Advanced Digital HDTV

ATRC

Introduction

- **ATRC supports the ACATS position that no substantial changes (affecting compression, data formats or signal formats) will be allowed after certification and testing**
  - would likely invalidate the entire testing process

- **AD-HDTV remains as certified - no changes necessary**

- **Prototype Hardware Improvements**
  - Trellis Coding
  - Receiver Carrier Recovery Pull-in Range
  - Quality of the High-Priority Safety Net
  - Adjustment of HP/SP Power Ratio
  - Upper and Lower Adjacent Channel Rejection
  - Receiver Adaptive Equalizer Range
  - QAM for Cable
  - Motion search range

- **As certified and tested, AD-HDTV readily accommodates T3/S3 recommendations on audio and ancillary data**

ATRC

Review Procedure

- **ATRC supports showing ATTC quality tapes**
  - part of official test process
  - recorded by ATTC under controlled conditions

- **ATRC objects to showing proponent supplied material because it could be misleading and result in erroneous conclusions**
  - different source material from official tests and among proponents provides no valid basis for comparison
  - this is an uncontrolled situation that provides no way to validate fundamental conditions such as:
    - data rate, bandwidth, etc. of the proponent system
    - picture quality/robustness/interference tradeoffs
    - consistency of system parameter settings among scenes
  - this situation bypasses all of the rigorously controlled conditions and procedures of ATTC tests
  - this alone is a "retest" of sorts, and it discriminates against proponents that believed statements from ACATS that there would be no additional testing opportunities
- **ATRC continues to strongly oppose any additional testing**

ATRC

Trellis Coding

- **Certified a 0.9 rate trellis code with 3 dB coding gain**
- **Tested at ATTC with a 0.9 rate set partition code (simple member of trellis family) with about 1.5 dB coding gain**
  - SS-WP2 notified and reviewed
- **Prototype hardware will be upgraded to meet certification**
  - simply change the technique of generating and decoding the 1 bit in every 10 that represents the trellis code
  - full 3 dB coding gain
  - all coding rates, data rates and signal format attributes remain as certified and tested
- **Upgrade to full Trellis code will improve random noise and ATV-ATV performance by 1.5 to 2 dB**
- **Prototype hardware will be upgraded to full trellis code by time of field testing**

ATRC

Carrier Recovery

- **Certified with second-order carrier recovery circuit**

- **Tested at ATTC with first-order carrier recovery circuit**
  - met NTSC VHF specs and our own laboratory tolerances
  - during ATTC testing, we found that frequency pull-in range of our receiver did not meet full NTSC UHF specs
  - SS-WP2 notified and reviewed

- **Current NTSC UHF tolerance is unnecessarily large with modern frequency synthesizer technology - UHF HDTV transmission may be established with tighter tolerance**

- **Carrier recovery is a receiver option, not a system attribute**
  - second-order carrier recovery
  - first-order with microprocessor controlled tuner search

- **Prototype hardware will be upgraded with second-order carrier recovery by time of field testing (will improve pull-in range, frequency offset performance...)**

