjusted to fewer H samples and interpolated to square pixels at output?*

   It will result in increased horizontal resolution. The system can also use reduced resolution (1408 pixels) for compression and transmission.

2. *How will existing and emerging production formats "dove-tail" with proposed transmission system? For example, what video/audio formats are being considered as appropriate for interface at the input to the transmission system?*

   Existing or emerging production formats (1080 line format, for example) can directly interface with the encoder. The encoder can perform any required format conversion.

3. *Will your system support any form of scalability?*

   No, but a compatible migration path to 1000-line 60 frames/sec progressive format is under consideration.

4. *By what tests will we be sure that option of multiple encoding techniques results in better pictures? Not obvious that inclusion of all techniques is better than use of the best one.*

   Extensive computer simulation will be used to ensure optimum performance.

5. *Describe the "non-uniform quantization with new VLC's".*

   It is similar to the quantization scheme described in the DSC-HDTV certification document.

6. *How many P frames for each I frame? Is relationship fixed for variable? If variable what are criteria for choice in any application, and what condition do we use to assess the system's image quality? Likewise, will the slice size be fixed for variable?*

   The number of P frames for each I frame will be variable. It is a tradeoff between acquisition time and video quality. The recommended range is between 10 and 60. The slice size will be variable.

7. *Explain the "VQ for selection with perceptual coding". Is this original DSC-HDTV proposal? How does it relate to MPEG's zigzag scanning?*

   It is similar to the VQ with perceptual coding as described in the DSC-HDTV certification document, except that the quantization is uniform and run-length coding is used for coefficient transmission.

8. *Please explain overhead required for inter/intra coding on 8x8 block basis. Would each macroblock contain extra bits to indicate which were which? (If chroma blocks were handled independently, seems to require 6 bits/macroblock or about 0.972Mbits/sec.)*

   Inter/intra coding on 8x8 block basis has been dropped as it makes little difference to HDTV resolution.

9. *Are the other additional syntax elements and the encoder prototype implementation features the same as previous systems? Please describe.*

Predicted frame motion estimation and large range hierarchical motion estimation are similar to previous system. The frequency dependent leak is explained in item 19 of MPEG RELATED ISSUES. For VQ and 8x8 inter/intra, see items 7 & 8 above.

10. *Will I and P frames without progressive refresh and P frames with progressive refresh ever be mixed in the same sequence?*

I frames and progressive refreshing will not be mixed in the same sequence except the fact that I frames can be used in addition to progressive refreshing for editing purposes.

11. *Many compression techniques. How will encoders select. Will all encoders support all options, or different applications or different broadcasters select different encoders?*

Broadcasters will be able to select certain options and/or parameters such as refreshing method and speed.

12. *What is the latency of your system?*

The end-to-end system delay depends on the refreshing techniques used. It will be approximately 0.5 seconds with I-frame and 0.1 seconds with progressive refreshing or AC leak.

## GRAND ALLIANCE ANSWERS TO QUESTIONS FROM ADVISORY COMMITTEE ON ADVANCED TELEVISION (ACATS) ON TRANSMISSION FORMAT PROPOSAL

### ANALYSIS/TESTING

1. *What are advantages/disadvantages associated with each of four modulation schemes proposed by GA? Provide more details on how paper analysis will be conducted along with criteria for ranking and selecting weighting factors.*

VSB uses a pilot carrier, training sequence, and NTSC interference rejection filter for robust performance. It features a Bi-Level Data (2/4 level) capability, suitable for extended audio threshold. It offers excellent phase-noise immunity. A trellis-coded 6 VSB version will also be considered for improved threshold performance. The VSB receiver can be low cost.

QAM is a widely used/proven classical modulation technique for digital communications. The QAM system requires no pilot tone or training sequence for carrier recovery and equalizer initialization. It employs powerful yet easily implemented trellis coding for low C/N threshold. It features simple, inexpensive receiver hardware. It can offer high cable capacity using 64, 128, or 256-QAM.

SS-QAM offers excellent co-channel performance with a high data rate. It features trellis coding for improved threshold performance. It offers a two-tier alternate mode for transmission robustness.

Factors to be considered in the paper analysis (and their weighting) are as follows:

1. ATV Coverage Area/NTSC Service Area Loss - 70%

   Use updated PS/WP-3 model to calculate:

   a. Total ATV UHF/VHF Service Area considering Co-channel, Adjacent Channel, and Taboos.

   b. NTSC Service Area lost considering ATV UHF/VHF Co-channel, Adjacent Channel, and Taboos.

   c. Ratio of ATV Service Area gained to NTSC Service Area lost when the ATV power level is increased.

   d. Total NTSC Service Area.

2. Robustness - 15%

   a. The difference between C/N threshold with multipath and C/N threshold without multipath.

   b. Phase Noise.

   c. Residual FM.

   d. LO Pull-in Range.

   e. Channel Acquisition.

   f. Impulse Noise.

   g. Bi-Level Data System/Alternative Mode System.

