

Advanced Digital HDTV

**Basic Principles of Transmission,
Coverage Area and Service Flexibility**

Glenn Reitmeier and Carlo Basile

**David Sarnoff
Research Center**

**Philips
Laboratories**

Advanced Digital HDTV

...was described at NAB' 91..

- **MPEG compression -- ISO standards**
- **MPEG++ approach**
 - ATRC adaptation of MPEG to HDTV simulcasting
 - two bit streams for robust service
- **Prioritized Data Transport**
 - provides robustness and flexibility

...but some critical aspects had to remain secret..

- **Spectrally Shaped QAM — what is it??**
- **Relationship between compression and transmission??**
- **Coverage Area — how much?? how is it robust??**

Outline

...the rest of the story...

- **Review AD-HDTV principles**
- **Introduce Spectrally Shaped QAM**
- **Describe how AD-HDTV works as a simulcast system**
- **Describe the resulting Coverage Area approach**
- **Discuss the full flexibility of AD-HDTV's Prioritized Data Transport to provide new kinds of services**

AD-HDTV System Layers

...a layered system offers standards and interoperability..

1050 line
Production Standard

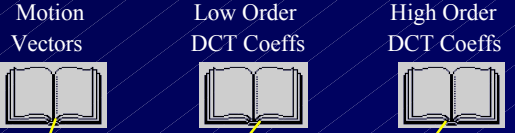


Pictures

MPEG Compression

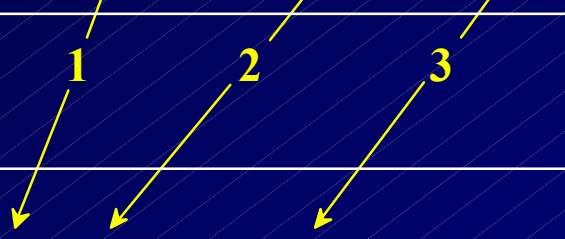


Video Data Structures



Coding

MPEG++
Prioritization



Parsing

Prioritized
Data
Transport

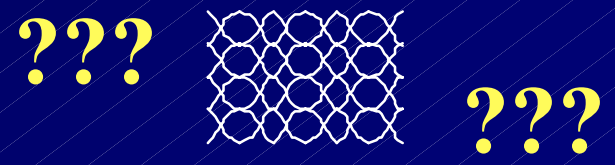


Packets

11010011101101001110100101010011

Bits

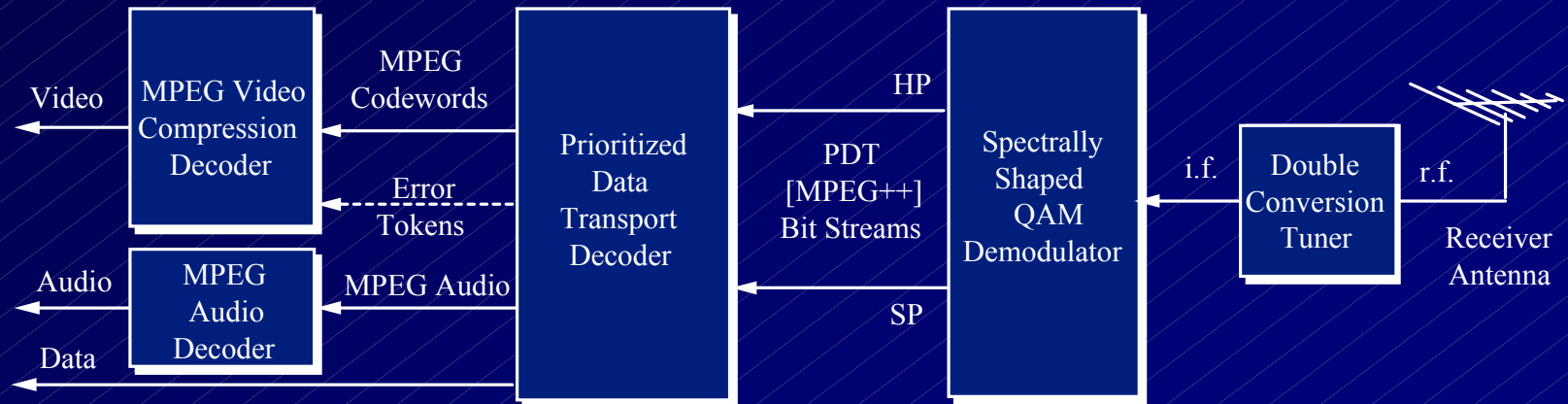
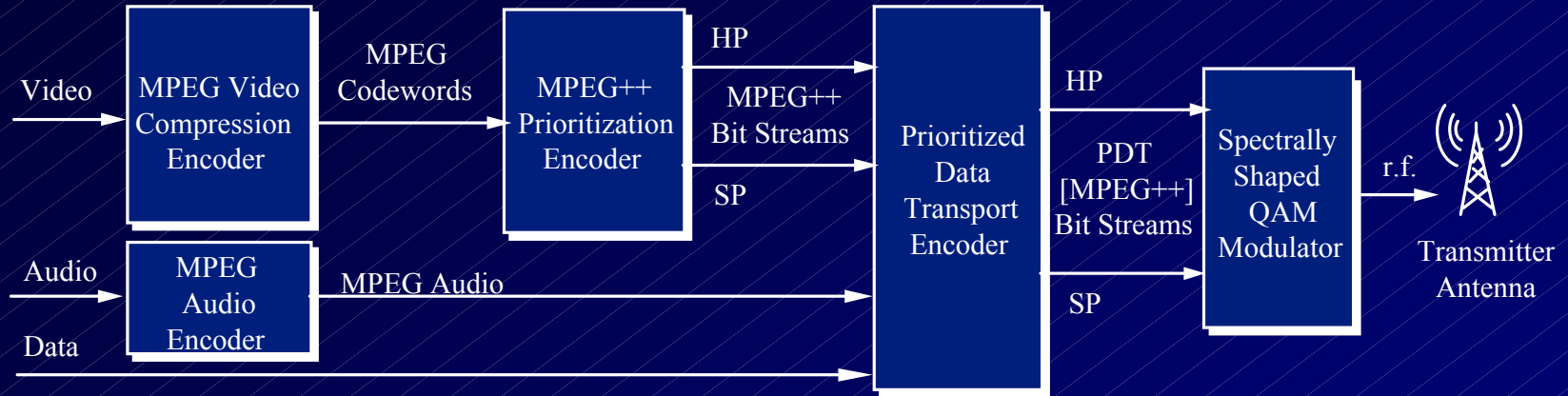
Spectrally Shaped QAM
Transmission



Symbols

System Block Diagram

...directly reflects the layered system architecture...