HP Safety Net Quality

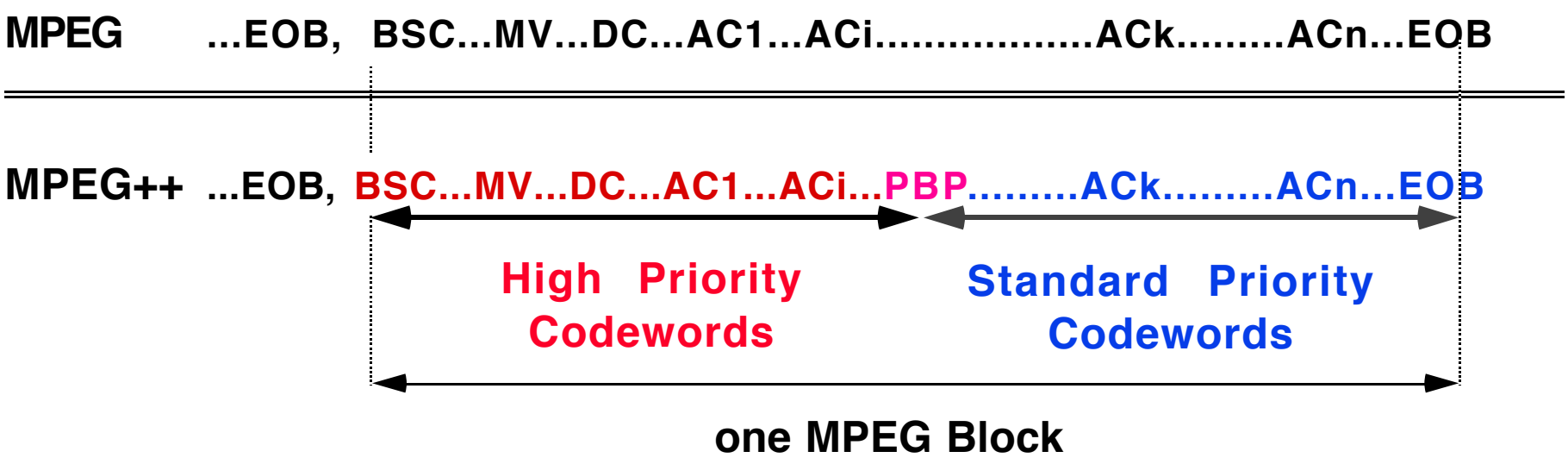
- **AD-HDTV certified with MPEG++ prioritization and two-tier packetization and transmission**
  - safety net for severely impaired transmission conditions

- **ATTC/ATEL results will not adequately verify the importance of this extra transmission robustness**
  - value of HP is continuation of audio and video service (not part of test procedures)
  - occassional difficulties with motion comp. hardware affected HP picture quality
  - "squelching" circuit that manages transition to HP mode not working optimally affected HP picture quality

ATRC

How Priority Assignment Works

- Does not affect compression or data rates in any way
- Prioritization simply splits MPEG data into two subsets



The HP codeword stream encodes a viewable picture

The full HP and SP codeword stream encodes full HDTV

HP Safety Net Improvements

- **Some hardware corrections already made - performance of the HP safety net demonstrated to industry during WRC-TV tests in September**

- **Further improved priority assignment algorithms are under development**

- **Improved priority assignment requires NO Changes to transmission standard or receivers**
  - only a function of the encoder
  - designed to improve steadily over the life of the standard

ATRC

HP/SP Power Adjustment

- **AD-HDTV nominally has 5 dB higher power spectral density in its HP carrier**
  - 5 dB value selected based on field strength statistics to provide an additional 7.5% time availability

- **AD-HDTV is the only proposed system that allows adjustment of a two-tier transmission approach**

- **System specific tests conducted at ATTC with 7 dB higher HP CNR threshold (time was unavailable to test other configurations)**

- **As a standard, AD-HDTV can allow adjusting HP/SP power on an individual broadcaster basis**
  - dependent on terrain and interference environment
  - requires 2 AGC's in receiver

Upper/Lower Adjacent

- **ATTC test results appear more than adequate**

- **Further improvements can be made**
  - internal tuner adjustments
  - custom SAW filter in tuner
  - improvement will be several dB

- **Tuner rejection of upper and lower adjacent channels is a receiver issue rather than a system attribute**

- **Prototype hardware will be improved by time of field testing**

Equalizer Range

- **Prototype hardware tested at ATTC had an equalizer range of ±4 μsec (per certification documents)**
- **ATTC results show excellent performance within this range**
- **Adaptive equalizer range and performance is a receiver design issue rather than a system attribute**
- **Ongoing improvements will be made**
  - ±8 μsec
  - ±16 μsec
- **Prototype hardware will be improved by time of field testing, with at least a ±8 μsec range**

QAM for Cable

- **AD-HDTV was designed to support both SS-QAM and QAM transmission for cable (per certification documents)**
  - cable does not have co-channel requirement of terrestrial
  - cost-effective cable transmission is important
  - SS-QAM for broadcast-originated programming
  - QAM for satellite-originated programming

- **AD-HDTV receivers can be designed to handle terrestrial SS-QAM, cable QAM and satellite QPSK**
  - closely related signal forms and data rates make this economical

- **Prototype hardware tested at ATTC had only one signal form (SS-QAM) per the test plan**

- **Prototype "cable regenerator" and receiver hardware delivered for field testing will be capable of both SS-QAM and QAM transmission on cable**

ATRC

Motion Search Range

- **AD-HDTV certified with MPEG compression that allows up to [-1024, +1023] pixel motion vector range**