3. System Attributes - 15%

   a. Terrestrial Data Rate.

   b. Peak-to-Average Ratio.

   c. Receiver Cost.

   d. Cable Capacity. (Data rate).

   e. Cable Interoperability.

2. *Provide details on how the computer programs used by PS/WP3 would be employed to select the optimum modulation method. What target criteria will be used for assessment?*

The GA will request that the computer programs be used as follows:

   a. Do some runs now with the "median" system.

   b. Incorporation of "real" antenna patterns in all runs.

   c. Sensitivity runs.

   d. Incorporation of multiple impairments curves.

3. *In terms of coverage area, what definitions are you using (instead of the traditional contour A and B definition)?*

We will use definitions provided by PS/WP3.

4. *What ATV receiver noise figure are you assuming in considering possible transmission schemes?*

PS/WP3 used 10 dB. We will consult with, and use the numbers decided on by, PS/WP3.

5. *What hardware-based laboratory tests will be used to select the modulation method, if paper analysis fails to reveal an optimum choice?*

We will perform all tests necessary to provide the inputs for the weighting factors discussed in the answer to question 1. under "ANALYSIS/TESTING".

6. *How will modulation format selection be made? What tests and under whose administration? Will tests include tuners, or will they compare inherent performance of modulation schemes by using a common tuner?*

We will use the weighting factors described in the answer to question 1., under "ANALYSIS/TESTING" to select a modulation format. The tests will be those discussed in the answer to question 5., above. The GA will do the tests at our own facilities at times and dates yet to be determined. We have invited the ACATS Technical Subgroup Expert Group on Transmission to observe this testing. The tests will include tuners. Tuners and demodulators will be compared as a package, i.e., each demodulator will be tested with its own tuner only.

7. *How will receiver and transmitter tolerance requirements be evaluated?*

Some limited information was already submitted to PS/WP3. We will work with the ACATS Technical Subgroup Expert Group on Production and Receiver/VCR Impact to further assess receiver and transmitter tolerance requirements.

8. *Will the tests include equalizers, and how will different equalizer performance be normalized? Will the tests be of bit error rate out of the demodulator (i.e., independent of video)?*

Each candidate demodulator will include an adaptive equalizer. We believe that it is not practical to normalize equalizer performance, as the performance of each candidate equalizer is greatly affected by other subsystems within each candidate modem. Thus we will not attempt to normalize but will test each demodulator design as a unit. The tests will be of bit error rate or block error rate, with a pseudorandom bit sequence as the modulator input.

9. *How will modulation support multiple priority data in "prioritized" data format? Will tests include comparisons of bit error rates for different priority data?*

Multiple priority data can be supported by SS-QAM or VSB. The threshold for the high priority data will be measured and used for the purpose of confirming system robustness.

## SPECIFIC QUESTIONS ON PROPOSED SCHEMES

1. *What kind of synchronization will be used in your system? Will a pilot be used?*

This is a very broad question and the answer will depend on which system is selected. There are several levels of synchronization such as symbol timing, carrier frequency and phase, equalizer training, FEC block sync, and sync for higher level data structure. Each system currently handles these synchronization requirements slightly differently, but there are no plans to deviate significantly from the techniques that have already been described within the documents submitted to ACATS by the members of the GA for each candidate modulation system. Thus, a pilot will be used if the VSB system is selected.

2. *Are bit sync and equalization training waveforms changed for VSB proposal from those originally tested? Is relatively low rep. rate a limitation for settling time or moving multipath?*

The bit sync and equalization training waveforms have not been changed. As part of the system improvements submitted to ACATS, it was proposed to change to an equalizer that trains on data as well as the training signal itself to improve the ability of the equalizer to track moving ghosts as might be encountered with airplane flutter. This change will be made before any testing of the VSB system at GA facilities.

3. *Provide technical details of the 6 VSB modulation scheme.*

6 VSB is a trellis coded version of 4 VSB. It uses a non-rectangular 2D constellation with FEC (trellis encoding and RS T = 10). The trellis code improves the C/N threshold by 1 dB and the 2D constellation provides another 0.5 dB improvement.

4. *What is the net data rate for 6 VSB? Describe the trellis code and compare gain to that achieved when trellis code is applied to QAM.*

The net data rate is 18.8 Mbits/s for 6 VSB. The trellis-coding gains achieved for VSB and QAM are similar.

5. *Are you planning to use spectral shaping (spectrum hole) in the ATV system to reduce interference to and from co-channel NTSC signals?*

   If SS-QAM is selected, spectrum shaping (as already described to ACATS), will be used for this purpose.

6. *Do SS-QAM and VSB formats continue to support gradual degradation?*

   Gradual degradation of video will no longer be supported.

7. *Are any changes contemplated for SS-QAM (e.g., HP/SP power ratio) or in distribution of W1/W2 data for VSB systems? If so, effects on video quality must be evaluated as well as BER.*

   The HP/SP power ratio used for SS/QAM will be reduced to 1.5 dB for the paper analysis and any testing. For the VSB systems, video will be W2 data only.

