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International Telecommunication Union
International Multimedia Telecommunications Consortium

MPEG-4 AVC/H.264 Digital Video Compression Standard

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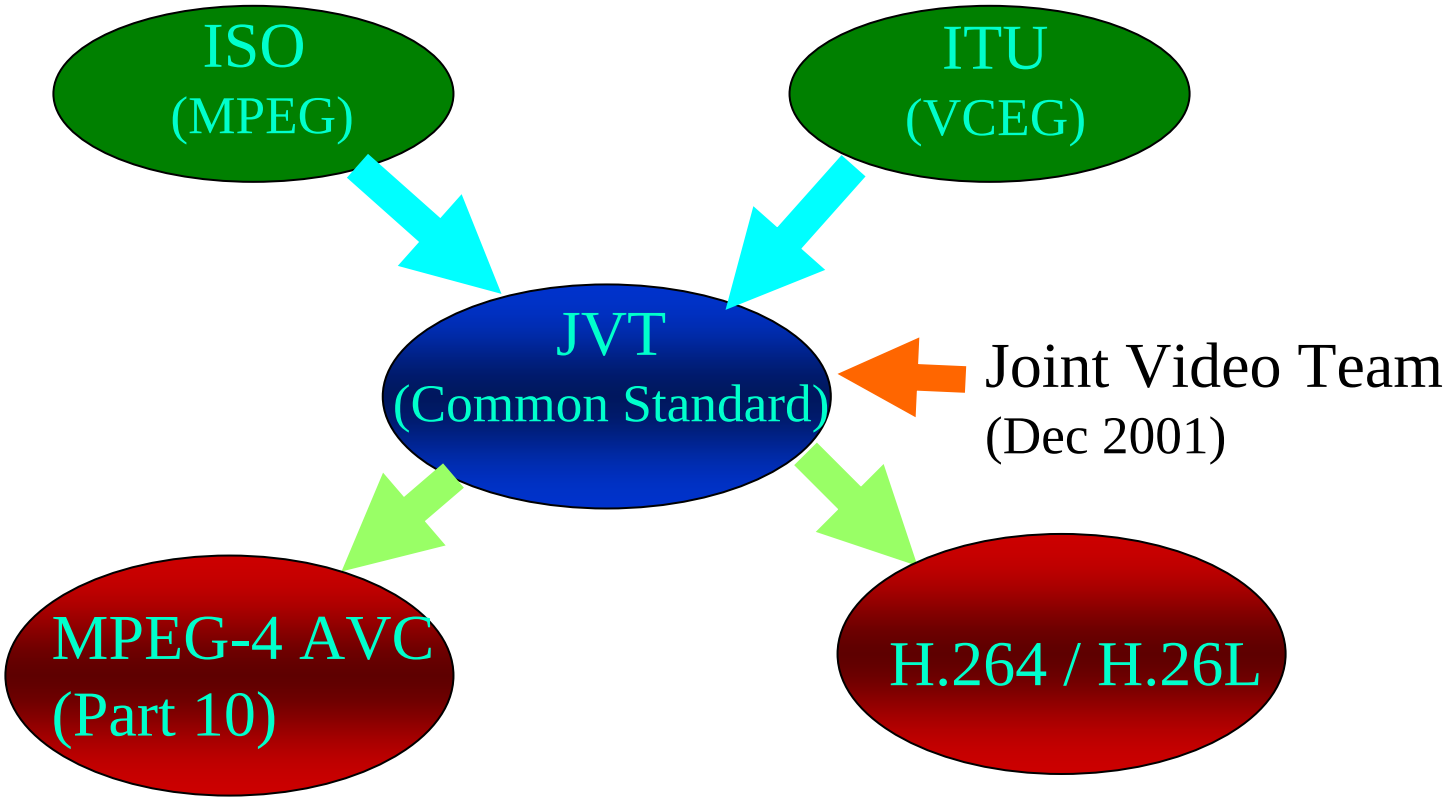
San Diego, 9-11 May 2006

MPEG-4 AVC/H.264

- History
- Technology
- Adoption
- Next Steps

- Start drinking from the fire hose

MPEG-4 AVC / H.264



AVC / H.264

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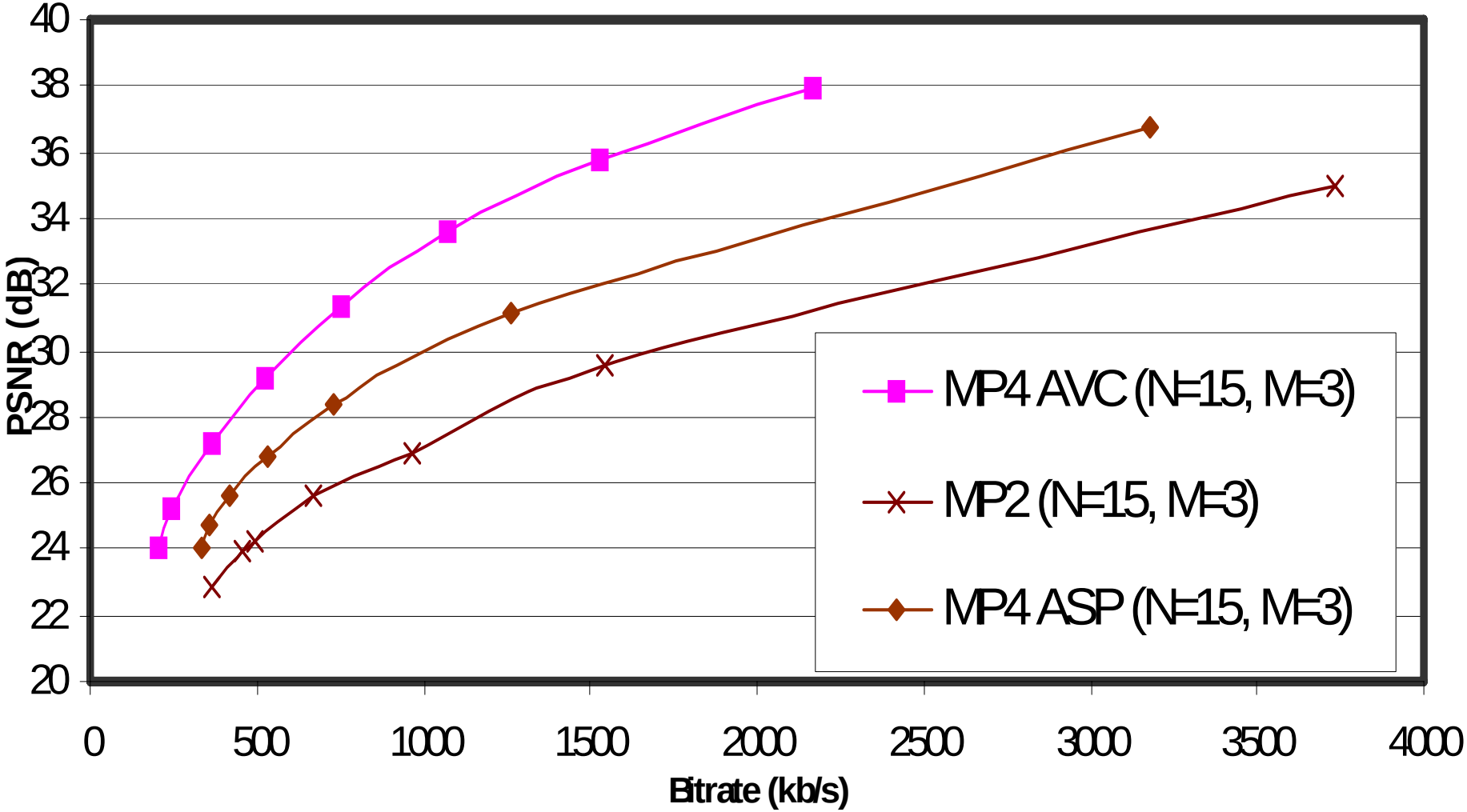
Better picture …

… Half the bit rate of MPEG-2

AVC/H.264 Video Quality Tests

- Objective
  - PSNR vs Bit Rate
- Subjective

MPEG-2, MPEG-4 ASP, AVC/H.264 (MP)
Mobile & Calendar (CIF)