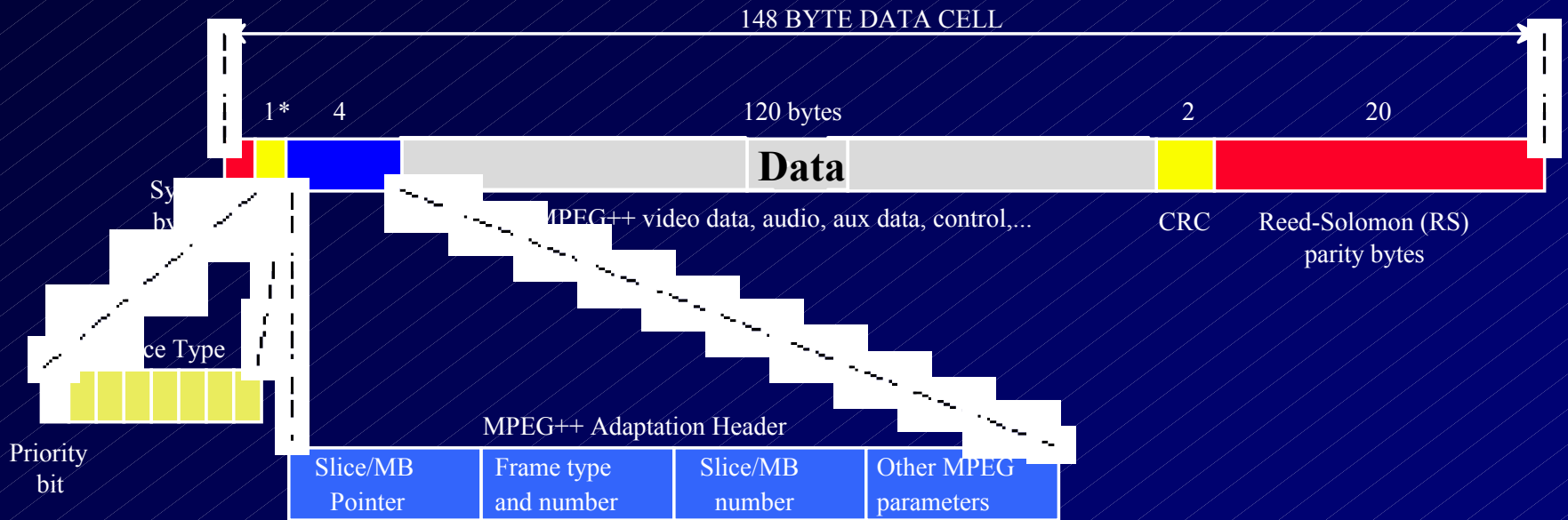
Prioritized Data Transport

...packaging data for transmission robustness...





- Packages and synchronizes data for two-tier (High-Priority and Standard-Priority) transmission
- Transport is a communications layer that encapsulates the MPEG++ bit stream in fixed-size transport cells (standard practice in data communications)
- Provides many layers of “safety nets”
 - error correction
 - error detection
 - decoder reentry
- Provides flexibility and extensibility

Prioritized Data Transport Format

...error correction, detection and recovery..



Legend:

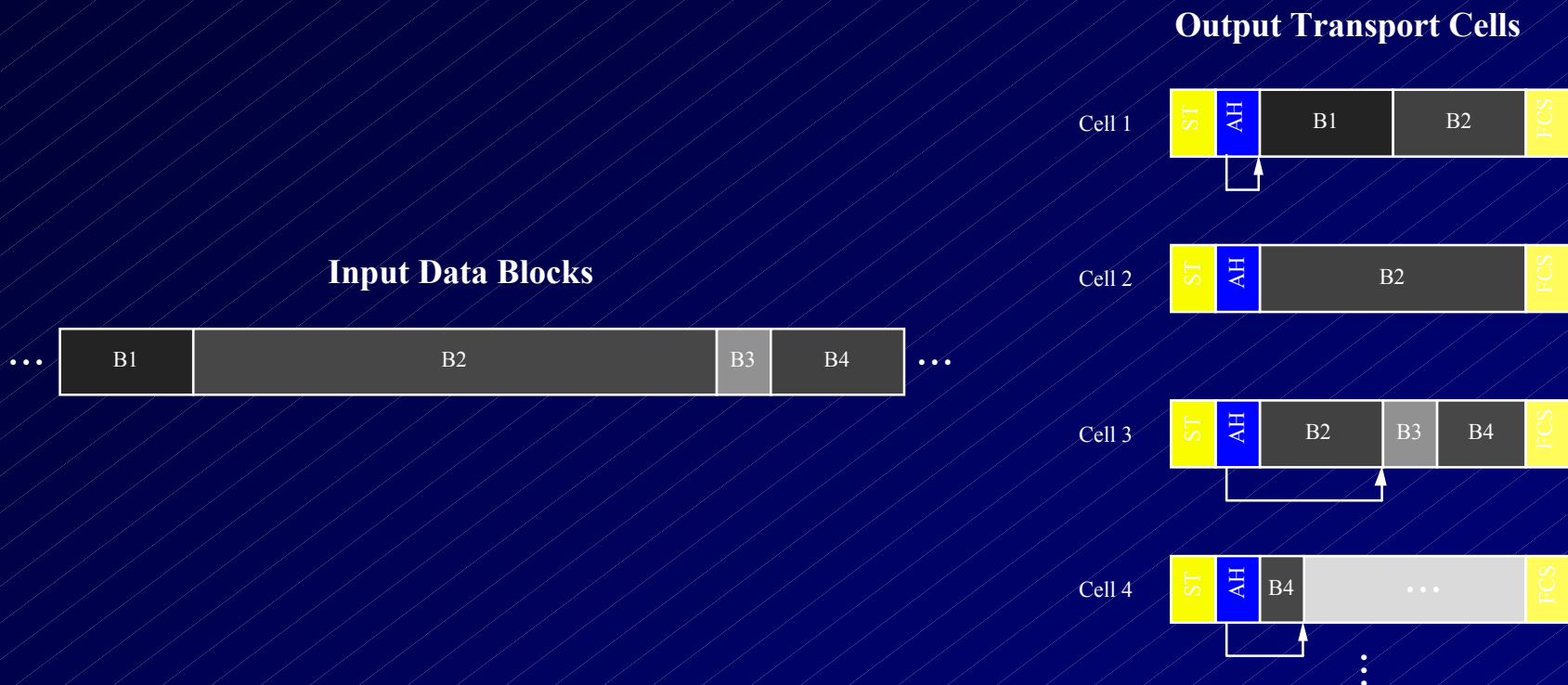
			
Error correction layer	Data-link layer	Adaptation layer	Service data

Data Transport Robustness

...error correction, detection and recovery..

- **Reed-Solomon FEC corrects up to 10 Byte errors per cell**
- **Data interleaving protects against burst errors**
- **Cyclic Redundancy Check FCS detects uncorrectable errors**
- **MPEG++ adaptation header provides a reentry pointer that allows the video decoder to smoothly resume processing good video data after a cell loss**
- **Erroneously received cells are discarded**
- **Cell sync and sequence number allow synchronization even under extremely poor transmission conditions**

Reentry Pointer Example



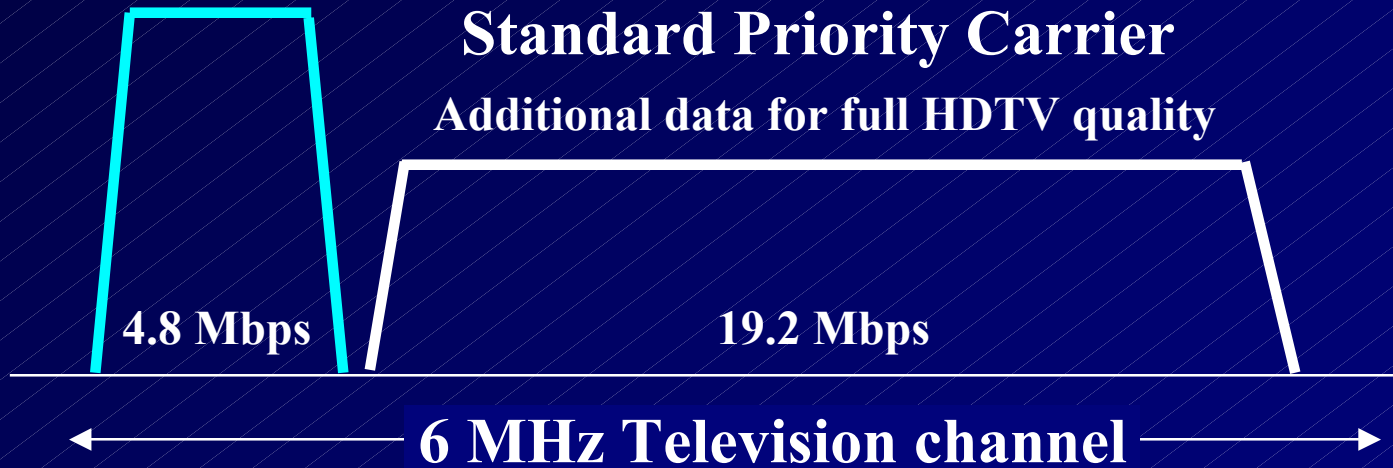
Four variable-length data records (B1, B2, B3, and B4) are to be formatted according to the PDT format specification into four transport cells. Cells 1, 3 and 4 each have an entry point corresponding to the start of the first new video record, while cell 2 (which contains video data segmented from within record B2) has no entry point. In the event that an error leads to a loss of cell 2, the entry pointer in cell 3 enables the receiver to decode B1, reject B2 and restart video decoding at record # B3.

Spectrally-Shaped QAM

...high priority data is sent with more power...