8. *Selected modulation technique will most likely be used to interface ATV receivers with other consumer electronic equipment (e.g. digital video cassette recorders). Has cost of implementing such interface been considered in selection of modulation scheme?*

   A serial baseband digital interface will most likely be used as the interface between ATV receivers and other consumer electronic equipment.

## ALTERNATIVE METHODS

1. *Is 16-QAM no longer being considered?*

   The Grand Alliance (GA) is working with the ACATS Technical Subgroup Expert Group on Transmission to investigate the status of OFDM/COFDM and report to ACATS. 16-QAM will not be considered as the primary mode but can be an alternate mode if QAM or SS-QAM is selected.

2. *Current GA proposal constrains consideration of transmission schemes to QAM and VSB techniques. Would consideration be given to other approaches which might offer advantages, and perhaps better achieve desired objectives?*

   The GA believes that all of the candidate modulation systems that it is currently considering have been shown to perform very well during previous testing, and that the process we have delineated will lead to the selection of a modulation system that meets desired objectives. For further clarification, please see the answer to question 1. under "ALTERNATIVE METHODS".

3. *How would GA consider other modulation schemes such as OFDM, COFDM, etc?*

Please see the answer to question 1. under "ALTERNATIVE METHODS".

4. *Some European research in terrestrial digital broadcasting favors use of the COFDM system. Are the GA partners amenable to including COFDM in their comparison of modulation systems?*

Please see the answer to question 1. under "ALTERNATIVE METHODS".

5. *Has COFDM been considered for TX? Have any of the proponents been tracking the proposed tests of COFDM?*

Please see the answer to question 1. under "ALTERNATIVE METHODS".

6. *Could your system support on-frequency repeaters for coverage extension?*

According to a study by one member of the GA, it is possible to support on-frequency repeaters for coverage extension. Their results appeared in the IEEE Transactions on Broadcasting, December, 1992.

7. *Would there be value in using a different antenna polarization for ATV transmission than the one used for NTSC as a means for reducing mutual interference?*

We will monitor PS/WP3 deliberations addressed to this question.

## CABLE ISSUES

1. *What provision could be made for higher capacity throughout on cable?*

High data rate cable modes are being considered including providing about 27 Mbits/s using 64-QAM and > 37 Mbits/s using 16 VSB or 256-QAM.

2. *Do proposed transmission techniques differ in suitability (compatibility, etc.) for carriage on cable?*

There will be some differences which we will take into account within our "System Attributes" weighting factor. This weighting factor includes consideration of cable data rate, cable interoperability, and receiver cost. In addition, our "Robustness"

weighting factor takes account of important cable impairments. For further clarification, please see the answer to question 1. under "ANALYSIS/TESTING".

3. *Will a compatible higher capacity transmission system be available for cable networks?*

   Please see the answer to question 1., under "CABLE ISSUES".

4. *Are 64-QAM or 16 VSB being considered for cable?*

   Please see the answer to question 1., under "CABLE ISSUES".

## LATE QUESTIONS

1. *Will the proposed modulation methods be tested in a single laboratory? What evidence will be provided to the Advisory Committee to show the rationale behind the selection?*

   We will do simultaneous testing of all candidate modulation systems. Measured results will be made public.

2. *Will the transmission chain (exciter, transmitter, etc.) performance requirements for each of the proposed modulation formats be evaluated? How about performance through other devices such as translators and MATV systems?*

   Some limited information was already submitted to PS/WP3. We will continue to work with transmitter manufacturers to assess performance requirements. We will work with the ACATS Technical Subgroup Expert Group on Production and Receiver/VCR Impact to further assess performance requirements for the transmission chain and other devices.

## GRAND ALLIANCE ANSWERS TO QUESTIONS FROM ADVISORY COMMITTEE ON ADVANCED TELEVISION (ACATS) ON AUDIO FORMAT PROPOSAL

1. *Will the multi-channel MUSICAM system be sufficiently defined in time to meet the proposed schedule of August 31 for a decision on selected audio system?*

   The audio system submitted by Philips is sufficiently defined to meet the proposed schedule. It should be noted that the hardware is only a prototype, and is certainly not "bug-free". In addition, it does not include all necessary features. However, the proposed system is adequately specified to allow those skilled in the art to make the necessary evaluations.

2. *What is the MIT-AC baseline audio system?*

   It is a 6-channel digital audio system consisting of independent coding/decoding of each channel using an adaptive transform algorithm at a bit rate of 115 Kb/s per channel for 5 of the 6 channels and low number of bits for the 0.1 effects channel. The total number of bits used for the 6 independent channels is 580 Kb/s.

3. *Is the AT&T system going to be considered?*

   No.

4. *What relationship, if any, is contemplated between proposed GA audio systems and MPEG-2 audio syntax?*

   The audio system proposed by Philips conforms to the specifications given in ISO/MPEG-2. Not all features allowed in ISO/MPEG-2 have been demonstrated in the hardware submitted for testing.