Note: PSNR at a given bit rate is encoder dependent and will vary from one encoder to another

MPEG-2, MPEG-4 ASP, AVC/H.264 (MP)
BUS (CIF)

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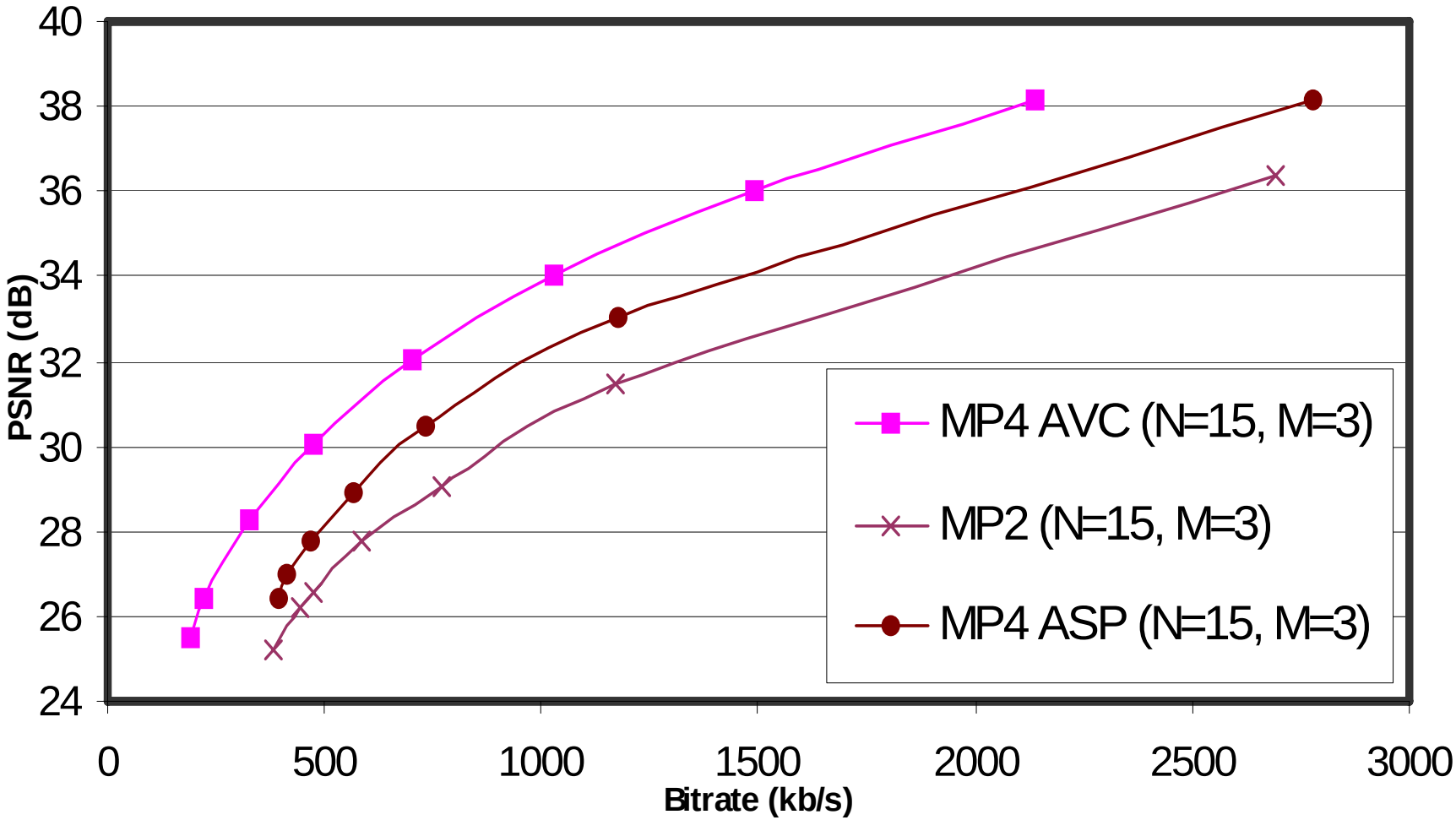

MPEG-2, MPEG-4 ASP, AVC/H.264 (MP)
Mobile & Calendar (HHR - 352x480)

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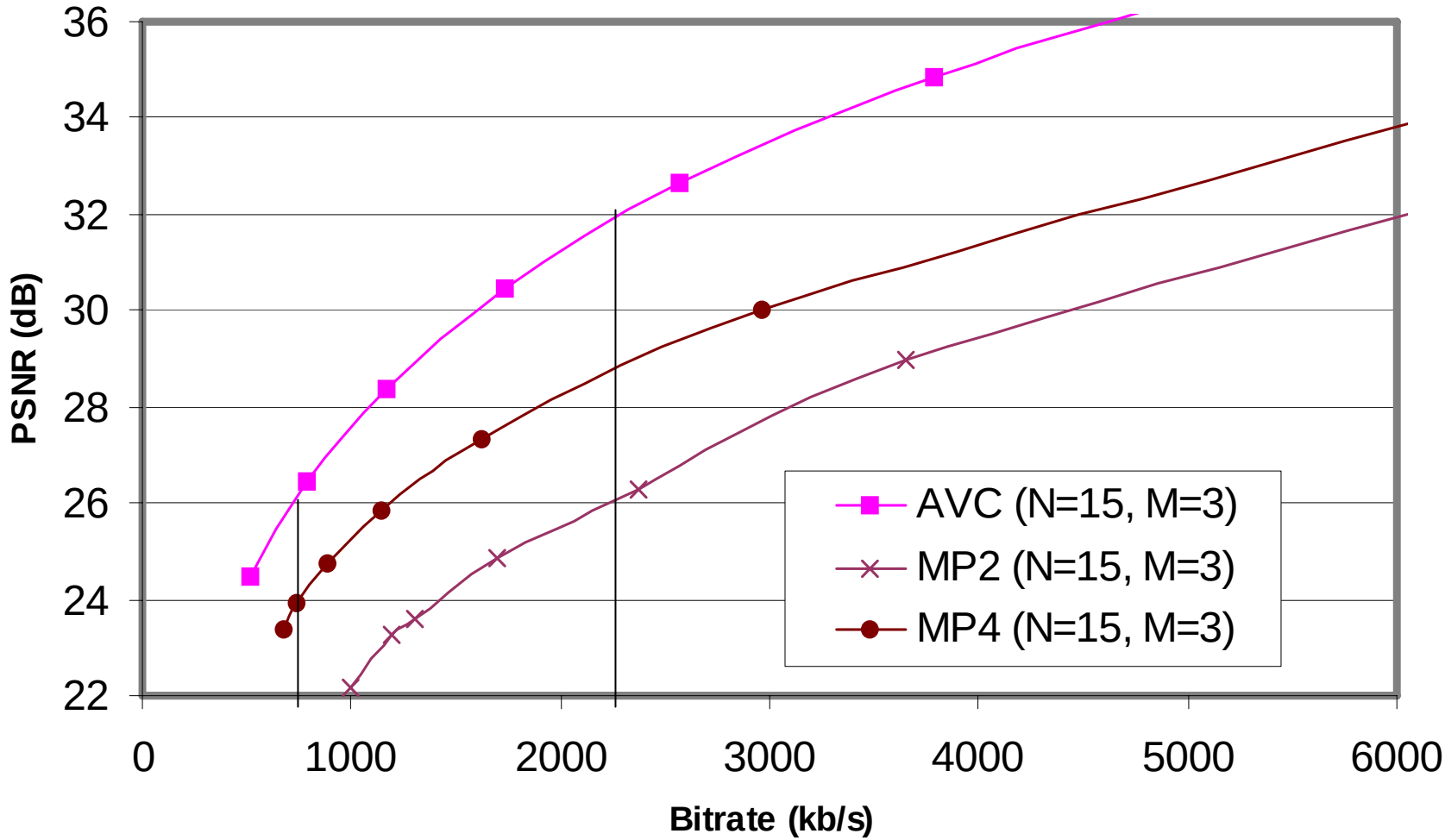