High Priority Carrier

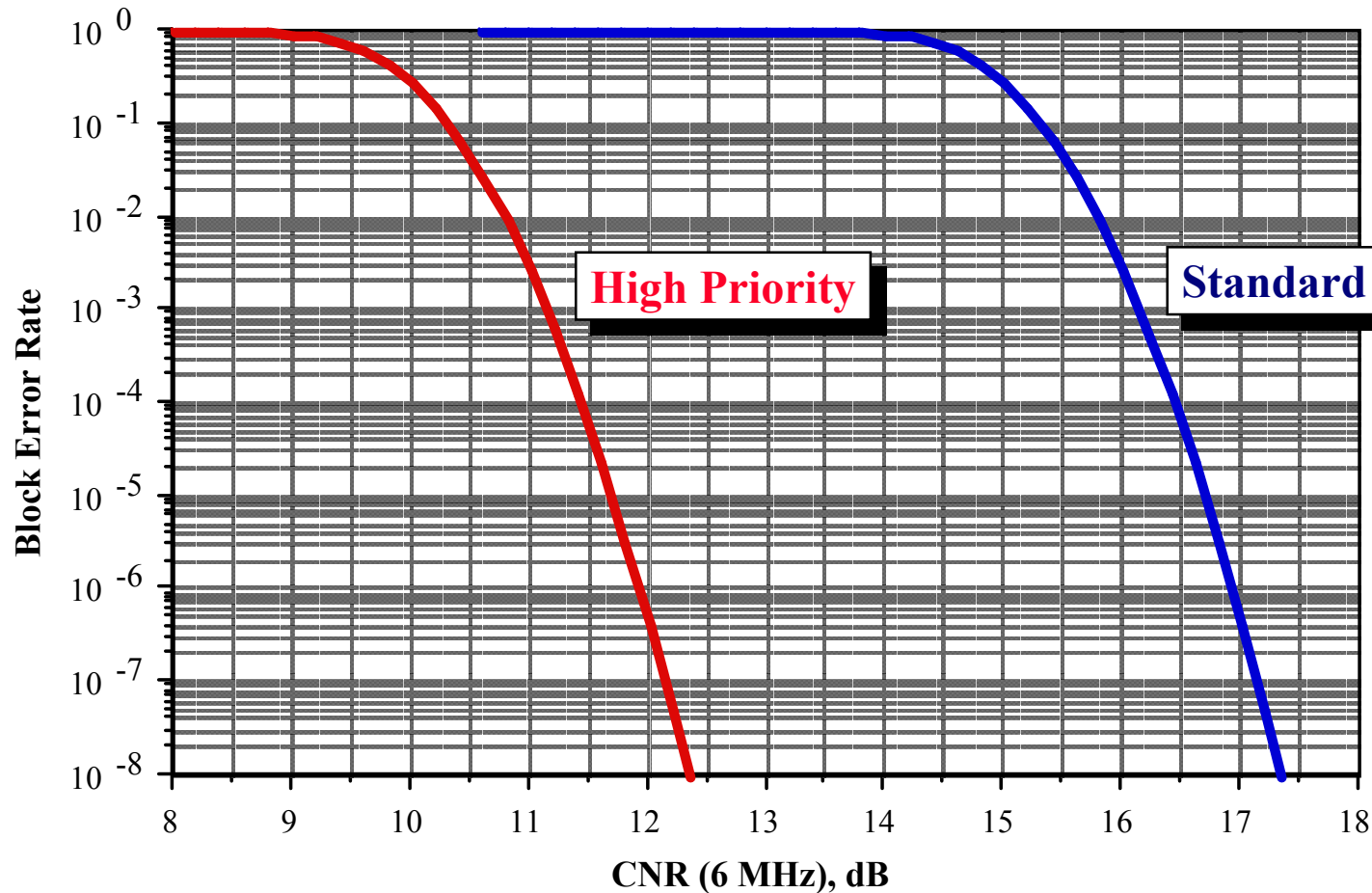
Sound and Viewable Picture data
have more power for higher
reliability



**Total data rate of 24 Million bits per second
delivers outstanding HDTV pictures and CD-quality sound**

BER vs. CNR Performance

...high priority data has greater transmission performance...



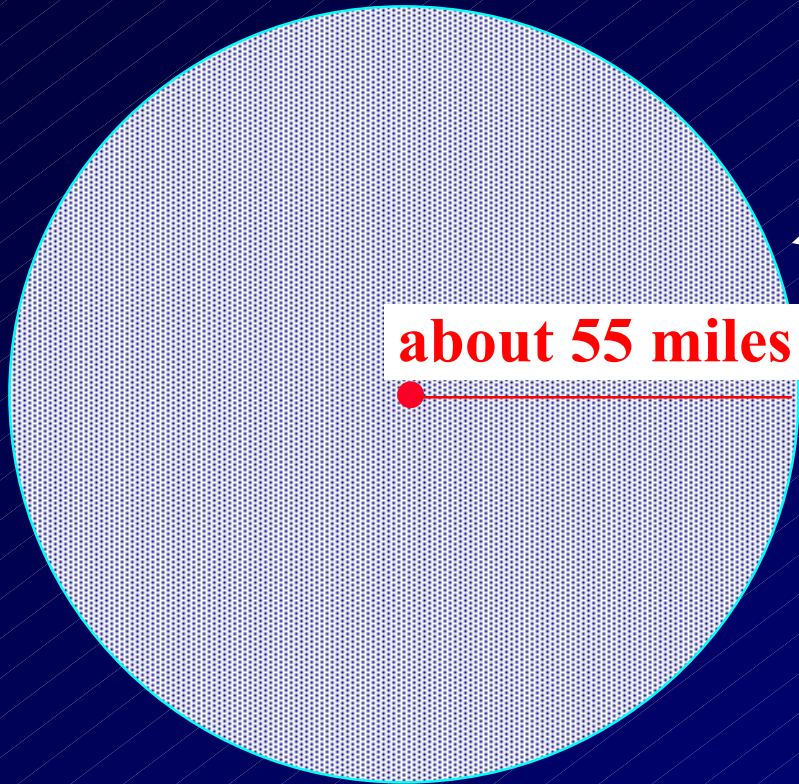
Coverage Area Parameters

- **CNR required for full HDTV quality (16.1 dB)**
- **CNR required for viewable pictures and sound (11.1 dB)**
- **D/U ratio required to receive full-quality ADTV when interfered with by an NTSC co-channel station (-2 dB)**
- **D/U ratio required to receive full-quality ADTV when interfered with by an ADTV co-channel station (16.1 dB)**
- **Noise Equivalence Factor - ratio of interfering signal power to random noise that results in an identical subjective impairment to NTSC (1.4 dB)**

AD-HDTV Coverage Area

...coverage area is based on full-quality service...

HP *and* SP reception provides full HDTV quality on the coverage contour with 90% time availability



Robust Reliable Service

...the HP Carrier protects against sudden loss of service...