   The audio system proposed by Dolby falls into a new non-backward compatible category currently under consideration by the MPEG-2 committee.

   The audio system proposed by MIT falls into a new non-backward compatible category currently under consideration by the MPEG-2 committee.

5. *What consideration should be given to maintain compatibility with the emerging MPEG-2 audio standard?*

The Grand Alliance (GA) recognizes that international compatibility is useful. The draft audio standard for MPEG-2 has defined a surround system which is backward compatible with the MPEG-1 stereophonic sound system. In addition, a new surround sound category is under consideration by the MPEG-2 committee which is not backward compatible with MPEG-1 stereophonic sound. One of the three systems proposed and being considered by the GA is backward compatible. However, the proposed system was not delivered to the GA for test. The system submitted and tested was partially backward compatible (only the left and right channels could be decoded in specific modes). The remaining systems are not backward compatible.

6. *Provide technical details on GA proposed simultaneous testing proposal?*

The testing plan devised by the GA makes us of pre- recorded audio sequences acquired from SS/WP-2 of ACATS. The audio system testing performed by the GA is very similar to that planned for the ACATS retesting which was to have been performed by the ATTC.

The test plan is three-fold: 5.1 channel basic quality, 2-loudspeaker stereophonic reproduction, and packet error impairment. Digital Audio Tape recordings are made of the original, 5.1 channel encoder/decoder cascade for basic quality, 2-loudspeaker stereophonic decoder downmixed from 5.1 channel encoded source, and 5.1 channel encoder/decoder cascade for impairment. For the latter case, the encoded audio bit stream (i.e., 320 Kb/s, 384 Kb/s, 580 Kb/s) is forced to all zeros or all ones for a duration of 5 milliseconds at a rate of one such forcing every 3 seconds. The above recordings (made at Zenith Electronics Corporation on two Alesis ADATS) are used in the subjective testing.

7. *What organization will perform the simultaneous testing referred to in the system description? It should probably not be the Proponents by themselves.*

The recordings mentioned above in answer to question 6. were used in subjective testing of basic quality, 2- loudspeaker downmixing, and impairment at the Skywalker Ranch facilities of Lucasfilm in Nicasio, California using Expert Observation and Commentary (EO & C). A total of 10 expert listeners were used. For the ACATS, J. Gaspar Chair, Audio Experts Group and B. Jones were in attendance. The tape recordings were played to the expert listeners in a reference, unknown order. The identity of the unknown signals was concealed from both the subjects and testers. The unknown signals, including a hidden reference, were presented in randomized order. The expert listeners reported the coding and spatial artifacts which were heard. The results of the tests have not yet been analyzed.

## ADDITIONAL INFORMATION

1. Complexity analysis of the decoder portion of the three Audio Advocate Systems is proceeding. Gate counts are being determined for the purpose of relative cost comparison.

2. Not all equipment provided by the audio advocates could perform in the configuration necessary to sensibly test performance with 2-channel Dolby Matrix Surround source material. Therefore, that test was not performed. An analysis will be done instead.

3. The performance of Audio Advocate Systems when fed with source material encoded with other algorithms was not performed because of the unavailability of such material at bit rates suitable for such pre-production use. It was felt that source material encoded at bit rates appropriate for emission (i.e., 64 Kb/s) were not suitable.

4. The GA method of impairment testing does not make use of a transmission system with transport. The feeling in the GA is that the testing which has been done at the bit rates of the audio codecs without a transmission system is valid and useful to evaluate the performance of error detection and concealment means in the hardware which implemented those features. The circuitry for error detection and concealment was incorporated in some Audio Advocate hardware and not in others.

## GRAND ALLIANCE ANSWERS TO QUESTIONS FROM ADVISORY COMMITTEE ON ADVANCED TELEVISION (ACATS) ON TRANSPORT FORMAT PROPOSAL

1. *What are the goals to be achieved by the transport layer? Is it intended to be used for delivery by several different media (e.g. broadcast, VCR, cable, etc.)? Will the transport layer attempt to supplant some of the video coding syntax layers?*

   The transport layer is the link between the compression layer and the transmission layer and will address terrestrial, cable, and satellite delivery systems. The transport layer also serves as an interchange format between the ATV receiver and external devices, such as VCRs and computers. The transport layer serves to multiplex program constituents of video, audio and data, regenerate decoder system clock, and deliver Presentation Time Stamp information to the elementary stream decoders.

   The transport layer will deliver a fully compliant MPEG-2 video bit stream to the decoder, and will not supplant any of the video coding syntax layers.

2. *Will the packetization be compatible with the MPEG-2 systems layer? If not, will one be a subset of the other?*

   The Grand Alliance transport definition is currently envisioned to be a constrained version of the MPEG-2 systems layer. Some deviation from the current working draft may be necessary to adequately address issues such as local program insertion. At the limit, the intent is to allow the Grand Alliance transport to be easily transcodeable with the MPEG-2 systems layer.