AVC/H.264 (MP) vs MPEG-2 (MP)

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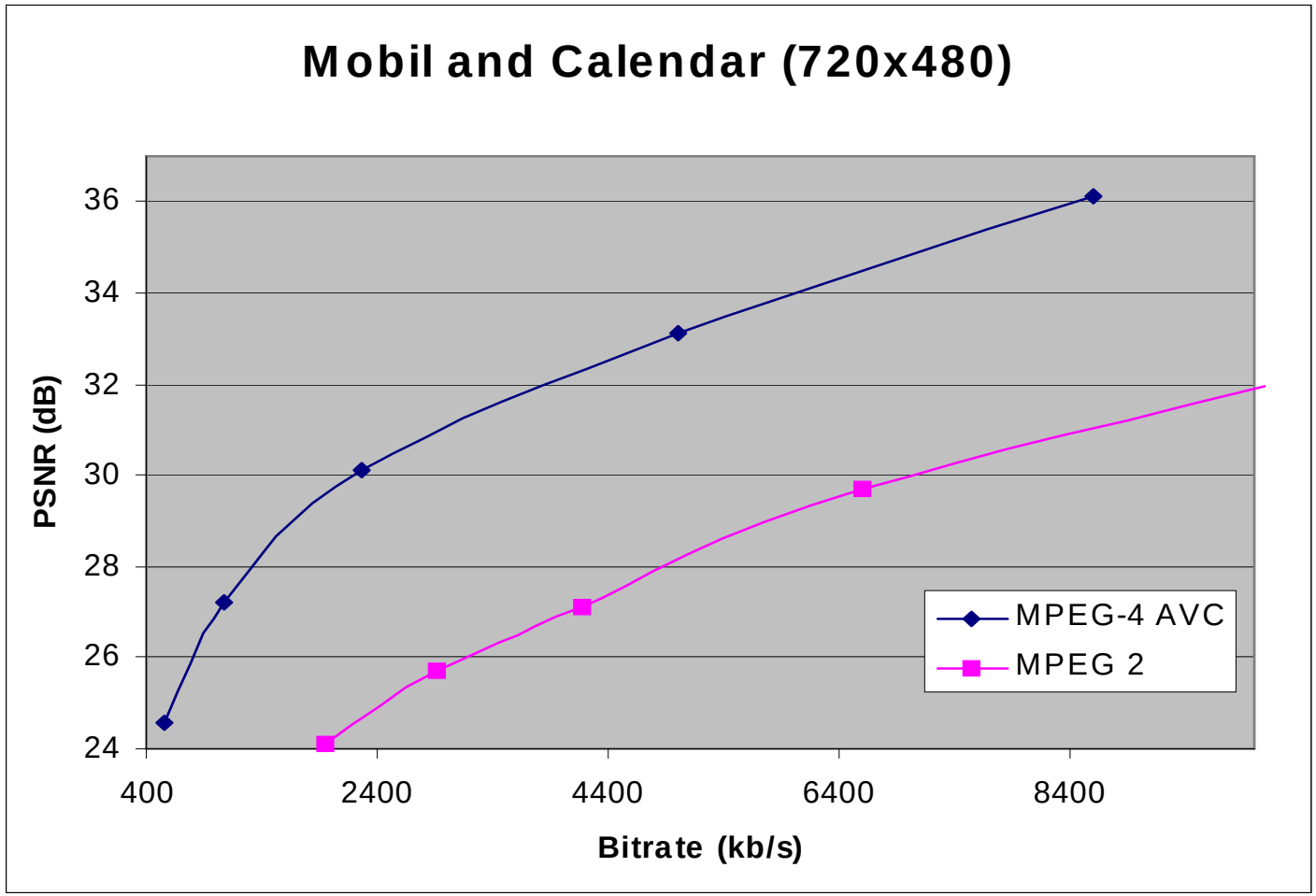

AVC/H.264 (MP) vs MPEG-2 (MP)

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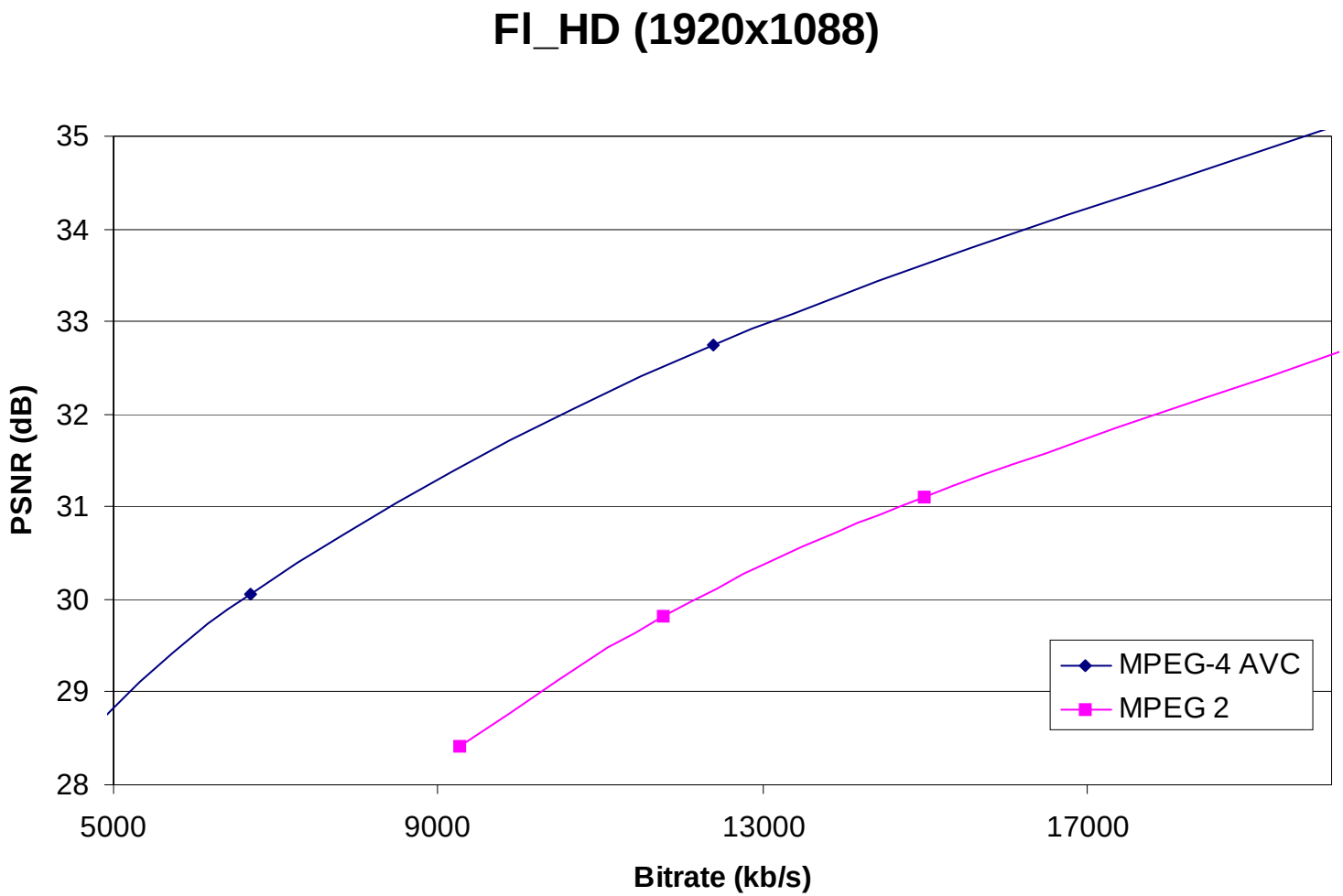

MPEG-2, MPEG-4 ASP, AVC/H.264 (MP)