HP and SP reception for
full HDTV quality
(90% time availability)



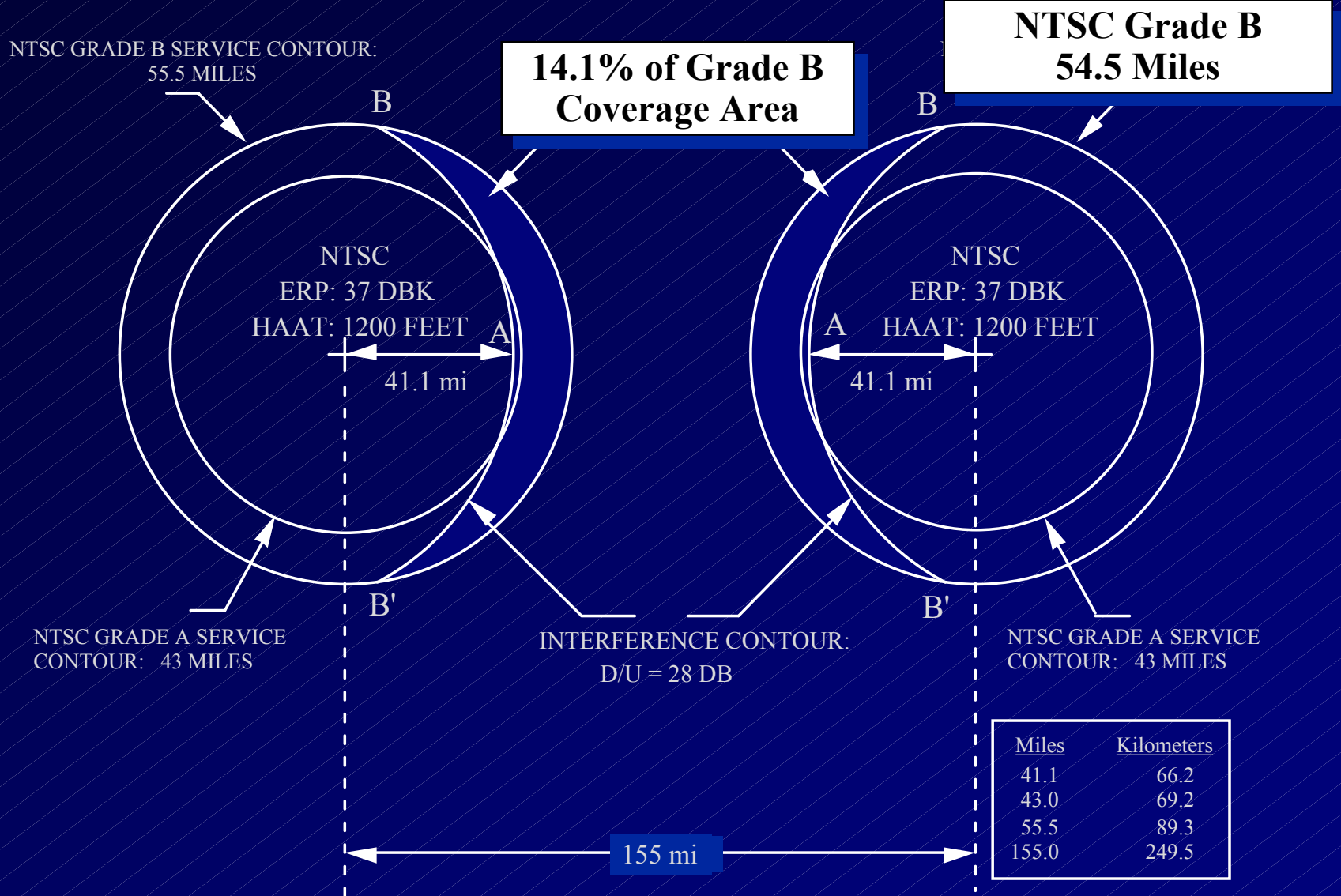
about 55 miles



The higher power HP Carrier
guarantees Sound and Viewable Picture
reception on the coverage contour with
97.5% time availability