3. *Issues beyond packet identifiers and proscan needed to support computer interactivity. "Baseband" interface spec must be created. More than connector spec. At what place would digital stream be inserted - after error correction, after decoding, in between?*

   The transport layer is intended as an interchange format between the ATV receiver and external devices, such as VCRs and computers. Exchange of information between these external devices and the receiver should comply with the transport format. Error correction is considered to be a part of the transmission layer, therefore the interface would be after the error correction circuitry.

4. *What capability will be provided for encrypted elective services?*

*and...*

5. *Is there explicit provision for conditional access on cable?*

There are 2 bits defined in the transport header for the purposes of conditional access, which allow for encryption on an individual service basis (e.g. encrypt video, but not audio). This provision allows for encryption keys to be associated with the correspondingly encrypted packets. Since key delivery and conditional access are not specified by MPEG-2, and are thus not constrained, this feature supports a variety of conditional access schemes.

6. *Describe how the transport format will support dynamic allocation of data capacity to services on an as-needed basis.*

The transport format supports dynamic multiplexing of a wide variety of services. The transport packet header uses 13 bits to identify the service ID. The algorithm for the multiplexing of these services will be resident in the transport subsystem and could be tailored to meet the needs of a given program provider. The multiplexing algorithm will, however, have to operate within constraints set by the video encoder (e.g. decoder buffer size). The algorithm can be capable of mixing in fixed rate services such as audio or dynamically allocate channel capacity to a data service on demand. Reduction in the video data rate will reflect into the video encoder rate control algorithm through the measure of video buffer fullness.

## QUALITY TRADE-OFF

1. *Has the inclusion of interoperability, packetization, etc. caused any significant loss in terrestrial transmission quality?*

There is certainly a loss in channel capacity for video in the implementation of a flexible, packetized system, however our experience is that this tradeoff does not significantly reduce picture quality. A major goal of the transport delivery system is to minimize overhead while addressing the needs of interoperability and terrestrial transmission in a robust fashion. Packets will be 188 bytes long with 184 bytes of payload and 4 bytes of packet header. Each packet will have a number of bytes added for Forward-Error correction by the transmission subsystem. Note that Forward-Error correction is required whether or not the system is packetized. In addition, elements of the transport layer which provide synchronization information to the receiver have been constrained to optimize the tradeoff between overhead and transmission robustness. The details of these constraints will be a part of the transport subsystem specification.

## PRIORITIZATION QUESTIONS

1. *Explain the intent and characteristics of the data prioritization. Is this intended to support gradual degradation or is it intended for other functions, such as VCR trick play, scalability, or multi-resolution service? Is it intended that the transmission system handle different priorities differently (e.g. with different power), or will prioritization be a simple data identifier?*

*and...*

2. *How will data be prioritized?*

*and...*

3. *Will the prioritization scheme be compatible with MPEG-2?*

and...

4. *How will the prioritized data be protected against channel errors? Will different priority levels have different amounts of error protective coding?*

   Prioritization will be compatible with the MPEG-2 video and systems layers. The systems layer contains two priority bits: a transport priority bit that resides in the header of each transport packet, and an application priority bit that resides in the adaptation header. While MPEG-2 specification provides syntax for data partitioning for specialized channels such as ATM networks or VCRs, there is not a defined profile that uses this mode. Consequently the Grand Alliance video coding will not use a prioritization scheme that relies on data partitioning. That is to say, the hooks for prioritization are provided for a user-defined system that addresses VCR trick play, scalability, or multi-resolution. The transport layer provides a flag in the header of each packet to signal the presence of a high priority packet. If the transmission layer is capable of providing additional protection for that packet it can do so. Details of this protection will be determined on selection of the transmission subsystem.

## GRAND ALLIANCE ANSWERS TO QUESTIONS FROM ADVISORY COMMITTEE ON ADVANCED TELEVISION (ACATS) ON SCANNING FORMATS PROPOSAL

1. *Describe why the Grand Alliance (GA) representatives chose the scanning parameters?*

   The GA scanning parameters were chosen to maximize performance within the 6 MHz television channel, provide flexibility and interoperability among television, telecommunications and computer and multi-media applications, and facilitate affordable receivers with potential for extensibility.

2. *The P versus I issue appears to have been resolved by compromise rather than definitive performance evaluation/demonstration. Some argue earlier system tests suggesting superiority of I-scan are anomalous. Seems possible to resolve P versus I issue by testing.*

   It is an illusion to believe that "definitive performance evaluation/demonstration" will resolve the issues concerning progressive versus interlace scanning. For one thing, each form of scanning has virtues that make it superior in some aspects, for some applications. Second, the issue is not one merely of performance, but involves the relative commercial effects on different industries that have different applications and markets.