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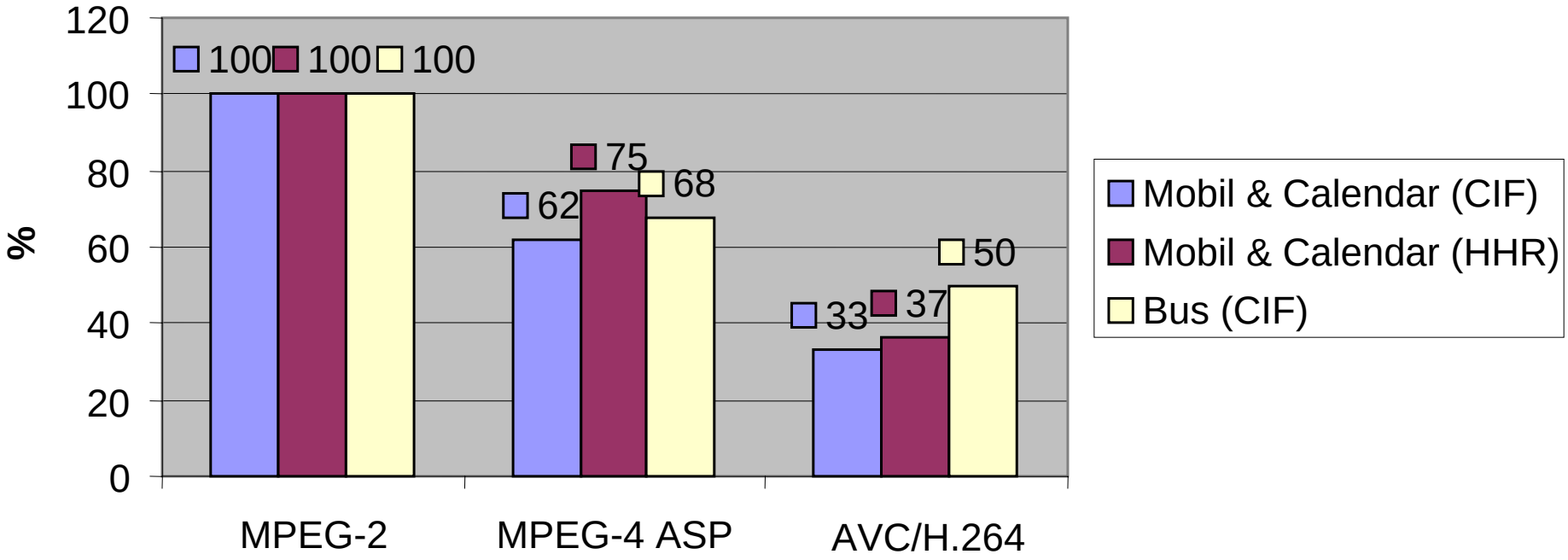
~ % Bit rates required for the same PSNR (~ 32dB)
(Normalization: MPEG-2 = 100%)



Note: PSNR at a given bit rate is encoder dependent and will vary from one encoder to another

Subjective Testing

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- MPEG Tests
  - AVC/H.264 (Main Profile), MPEG-2 (Main Profile)
- Blu-Ray Disc Founders (BDF)
  - AVC/H.264 (High Profile), MPEG-2 (Main Profile)

MPEG Verification Test

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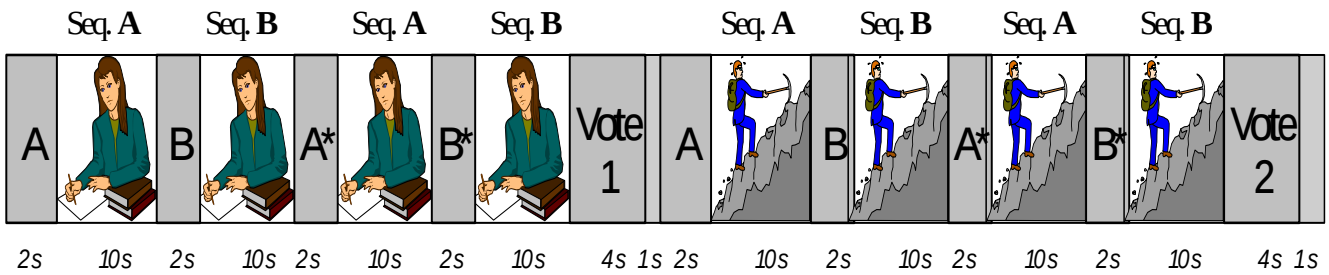
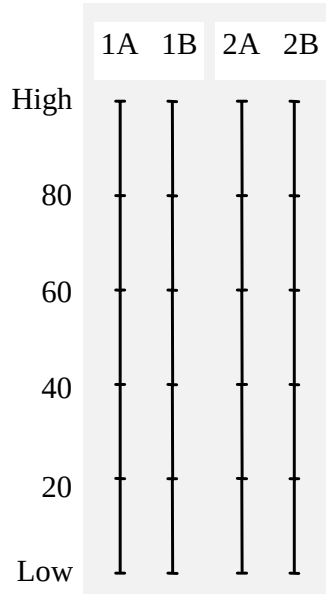
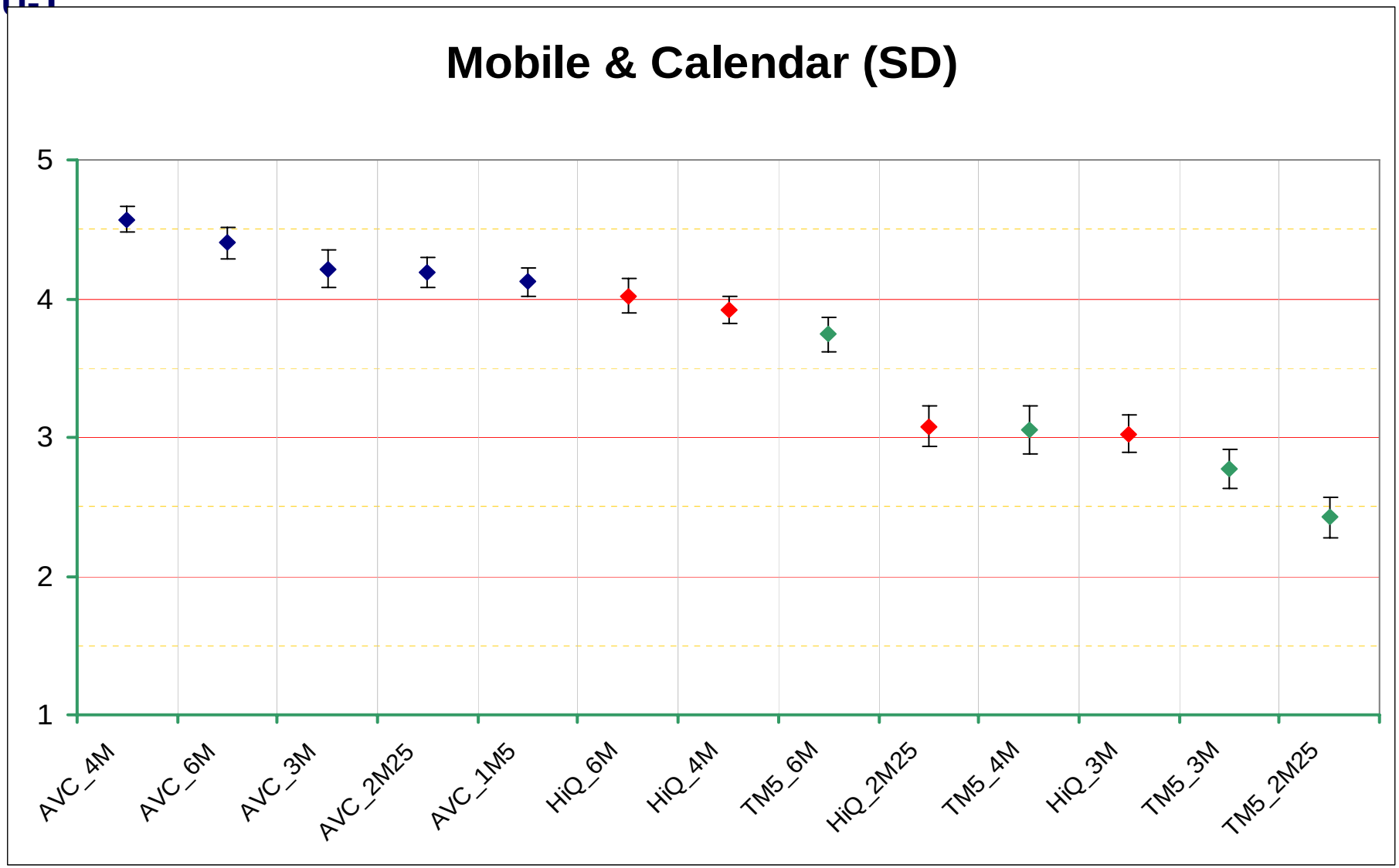
- ITU-R 500-11
  - Double Stimulus Continuous Quality Scale (DSCQS) Method