- **Prototype encoder tested at ATTC had a motion compensation range of [-32,+31] pixels (per certification documents)**
  - produces outstanding picture quality
  - full MPEG syntax (had room for full MVs to be transmitted)

- **MPEG compression allows different encoders to have different motion compensation ranges**
  - A range of encoder products will evolve
    (low-cost units for newsroom and drama use)
    (more expensive units with lots of motion comp for sports)
  - Better encoders will deliver better pictures, even to old receivers (no change to transmission standard or receivers)

- **Computer simulation to demonstrate improvement; Hardware implementation in a second generation prototype after field testing**

Hardware Improvements

- Trellis Coding
- Receiver Carrier Recovery Pull-in Range
- Quality of the High-Priority Safety Net
- Adjustment of HP/SP Power Ratio
- Upper and Lower Adjacent Channel Rejection
- Receiver Adaptive Equalizer Range
- QAM for Cable
- Motion search range

ATRC

MPEG2

- **AD-HDTV certified and tested with with MPEG1 compression**

- **ATRC will consider change to MPEG2 at an appropriate time**
  - MPEG2 syntax is not fully defined

- **MPEG2 compression will be more like MPEG1 (AD-HDTV) than any other proponent system**
  - B-frame structure will remain
  - VQ on DCT coefficients (like DSC-HDTV) was rejected

- **ATRC believes that AD-HDTV is the only acceptable basis for moving to MPEG2 compression**
  - MPEG2 will have minor changes to MPEG1 (AD-HDTV)
  - MPEG2 is a fundamental change to other proposed systems

ATRC

T3/S3 Recommendations

- **AD-HDTV's packet format (Prioritized Data Transport) already supports most T3/S3 recommendations**
  - Flexible Allocation
  - Extensibility
  - Service Identification Data
  - Multiple Languages
  - Audio Services to the Visually and Hearing Impaired
  - Ancillary Data Services
  - Programmer Control of Audio and Ancillary Data Services
  - Error Correction and Concealment for Audio Services

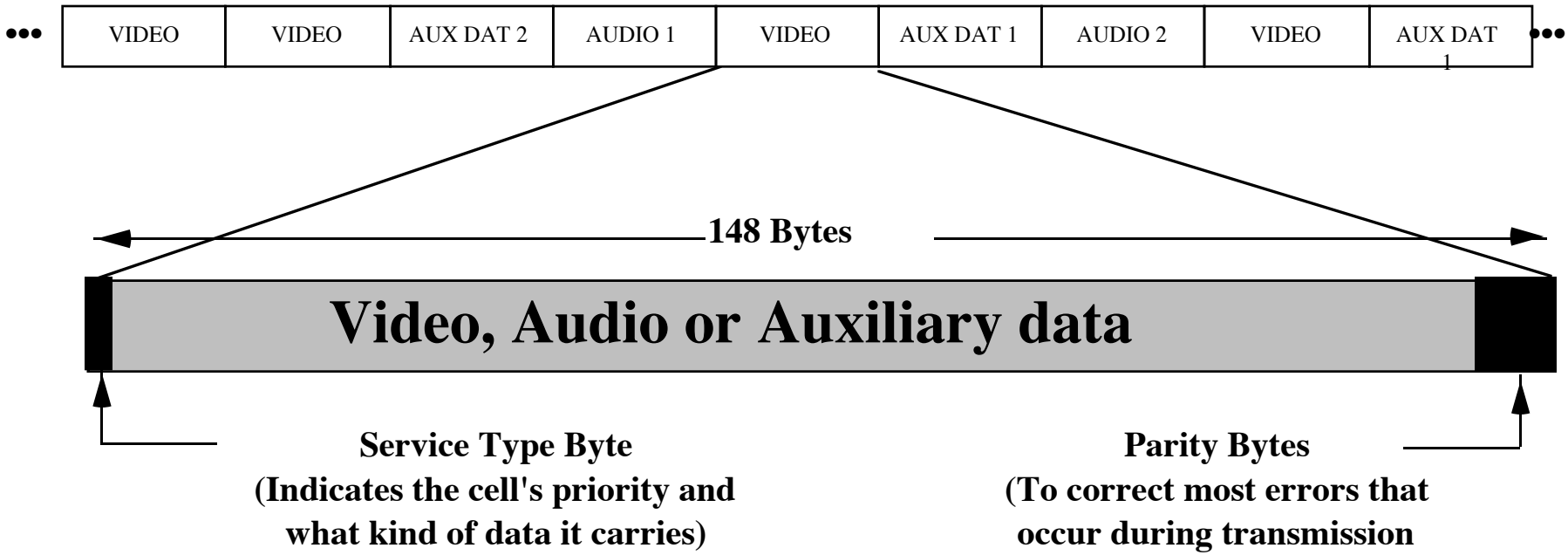
- **AD-HDTV has been certified and tested with these capabilities**