3. *FCC regulatory interest as presently defined must focus on spectrum and TX channel. Earlier recommendations from ACATS specified "progressive scan & square pixel format in transmission channel." Is the GA proposal consistent with this recommendation?*

   The GA proposal is consistent with the concept of "transmission in a progressive scan mode, with square pixels," for all of the variations of the 720-line format, and for the 30 Hz and 24 Hz film modes with 960 lines. The interlaced mode for the high line number (960-lines, 1408 or 1728 pixels per line) 60 Hz mode may best be thought of as being transmitted in interlaced format, consistent with the MPEG-2 incorporation of modes optimizing performance for interlaced scanning. Further, the high line number format has two variations, and the 960 by 1408 version of the 2:1 interlaced format does not incorporate square pixels, while the 960 by 1728 version does support square pixels.

4. *Does GA expect FCC to adopt the TX scanning formats described in technical submission? Does GA expect the FCC to mandate decoding of all scanning formats in receiver?*

The GA does expect the FCC to incorporate all the GA scanning formats in an HDTV transmission standard. We believe that it will be cost-effective for a receiver to be designed with a flexible architecture that can handle all the GA formats, and manufacturers should be required to design receivers to decode and display all of the approved transmission standards. It should be a manufacturer's option how the received signals are displayed.

5. *Has GA given any thought yet to digital infrastructure required to support HDTV origination, broadcast plant distribution, inter-city studio links, contribution feeds, distribution to affiliates? Has the impact of multiple format handling on the total system been studied?*

The digital infrastructure referred to is conceptually simplified by the flexibility built into the GA system through the digital representation, with packetized transport, of the compressed HDTV signals. While production facilities may not use the same compressed signals, and may in fact use little or no compression, the same underlying technology that makes possible the GA compression system will support development of a more flexible production infrastructure than exists today.

Since the packets of compressed video contain headers and descriptors that make them self-identifying, the complexities in handling multiple formats can be submerged or eliminated. The traditional common continuous synchronization that characterizes current production for (digitized) analog NTSC production will be interrupted for compressed video through the packetization and compression process. With sufficient processing speed, the feasibility of production processing will be indifferent to the nature or complexity of processing steps that intervene during production. The same principle can apply to uncompressed or differently compressed video that may exist in the plant for production or distribution purposes.

See the answers to Question 8 in section B.

6. *Does the GA accept that this can only be implemented by sharply focussing on an initial well defined system? Does the GA see merit in defining one unique start-up format with better defined migration path to other future options?*

Yes, the GA understands the importance of beginning with a well-defined system. There would only be merit in defining a single start-up format if the goal were to limit applications of advanced television to a single application, in a single industry, without embracing the concept of interoperability or extensibility.

## IMPLICATIONS OF MULTIPLE FORMATS

1. *Explain the inter-relationship between the scan formats supported by the GA system.*

   The 720-line formats have 1.5 times the number of active lines of the NTSC format, and for that number of lines, 1280 samples per line yields the very desirable square pixels that some consider to be important for computer applications.

   The 960-line formats have double the vertical resolution of the NTSC scanning format, and 1728 samples per line allows a (virtually) square pixel aspect ratio to be implemented.

   Use of 1408 samples per line as a variation of the 960-line format eases the burden on compression by reducing the number of pixels/sec that need to be processed.

2. *What is the number of active lines and the number of active samples per line for each scanning format?*

   See the chart displayed in the format presentation on June 30, 1993. (A copy is appended to this report.)

3. *Will multiple clock frequencies be required?*

   A consistent set of internal clock frequencies for all formats could be derived from a single frequency source (crystal), for either 59.94 Hz or 60.0 Hz frame rates. If both 59.94 Hz and 60.0 Hz frame rates need to be supported, then a possible design for a receiver would be to include two crystals, switchable, for the two frame rates. There are also competitive receiver designs that require two crystals for clock synchronization for a single format or for all of the GA formats.

4. *Long term standard built around family of 1050 line progressive formats. Why is 1050/1:1/60 not shown in the table?*

   The table indicates the baseline formats for the GA system. These are the formats that the FCC would need to incorporate in a transmission standard. The specific final method of enhancing coding to a higher line number progressive scan format is being studied, but the "hooks" that will enable such future migration will be designed into the original HDTV system. Since the packet headers will allow receivers to selectively use parts of the HDTV data stream, the details of the ultimate systems do not need to be a part of the initial FCC standard for HDTV.

| Format | Vertical Size | Horizontal Size | Frame/Field Rate | Scan Mode | Aspect Ratio | Square Pixels |
|---|---|---|---|---|---|---|
| A | 720 | 1280 | 60 Hz | Progressive | 16:9 | Yes |
| B | 720 | 1280 | 30 Hz | Progressive | 16:9 | Yes |
| C | 720 | 1280 | 24 Hz | Progressive | 16:9 | Yes |
| D | 960 | 1728 or 1408 | 60 fields/sec | Interlaced | 16:9 | Not for 1408 pels/line |
| E | 960 | 1728 | 30 Hz | Progressive | 16:9 | Yes |
| F | 960 | 1728 | 24 Hz | Progressive | 16:9 | Yes |

5. *Will your prototype hardware support all of the six scanning formats?*

Yes, the prototype system will internally support all of the defined formats. Since there will be no source equipment for providing 24 Hz or 30 Hz test material (designated film modes) directly, those progressive-scan formats, with square pixels, will be detected automatically by the encoder equipment and processed accordingly, when 24 Hz and 30 Hz material is presented using a pull-down process. A direct interface for 24 Hz and 30 Hz material will eventually be provided and be a part of the standard.