- Mean Opinion Square and 95% Confidence Interval

MPEG Verification Test



MPEG Verification Test

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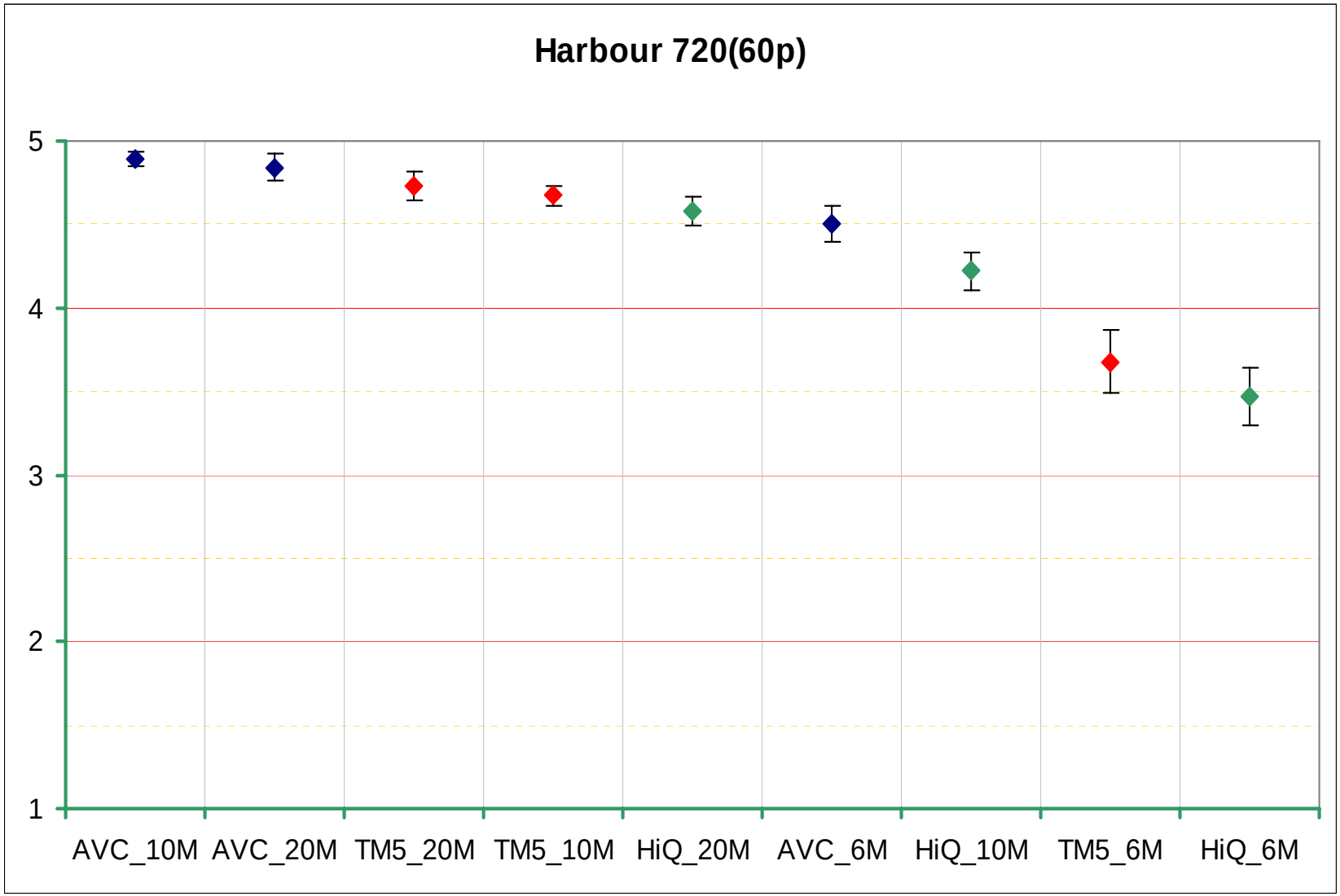
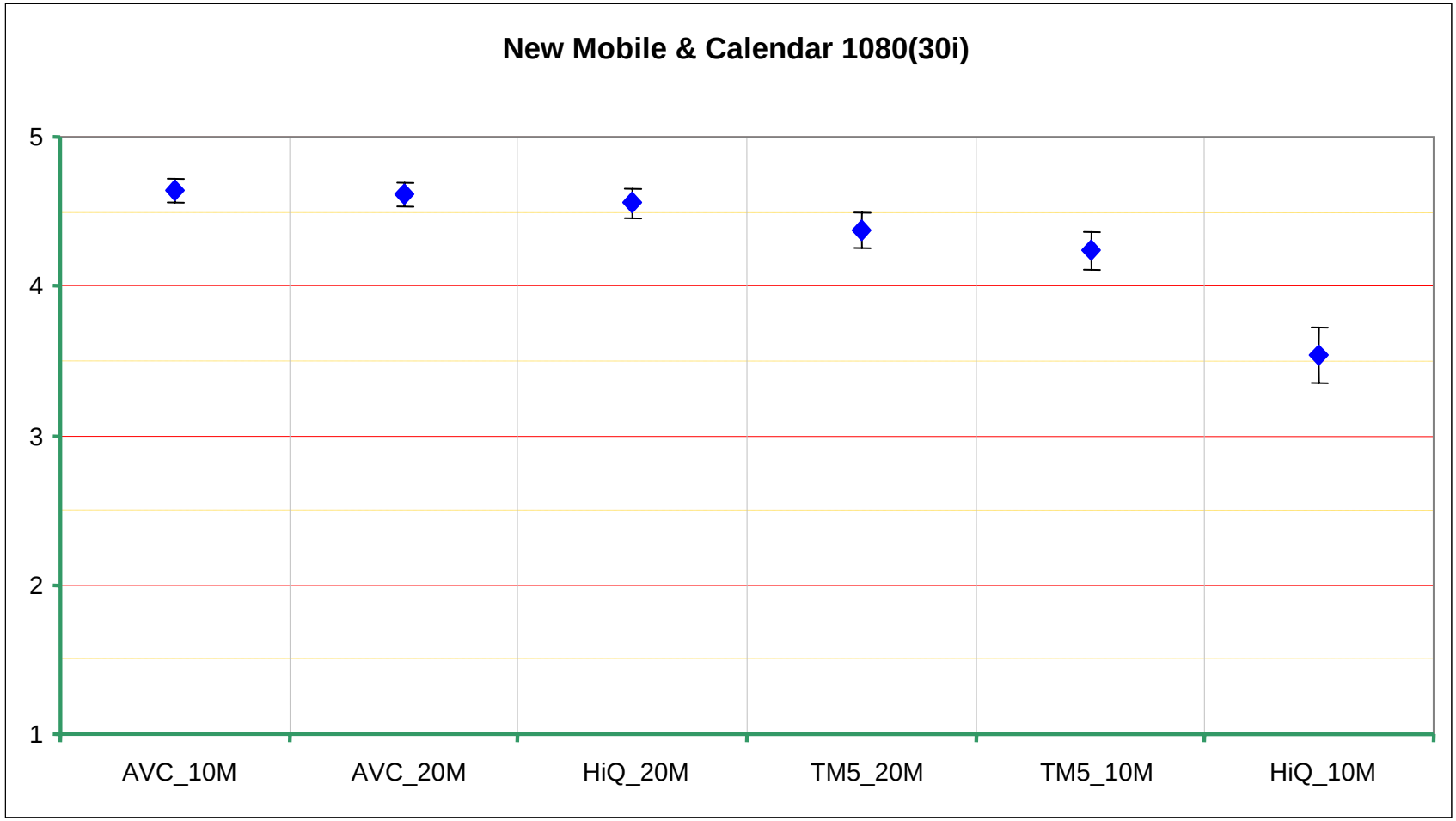
IMTC