- **Audio aspects of T3/S3 are readily accommodated**
  - Multi-Channel Audio
  - Uniform Loudness
  - Dynamic Range Control
  - Monitor Electro-Acoustic Frequency Response

ATRC

Service Identification Data

- **Service Identification Data is provided directly by AD-HDTV's Prioritized Data Transport format, that includes Service Type header/descriptors at the beginning of every cell**



- **Service Identification Data is a fundamental attribute of AD-HDTV that was certified and tested**

Flexible Allocation

- **Nominal configuration tested at ATTC:**
  - HDTV video (17.7 Mbps)
  - two channels of audio (2 x 256 kbps)
  - auxiliary data (256 kbps)

HP video	SP video	audio 1	audio 2	SP video	SP video	text	CCaption	SP video

- **Flexible allocation of data is a fundamental attribute of AD-HDTV that was certified and tested**
  - readily demonstrated in our prototype hardware
  - during ATTC testing, we were required to load the auxiliary data channel in order to ensure that nominal data allotments were met

- **AD-HDTV's Service Type header/descriptors at the beginning of every packet allow a self-defining packet stream**

Flexible Allocation

- **AD-HDTV allows mix of services (and their data rates) to be flexibly and dynamically allocated**

  - by programmer (e.g., allowing certain programmers to broadcast in many languages)

  - on a program-by-program basis (e.g., allowing certain programs to have increased closed-captioning capacity).

  - on a second-by-second basis (e.g., to allow high data rate burst-mode delivery of software or other auxiliary data)

ATRC

Extensibility

- **AD-HDTV's service type header/descriptor on each packet also provides extensibility**
- **Future enhancements and new services will be assigned new service types**
- **This eliminates future backward compatibility problems**
  - cells with unrecognized services types will simply be discarded by older AD-HDTV receivers that do not recognize or cannot handle the new service type

Old receivers only "know about" basic video and audio cells (anything else is ignored)	NEW1 receivers accept basic video, audio and NEW1 cells (NEW2 cells are ignored)	NEW2 receivers accept basic video, audio, NEW1 and NEW2 cells

ATRC

Ancillary Data Services

- Nominal configuration is 256 kbps for ancillary data services

- Only initial use that is currently planned is closed captioning service at 9.6 kbps

- The 256 kbps capacity was picked because we believe that it is sufficient for most traditionally anticipated uses for ancillary data.

- More or less ancillary data is flexibly accommodated

- Text and program guide data will be delivered as separate service types

ATRC

Programmer Control of Audio and Anc. Data Services

- Separately packetizing each service into its own sequence of cells facilitates programmer control of audio and ancillary data services
- Undesired services that are distributed to the programmer may be deleted by replacing the cells of that service type with cells of a “null” service type
- Alternatively, other services (e.g., locally originated) may be substituted in the vacated portion of the data capacity. Likewise, space for local insertion of data can be reserved by distributing a data stream with a portion of “null” cells that can be replaced by the programmer
- AD-HDTV prototype hardware tested at ATTC actually made use of null cells to fill the channel during buffer underflow conditions

ATRC

Programmer Control

Programmer Receives:

Programmer Deletes: TEXT and NULL cells

Programmer Transmits: Local TXT ••• Local AD cells

ATRC

Error Correction and Concealment for Audio Services

- **Separately packetizing each service into its own sequence of cells facilitates error correction and concealment for audio services**

- **Each cell contains 20 bytes of Reed-Solomon error correction code and 2 bytes of CRC error detection code**
  - correct up to 10 byte errors per cell
  - CRC code detects uncorrectable errors

- **As tested at ATTC, AD-HDTV performs audio muting (simplest form of concealment) when subjected to uncorrectable audio bit errors**

- **In AD-HDTV, programmers also can select which audio services to send as High Priority data, providing these services with an extra 5 dB of transmission robustness**

Multiple Languages

- Nominal configuration tested at the ATTC provides two stereo pairs of high quality sound (each at 256 kbps).