6. *Describe relationship of system to be tested to future development/improvements.*

The improvements already described for the previously tested prototype systems have been incorporated in the GA system to be tested, with adjustments as needed for the now common system.

7. *What are the cost implications of conversion from various anticipated source formats to each of the multiple formats proposed?*

It is anticipated that initial operation will involve substantial conversions from all sources, whether film or camera or other source material. The cost of conversion is expected to be low, once the system designs are frozen and converter requirements can be specified. Formats were chosen with the goal of making needed conversions simple and inexpensive.

8. *Six scanning formats are listed. Is it planned that very first system that is implemented will incorporate as many of these as possible - or is it intended to choose one only for initial deployment of a US ATV Service?*

The full set of formats will be available for a user of the system to choose among for initial applications, although the prototype equipment will not support direct interfaces to 24 Hz and 30 Hz formats, since there will be no sources for such signals. There is no impediment to a broadcaster, for example, choosing a single format for initial deployment, if that fits the needs of the broadcaster. We believe that in the long run, the virtues of the different formats will result in broadcasters and others selecting a format that best fits each particular application. See also the answer for Question 4 in Section A.

9. *If it's intended to incorporate most scanning formats from outset-have technical & economic implications for broadcast origination plant been considered? Are broadcasters expected to make individual choices to implement plant entirely in 787P or 1050I?*

Broadcasters may choose one or several or all of the formats, depending on business value. One example of such a choice might be the use of a 60 Hz progressive-scan mode for sports, to achieve good temporal rendition. A 720-line film mode may support all the resolution that is needed for a particular movie, with a resulting surplus channel capacity that has significant commercial value to the broadcaster. A 960-line film mode may be desirable for a prime-time feature movie.

10. *Are professional broadcast origination equipment manufacturers expected to offer HDTV studio equipment's that are switchable between 1050I and 787P scanning formats? Have technical and cost implications of this been considered?*

Cameras and monitors will not likely be switchable between 720-line and 960-line formats. However, the self-identifying nature of the compressed data means that equipment like recorders and switchers could easily be designed with an architecture that allows for such switching. The detection, switching, and modification of processing could be automatic, and effectively in real time, although in a packetized digital environment, the temporal dimension is intrinsically interrupted. That fact is at the heart of the great flexibility offered by a modern digital plant that takes full advantage of digital processing opportunities. (See the answer to Question 9 above.)

11. *When compared to single format system, what are added design considerations and/or tradeoffs (coding efficiency, complexity, cost, etc.) required to develop multi-format system such as one proposed by the GA?*

The principal design considerations required for a multi-format system are a fully digital implementation, with a flexible representation of the elements of the television signals, and a departure from traditional views of synchronization. The fact that data will be "chunked" into packets for communication among processing elements (using variable rate coding) means that the temporal dimension is intrinsically disrupted (except for digitized analog systems in which the signals are merely digitally sampled analog signals). The time structure of the output frame sequence must necessarily be reconstructed for display or for editing purposes. Once packets of television data are handled separately, and reassembled in a reconstituted temporal sequence, the conceptual differences between on-line and off-line processing are reduced, and depend on the speed and power of processing that can be applied to a particular "real-time" operation.

Given a fully-digital implementation, including transport, the format conversions that may evolve for production processing and before display in a receiver represent the application of increasingly powerful and cost-effective semiconductor technology. A principal penalty for using multiple formats is the extra burden of flexibly addressing an image frame store. Creating an architecture that avoids

multiple formats would not take advantage of current advances in semiconductors.

For receivers, the main impact of multiple formats will be the need for scan conversion circuitry to convert between the transmission format and the display format (or alternatively, to use a multi-scan display, which seems unlikely for a consumer receiver). (See answers in Section G.) Note that a frame store memory is required in the receiver in any event for decompression, and that practical receivers may need to re-format received NTSC pictures for the HDTV display.

12. *Are all the modes justifiable in terms of image quality versus cost? Will there be any restrictions on the "burst" data characteristics of the encoder in order to simplify the decoder?*

a. Yes, all the modes yield excellent HDTV images at affordable cost.

b. The burst data characteristics of the encoder/decoder are part of the design tradeoffs, particularly in the sizing and control of the transmission buffer.

13. *Is multiple format proposed economically feasible from receiver cost and/or terrestrial/cable/satellite signal delivery viewpoint? Do we run the risk of multiple formats being resolved down to more limited number of formats driven by implementation cost?*

The GA believes that each format in the set defined for the baseline system will find significant application. (See the answers for questions 11 and 14 in this section.)