MPEG Verification Test



Blu-Ray Disc Founders (BDF)

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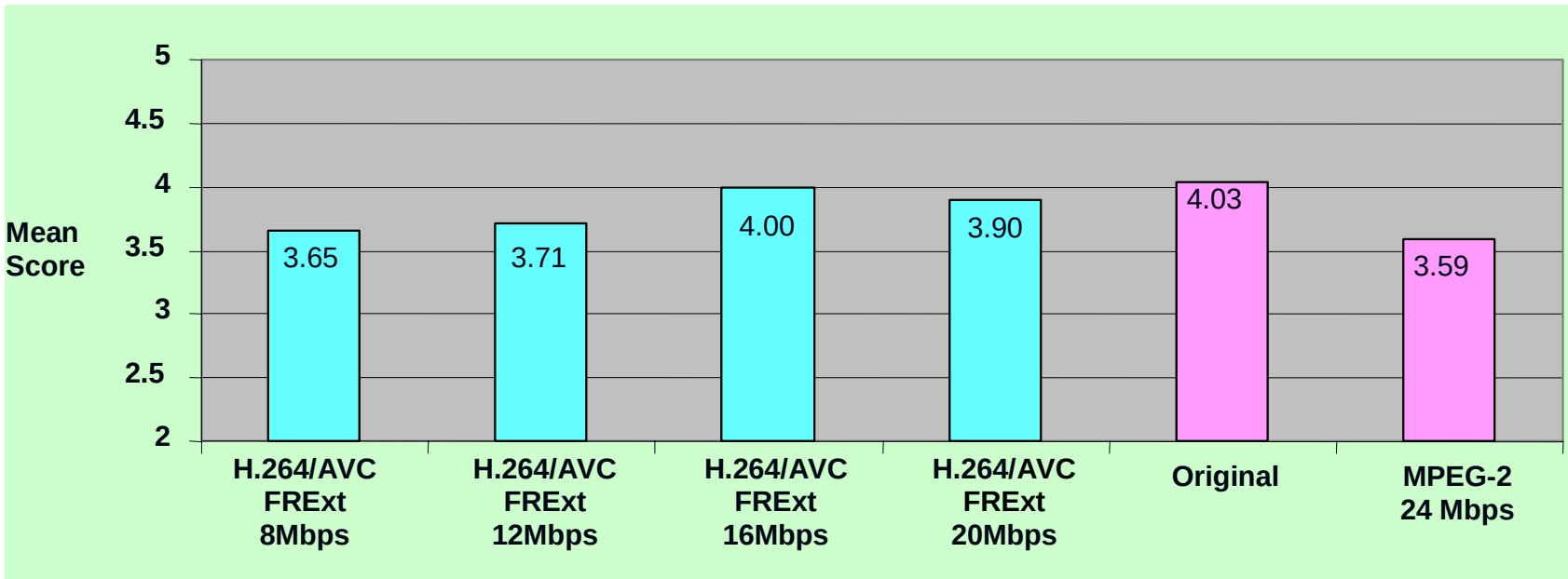
- HDTV Subjective Testing

Blu-Ray Disc Founders
JVT_L033 - High Profile Tests (HDTV)

- High at 8 Mbps nominally beats MPEG-2 at 24 Mbps
- Nominally transparent on 1080p24 at 16 Mbps



AVC / H.264

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Better picture …

… Half the bit rate of MPEG-2

AVC / H.264

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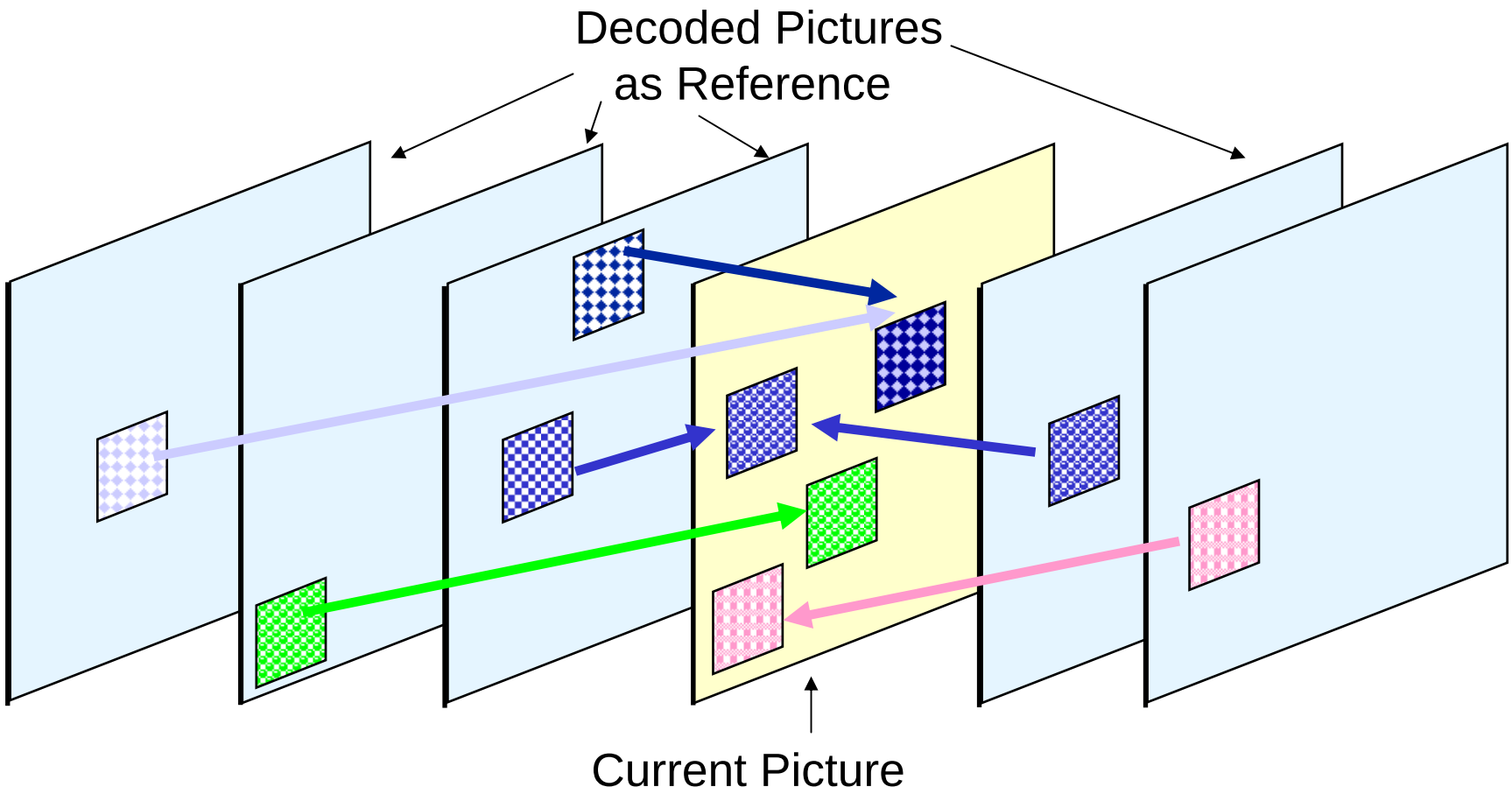
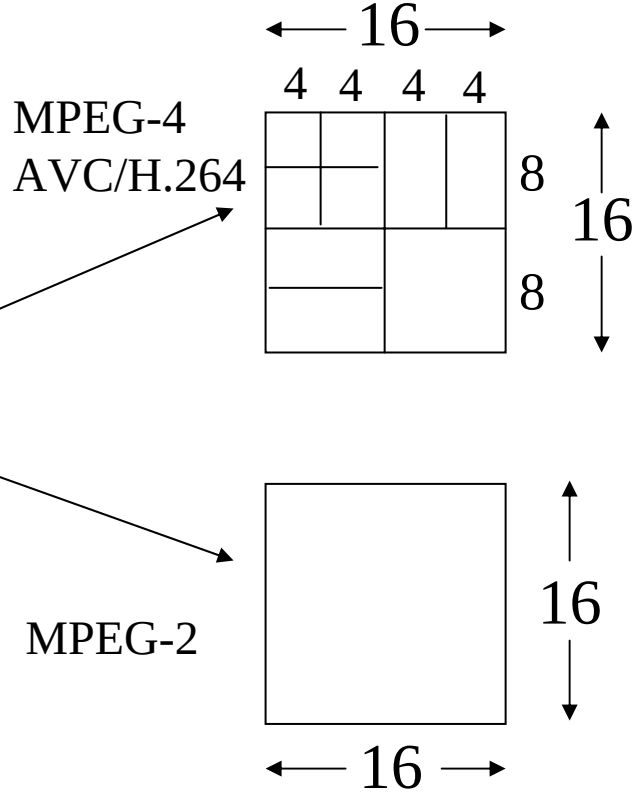
- I, P, B, Bs, SP, SI
- Improved Spatial Prediction
  - 4x4
  - 8x8
  - 16x16
- Improved Temporal Prediction
  - Multiple reference frames
  - Variable block size MC - 7 Block Patterns
    - 16x16, 16x8, 8x16, 8x8, 8x4, 4x8, 4x4
  - Up to 16 MVs per MB
  - Quarter Pixel Interpolation
  - Loop filter
  - Skip
  - Direct
  - Weighted
- Interlaced Video Coding Tools
  - Frame or Field predictions
- Context-based Adaptive Binary Arithmetic Coding (CABAC)
- 4x4 or 8x8 Transforms
- Other