- Like all data in AD-HDTV, each audio stream is separately identified as a unique service type and packetized as its own series of cells. This approach allows many additional audio streams for additional languages to be added by the programmer, with a commensurate reduction in picture quality

Audio Services to the VI and HI

- Each additional audio stream is handled as a separate service type in the packet layer
- Appropriately featured receivers will receive and decode the additional audio services
- Note that multiple captioning streams can also be supported to enhance the audio services to the VI and HI

Multi Channel Audio

- AD-HDTV can easily support the data capacities required for multiple audio coding modes, including independent and composite coding

- The MUSICAM audio tested at ATTC provided high quality stereo sound (2/0 mode) with a 256 kbps data stream

- Full surround sound (3/2 mode) and/or three channel frontal sound (3/0) capabilities can be provided by an extension of the MUSICAM compression system

- Compatibility with MPEG Layer II audio is an extremely important interoperability and extensibility consideration

MPEG Audio

- The ISO-MPEG audio committee is currently in the process of defining a five channel composite coding extension that is backward-compatible with the Layer II two-channel coding (i.e., the MUSICAM audio system used in AD-HDTV)

- This composite coding will require between 320 and 384 kbps to provide high quality five-channel service.

- Decoders will be able to provide either five channel or two channel service, as either delivered by the programmer or determined by the capabilities of the receiver

Multi Channel Audio

- **ATRC plans to meet the T3/S3 recommendations by incorporating the MPEG five channel coding approach as part of AD-HDTV**

- **Prototype hardware construction, testing and demonstration will occur as soon as possible**

- **Of course, AD-HDTV can deliver any (one or more) audio encoding system(s)**
  - AD-HDTV may be demonstrated with other audio encoding approaches by the time of field testing

  - Note that AD-HDTV could, for example,deliver both MUSICAM and Dolby audio simultaneously

Other Audio Principles

- **Uniform Loudness**
  - While the tested prototype hardware does not implement this feature, the MUSICAM system can be adapted at the receiver to provide uniform loudness.

- **Dynamic Range Control**
  - While the tested prototype hardware does not implement this feature, the MUSICAM system can be adapted at the receiver to provide dynamic range control.

- **Monitor Electro-Acoustic Frequency Response**
  - (This is an audio production issue.)

ATRC

Summary

- **No changes to AD-HDTV system as described at certification**
- **No fundamental changes to compression, data formats or signal format**
- **Only prototype hardware performance improvements**
  - Trellis Coding
  - Receiver Carrier Recovery Pull-in Range
  - Quality of the High-Priority Safety Net
  - Adjustment of HP/SP Power Ratio
  - Upper and Lower Adjacent Channel Rejection
  - Receiver Adaptive Equalizer Range
  - QAM for Cable
- **As certified and tested, AD-HDTV readily accommodates T3/S3 recommendations for flexibility, extensibilty, etc.**
  - AD-HDTV will be upgraded with MPEG five channel audio encoding (that is backward-compatible with its current stereo sound) ASAP

Comments on GI Changes

- **Peak-to-Average power ratio (1.5 dB clipping)**
  - the claimed benefit of 1 dB reduction in peak ERP for equivalent coverage assumes a .5 dB increase in average power (to compensate for .5 dB increase in CNR threshold)
  - **this will increase cochannel interference into NTSC!**

- **Refresh is a fundamental aspect of a compression system**
  - picture quality impact?
  - transmission robustness impact?

- **Packetized Transmission is a fundamental *system* change!**
  - performance impact of GI packet structure unknown
    - packet bit patterns interference into NTSC
    - immunity of packet headers to bit errors
    - immunity of data frame headers to bit errors
  - MPEG-2
    - will be more like MPEG1 (AD-HDTV) than anything else

More Comments on GI

- **Subpixel accuracy**
  - requires more bits to be sent for motion vectors
  - fundamental aspect of compression syntax
- **Variable Block Size**
  - requires more bits to be sent for motion vectors
  - fundamental aspect of compression syntax
- **Chrominance Resolution**
  - requires more bits to be sent for color
  - less bits available for motion, luma resolution, etc.
- **Raster parameters**
  - ATRC generally agrees

Conclusions - GI

- Extensive retesting would be required to assess impact of proposed changes

- Packetized transmission is a fundamental system change that cannot be allowed without destroying the credibility of the process

Comments on MIT Changes

- **Changes in Quantization tables involve many fundamental picture quality tradeoffs**
  - changes to reduce high freq. quantization must increase low frequency quantization

- **Source adaptive encoding is a fundamental aspect of a compression system that was not certified**
  - picture quality impact?
  - cost impact?