14. *Will consumer products support both 1050I and 787P format? If yes, will it involve some form of format conversion?*

Consumer products will support both formats. We expect that a given receiver will have a native-mode display format optimized for the receiver's intended market, and that the receiver will convert whatever signal is decoded in the receiver to its native display mode. The conversions required are simple relative to the processing capacity of the receiver, and conversions for NTSC will undoubtedly be incorporated (although that would be a manufacturer implementation option), so receivers could cost-effectively incorporate a menu of conversions that manufacturers anticipate.

15. *How do the Proponents expect to get 1050P in the 6 MHz bandwidth?*

The 960-line progressive format is found in the 24 Hz and 30 Hz film modes. The migration to a high line number format with progressive scan at 60 Hz has not been settled.

16. *Will backward compatibility from the target 1050/1:1/60 format be built into the early receivers and other display devices?*

Yes. The implementation of backward compatibility depends on the migration scenario(s) that are now under consideration. One approach to backward compatibility is to specify that the original HDTV receivers will contain the capability of decoding the high line number progressive scan target format. Backward compatibility will be facilitated by the use of packet headers that identify the type of data in each packet. Receivers can therefore be designed to disregard packets that are not recognized or not needed.

17. *If the intention is to evolve system over time (from one initial unique scanning standard), has a specific migration plan yet been considered?*

No. Many migration scenarios exist. It is incorrect to assume that initial operation will necessarily be restricted to a single scanning standard.

18. *What are the technical impediments to implementing a 1050 line progressive scan transmission mode? What migration path is envisioned and how will compatibility with older receivers be handled?*

The chief technical impediment to a progressive 960-line mode at 60 Hz is the limited channel capacity of the 6 MHz channel. In order to fit a compressed 60 Hz 960-line progressive-scan video signal into the 6 MHz channel, the horizontal (and/or vertical) spatial resolution would need to be so reduced that HDTV sharpness could not be maintained, or the transmitted power would have to increase. See the answer to Question 15 in this section.

19. *What is the transition scenario to the ultimate 1050P format? What are the trade-offs between coping with multiple interim formats versus direct path to ultimate format ASAP?*

See the answer to Question 17. Multiple formats are not an interim step, but part of the system definition. Migration to a higher line number with progressive scan will not diminish the value, for some applications, of the original baseline formats.

20. *What migration path is envisioned for achieving 1050P scan TX mode? What changes will be required from broadcasters and consumers to upgrade to a 1000-line P scan system? What are technical and economic impediments to implementing 1000P scan today? 5 years?*

See the answers to Questions 17, 18, 19.

21. *Will migration to future target system be resolved by 9/15/93? Be planned for in*

*startup service? Is it more difficult/critical at encoder or receiver? Is the path easier for receivers based on 720 x 1280 x 1:1 or 1080 x 1440 x 2:1? Will early receivers be unusable after migration?*

Migration strategies are still under consideration, and will be incorporated as soon as possible. Early receivers will be usable after migration. Approaches that will enable backward compatibility will be designed into the standard (and all receivers). Practical scenarios for migration are under consideration by the GA. The migration issue centers on the lack of channel capacity. A policy for backward compatibility affects relatively more consumers than originators, therefore it could be argued that the policies surrounding receiver migration are most important.

22. *Is 1080 x 1440 x 2:1 x 60 a practical system for a startup service?*

The 1080 by 1440, 60 Hz, 2:1 interlaced format appears to have some advantages. However, using 1080 lines implies that the square pixel format for film would have 1920 samples per line, so the receivers would need substantially larger frame memories. There are other consequences of changing to a 1080-line format, and questions concerning the availability of test materials and test equipment for the 1080-line formats. (See the GA "white paper" on this subject submitted to the Expert Group on Scanning Formats and Compression.)

**525/59.94 ISSUES**

1. *Is this an HDTV system only, or an ATV system that could also support multiple channels of lower quality (eg. 525I line) service?*

The GA system has been conceived as an HDTV system only. The modulation system that is a sub-system of the GA system delivers about 20-25 Mb/sec over the 6 MHz television channel, and one could imagine any number of uses for that type and amount of channel capacity.

2. *Archival NTSC material will have to be transcoded into ATV. Which of the ATV formats is best suited to this task? Broadcasters may have to transcode ATV material into NTSC for simulcasting. How will they cope with all the ATV formats?*

Both the 720/1:1/60 and the 960/2:1/60 formats are well suited for NTSC up-conversion. The quality of up-conversion in either case depends on the quality of de-interlacing/interpolation applied to the 525-line interlaced source.
Down-conversion from either 720-line progressive scanned formats or 960-line progressive and interlaced formats will be straightforward. Coping with multiple formats will be automated, since the data streams will be self-identifying, so that needed conversions are routinely anticipated and smoothly introduced without