AVC/H.264 Coding Tools
Multiple Reference Frames



AVC/H.264 Coding Tools

- Variable macroblock size



AVC/H.264 Coding Tools

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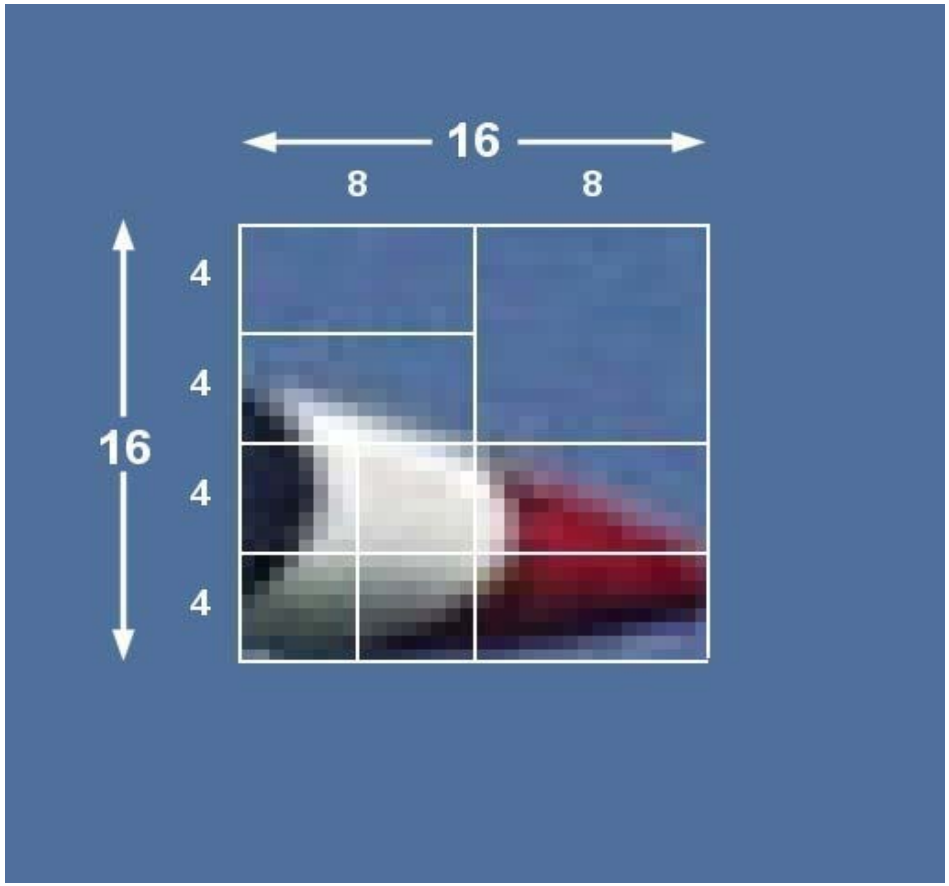
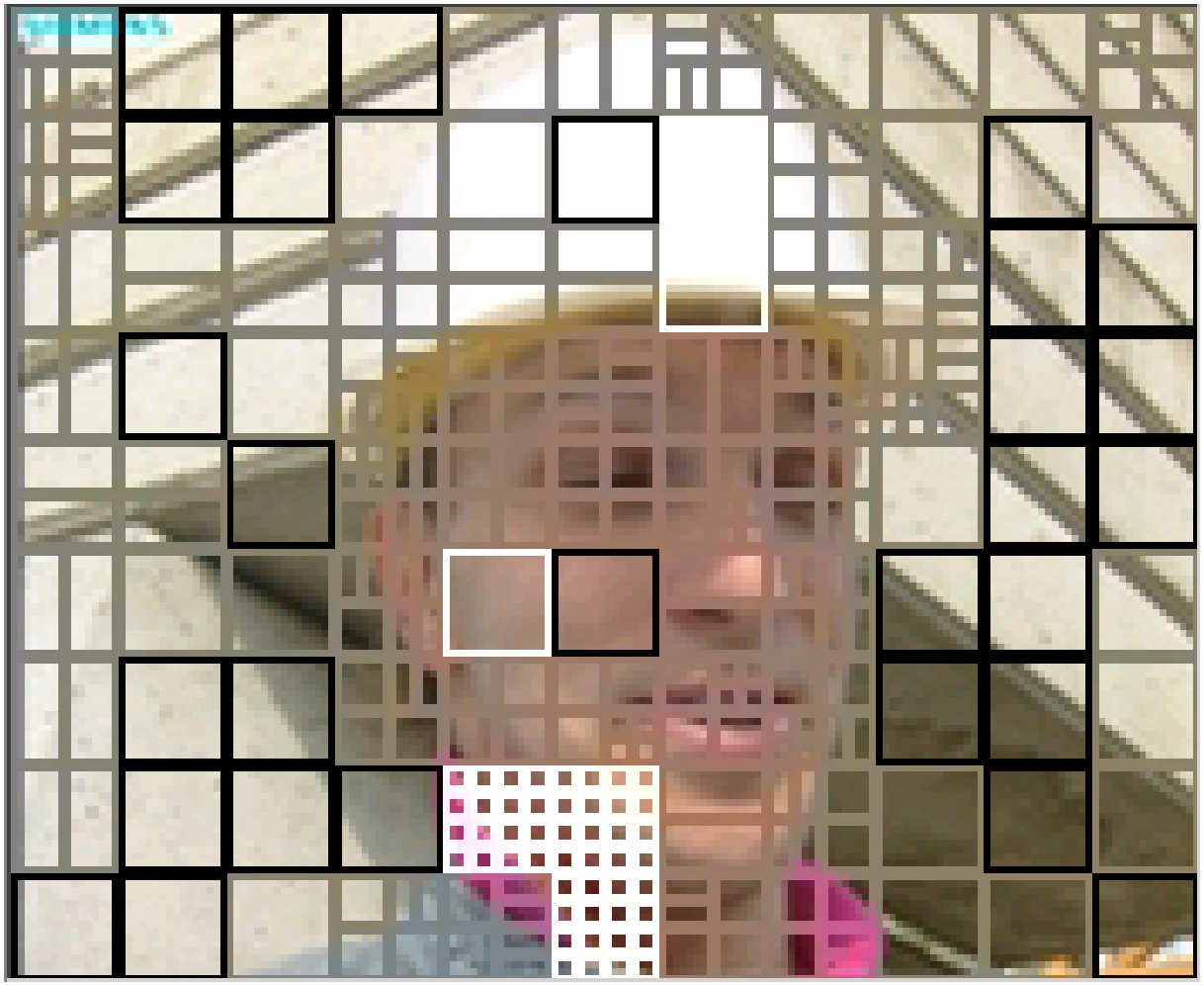
- Variable macroblock size