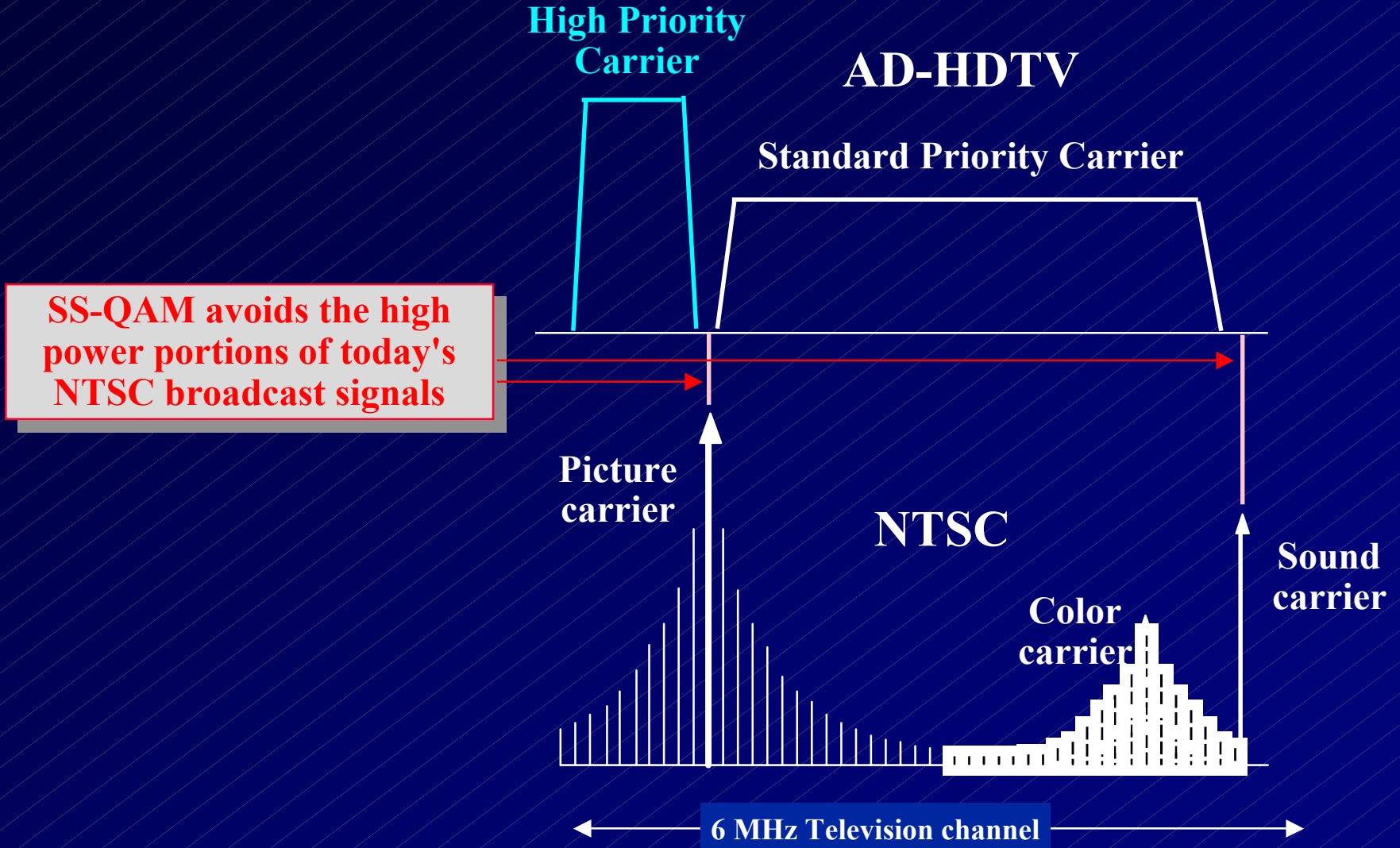
NTSC Coverage Area

Co-Channel NTSC Transmission with 155 Miles Station Separation



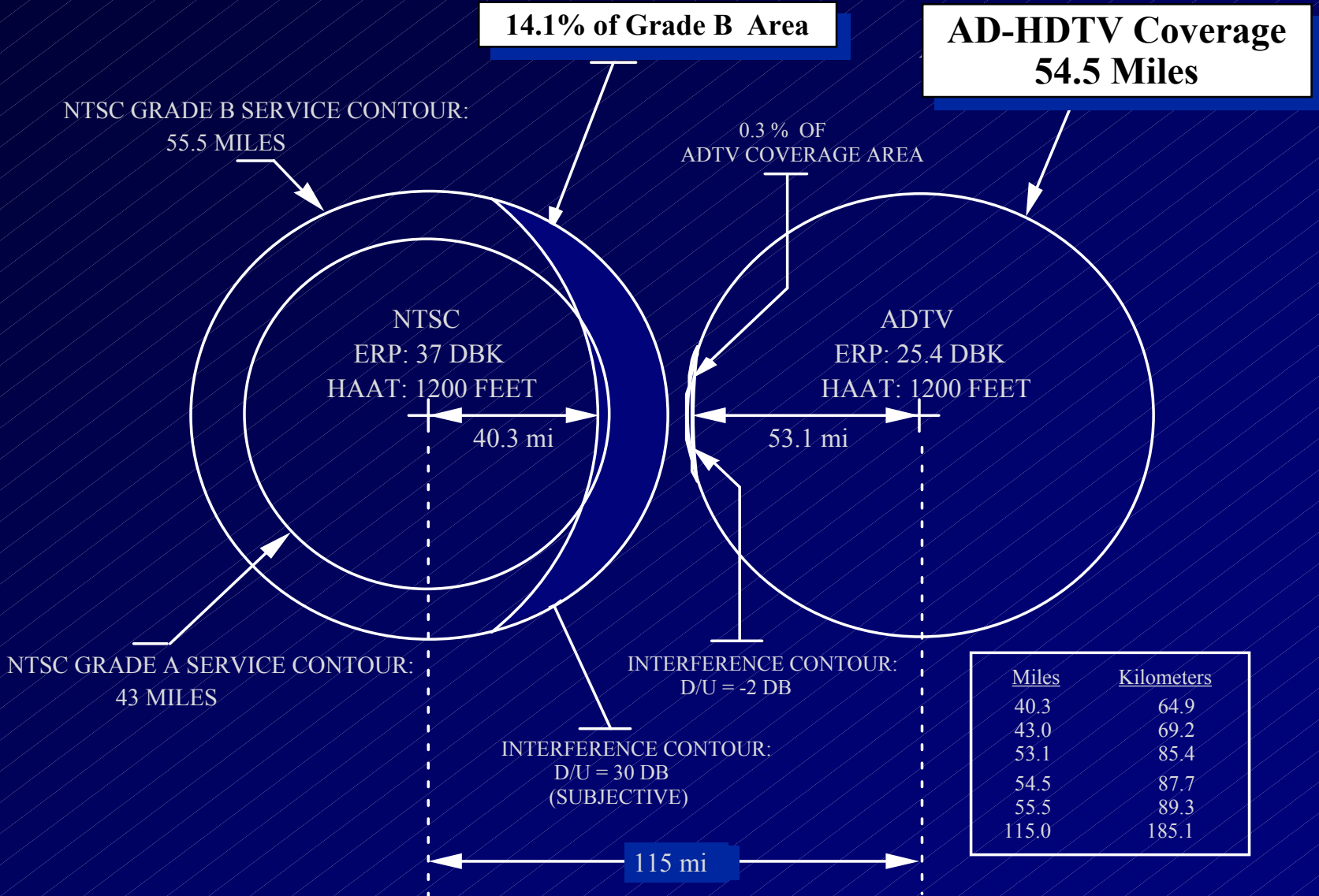
Spectral Shaping Avoids Interference

...a simple and effective approach...