- **Full chrominance resolution has important quality and cost impacts that must be assessed**

- **Position dependent RLC impact is uncertain**
  - picture quality impact?
  - transmission robustness impact?

More Comments on MIT

- **Peak-to-Average power ratio (1.5 dB clipping)**
- the claimed benefit of 1 dB reduction in peak ERP for equivalent coverage assumes a .5 dB increase in average power (to compensate for .5 dB increase in CNR threshold)
- **this will increase cochannel interference into NTSC!**

- **Packetized Transmission is a fundamental *system* change!**
  - performance impact of GI packet structure unknown
    - packet bit patterns interference into NTSC
    - immunity of packet headers to bit errors
    - immunity of data frame headers to bit errors
  - MPEG-2
    - will be more like MPEG1 (AD-HDTV) than anything else

- **Audio changes require retesting**
  - different coding (Dolby) for composite multichannel is a backward compatibility issue

Notable Quotes - MIT

- **"A clear peice of evidence of the suboptimal choice of tables comes from the quantization levels observed during the ATTC testing..." (p. 3)**

Conclusions - MIT

- Very extensive retesting would be required to assess impact of proposed changes
- Cost reassessment by SS/WP3 would also be required to assess impact of proposed changes
- Packetized transmission is a fundamental system change that cannot be allowed without destroying the credibility of the process

DSC Compression

- **Vertical noise coring is a questionable improvement**
  - compression systems must deal with noisy sources (an inherent disadvantage of progressive scan systems)
  - coring makes picture quality tradeoffs between noise and detail
  - preprocessing tailored to ATTC sources will invalidate tests

- **VQ codebook changes involve fundamental tradeoffs**
  - changing VQ tables makes some pictures better, others worse
  - increasing table size affects data rate

- **Quantization, Perceptual weights ands VLC involve many fundamental picture quality and system tradeoffs**
  - changing PWs to reduce high freq. quantization must increase low frequency quantization
  - new VLCs will create new data patterns and change both

ATRC

DSC Compression

- **Leak**
  - impact of errors on synch bit in global data?
- **Error concealment improvements are not fundamental**
  - improvements can likely be made in every system
- **Buffer control changes are not adequately explained**
  - explain causer and effect of lower limits?
  - why is increased distortion on scene changes not perceptable?

DSC Transmission

- **Pilot level change has extensive impact**
  - affects all cochannel, adjacent channel and taboo tests (all combinations of A&N and all levels)
- **Offset frequency and dispersion are significant changes**
  - offset frequency effect already on test record
  - impact of offset on A->A interfernce is uncertain
  - changes to dispersion require more explanation (e.g., effect on multipath, etc.)

DSC - Field Test and Later

- **Spatially adaptive leak is a fundamental compression change**
  - requires additional control, changes effect of errors, etc.

- **New data format is a fundamental change**
  - impact on interference is uncertain
  - impact on transmission robustness is uncertain

- **Data network proposal is unclear**

Conclusions - DSC

- Many proposed changes are absolutely fundamental
- Very extensive retesting would be required to assess impact of proposed changes
- Especially true since DSC-HDTV has W1/W2 tradeoffs that involve picture quality, robustness and interference (p. 22)
- ATRC is strongly opposed to any additional testing

Notable Quotes - DSC

- **"At this time, the tradeoff between picture quality and transmission robustness is being readjusted to achieve better soft coding. Since the results of this tradeoff are not completely in hand, the overall performance improvement in the final system may be slightly different..." (p. 3)**

- **"...the system tested at ATTC suffered from two implementation problems. Both of these problems are mentioned in the report on DSC-HDTV, but they did not affect the performance of DSC-HDTV in the test center." (p. 15)**

- **"After this is done (W1 segment selection), we will optimize the tradeoff between picture quality and transmission performance." (p.22)**

PDT Cell Headers