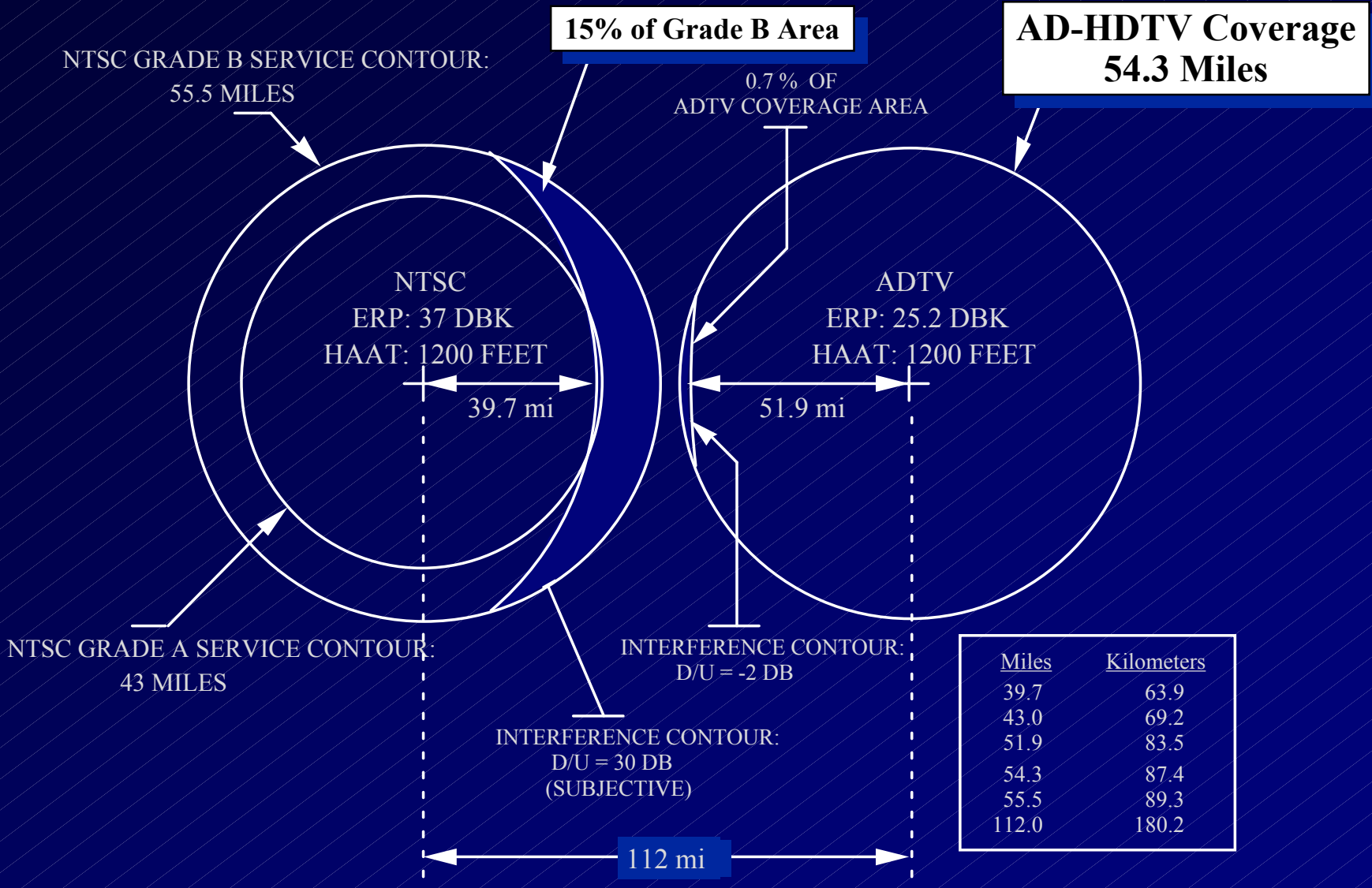
Coverage Area Example #1

NTSC and AD-HDTV Co-Channels with 115-Mile Station Separation



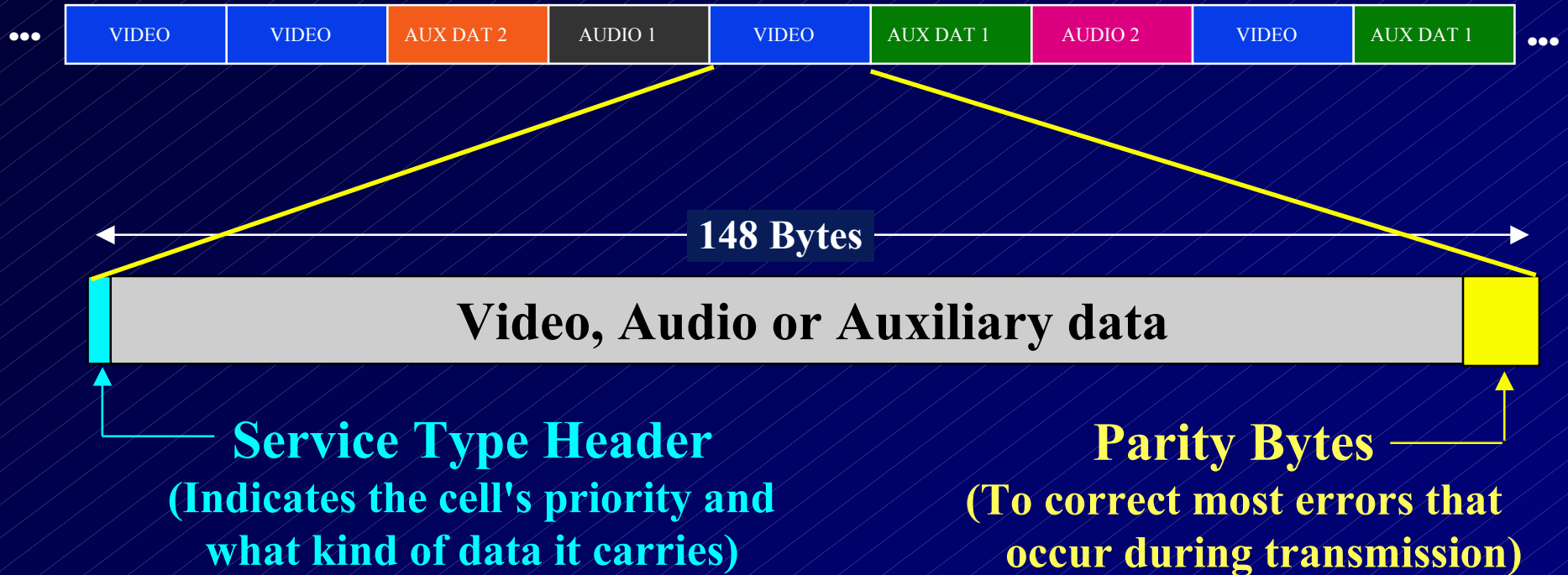
Coverage Area Example #2

NTSC and AD-HDTV Co-Channels with 112-Mile Station Separation



Prioritized Data Transport Flexibility

...enables innovative new programming...



AD-HDTV packages its bits in *data cells* — providing flexibility and new programming opportunities by delivering a dynamic combination of video, audio and auxiliary data to receivers

Advanced Digital HDTV Services

...a broad scope of services with new opportunities..

- **High-quality 1050 line HDTV pictures**
 - HDTV and film production
 - transcoded from NTSC
- **Two stereo pairs of CD-quality digital audio**
- **A flexible mix of video, audio, and auxiliary data**
(station-by-station or hour-by-hour)
 - selectable number of audio channels
 - selectable number of data services
 - more local service opportunities
- **A dynamic mix of video, audio, and *software***
(new kinds of programming)
 - interactive educational programming...
 - interactive game shows...
 - let your creativity go!

AD-HDTV System Overview



Production and Display

Pictures

MPEG Compression



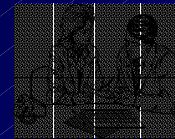
Data Headers



Motion Vectors



Low Order DCT Coeffs



High Order DCT Coeffs

Video Data Structures

Code

MPEG++ Prioritization

HP

SP

Parsing

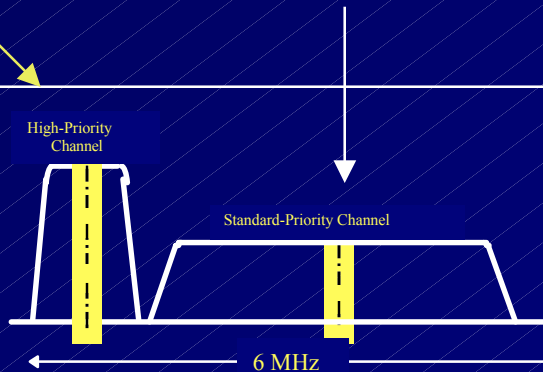
Prioritized Data Transport



Cells

Serial Bit Stream

Spectrally-Shaped QAM Transmission



Signal Spectrum

AD-HDTV Features

...new capabilities for the future..

- **Multiple video formats that:**
 - support both film and HDTV production
 - support both television and computer applications (both interlaced scan and progressive scan/square pixels)
- **Data compression that:**
 - achieves outstanding picture and sound quality
 - is compatible with international standards
 - is practical for broadcasting (survives uncorrectable bit errors)
- **Digital transmission that:**
 - provides a high 24 Mbps data rate
 - is immune to NTSC interference and friendly to existing stations
 - provides a large coverage area (comparable to NTSC)
 - provides reliable fringe area service
- **A system that:**
 - has a broad scope of services
 - has interoperability with film and computers
 - has extensibility for future growth

AD-HDTV and MPEG

...the quest for standards...

- **The current ISO-MPEG standard (MPEG-1) was originally intended for lower resolution video**
- **AD-HDTV's MPEG++ uses MPEG-1 compression**
(MPEG++ transforms standard MPEG syntax into two bit streams for robust terrestrial transmission)
- **MPEG-2 is currently underway to standardize compression for 525/625 and HDTV resolutions**
(of course, ATRC is participating in MPEG-2)
- **What will the differences be between MPEG-2 and MPEG-1??**
- **What does this mean to the U.S. HDTV standard??**

AD-HDTV Benefits

...new capabilities for the future...

- **Outstanding HDTV pictures in a simulcast channel**
- **Format flexibility — deliver HDTV and film productions**
- **Large coverage area with low interference**
- **Flexible mix of video, audio and data services**
- **Opportunities for the future — new kinds of programming**

MPEG Video Compression

...ISO standard video compression allows format flexibility...

**1050 line
HDTV production**



**MPEG
Video
Compression**

**Standard MPEG
Compression
Codewords**

...0F4A73B2A02D5793A...

**1050/2:1/59.94
1050/1:1/29.97
1050/1:1/24**

Pictures

*Receiver
"Instructions"*



MPEG++ Prioritization

...MPEG is separated into two separate bit streams...

High Priority Data
that makes a viewable picture

...0F4AD5793A...

**MPEG
Compression
Codewords**

**MPEG++
Prioritization**

...10011001111101001011

...1101101010101100011100101001

Standard Priority Data
that in addition makes
full HDTV quality

MPEG++ Robustness

...two data priority classes provide transmission robustness...

High Priority Data that makes a viewable picture is transmitted so as to be highly immune to bit errors

...1011010101111100101001010011011...

...110101101001011001101100111001??101...



Standard Priority Data is not as vital, so transmission bit errors will have a small impact on picture quality

MPEG Encoder

...motion-compesated DCT compression...