AVC/H.264 Coding Tools



Legend: QCIF; Black Boundary Line – Skip; White – Intra; Gray - Inter (P)

AVC / H.264

- Motion estimation accuracy
  - ¼ Pixel

Built-in (In Loop) Deblocking Filter

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No Deblocking

Deblocking

AVC/H.264 Profiles

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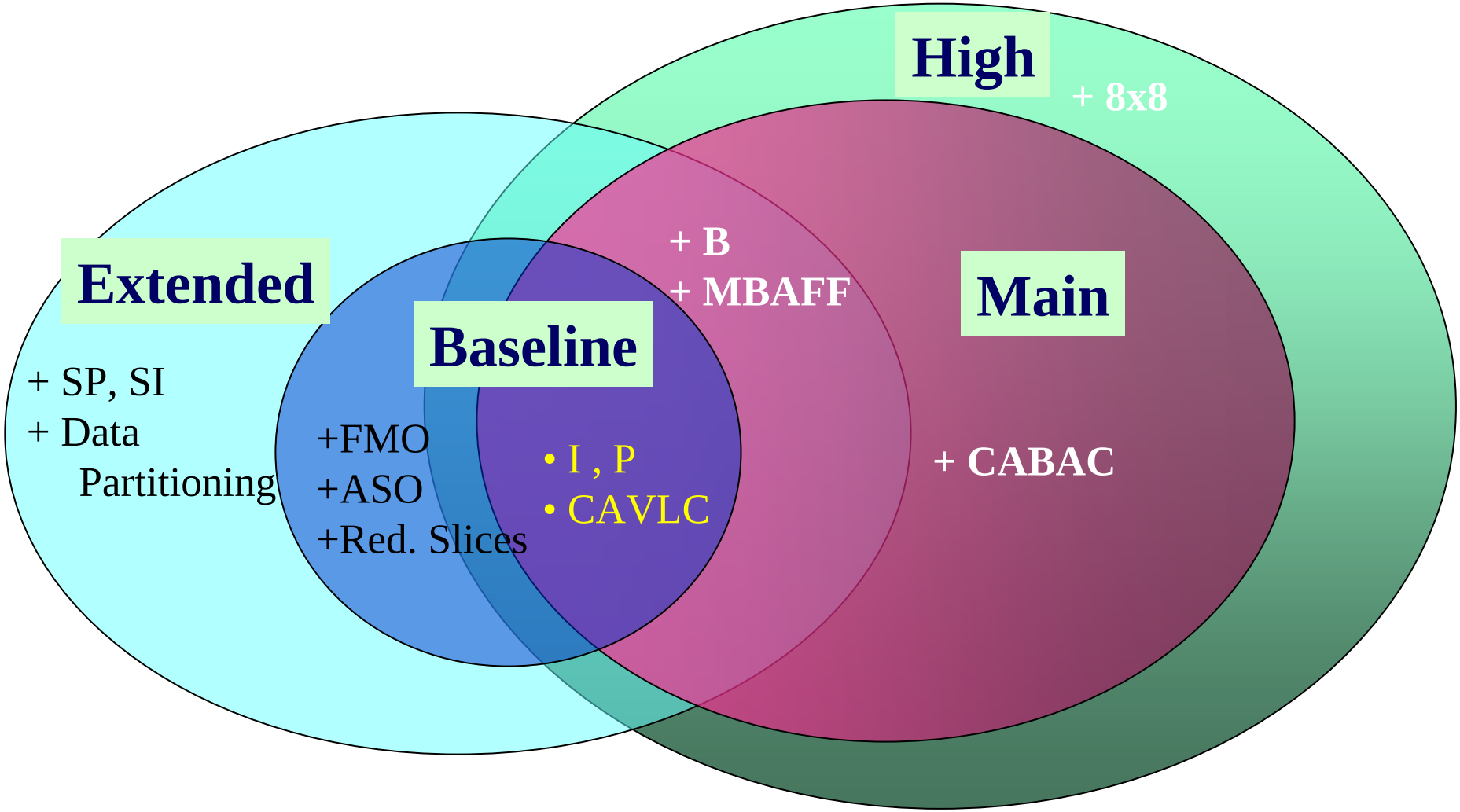

AVC/H.264 Profiles

- High Profile
  - Highest compression or video quality at a given bit rate
  - Suitable for good quality entertainment video distribution
- Baseline Profile
  - Least complexity
  - Error resilient
  - Suitable for telephony, conferencing application

AVC/H.264 – Levels

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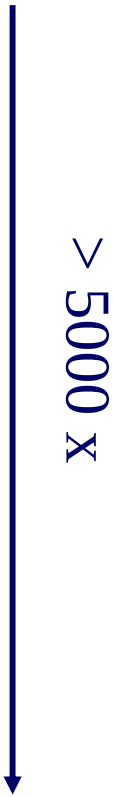
- Level 1.0: QCIF @ 15frames/sec
- Level 1.1: QCIF @ 30 frames/sec, CIF @7.5 frames/sec
- Level 1.2: CIF @ 15 frames/sec
- Level 2.0: CIF @ 30 frames/sec
- Level 2.1: HHR @ 25 or 30 frames/sec
- Level 2.2: SDTV @ 15 frames/sec
- Level 3.0: SDTV: 720x480x30i, 720x576x25i
  - 10 Mbps (max.), up to 5 (max. resolution) reference frames
- Level 3.1: HDTV - 1280x720x30p, SVGA (800x600) 50+p
- Level 3.2: HDTV - 1280x720x60p
- Level 4.0: HDTV (all formats) - 1920x1080x30i, 1280x720x60p, 2kx1kx30p
  - 20 Mbps (max.), up to 4 (max. resolution) reference frames
- Level 4.1: HDTV - 1920x1080x30i, 1280x720x60p, 2kx1kx30p
  - 50 Mbps, up to 4 (max. resolution) reference frames
- Level 4.2: S-HDTV - 1920x1080x60p
- Level 5.0: S-HDTV/D-Cinema – 2kx1kx72p
- Level 5.1: S-HDTV/D-Cinema – 2kx1kx120p, 4kx2kx24p, 4kx2kx30p

< 64 kbps



> 5000 x

< 250 Mbps

Transport of AVC / H.264

- Transport of MPEG-4 AVC using MPEG-2 System: ISO/IEC 13818-1
  - PDAM (Proposed Draft AMendment) in May 2002
  - FPDAM (Final Proposed Draft AMendment) in Dec 2002
  - FDAM in July 2003
  - Approved AMD
- IP delivery
  - MPEG-2 TS over UDP/IP, or
  - RTP over IP

AVC/H.264

- Applications
  - Wherever you need to save bandwidth and/or storage capacity

AVC/H.264 Adoption

- 3GPP
- 3GPP2
- ARIB (Japan)
- ATSC
- Blu-ray Disc
- DLNA
- DMB (Korea)
- DVB
- DVD Forum (HD-DVD)
- IETF AVT - RTP payload spec approved as RFC 3984
- ISMA
- SCTE
- US DoD MISB - Adopted as US government preferred codec up to 1080p

AVC/H.264 Commercial Deployment

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- Direct Broadcasting Satellite
  - DirectTV, BSkyB, DISH, Premiere, Euro 1080
- Terrestrial broadcasting
  - HDTV pay DTV in France
- IPTV
  - KPN in Netherlands, Belgacom in Belgium, SBC/ATT …
- Streaming
  - Quicktime
- Video Conferencing
- Mobile TV
- Portable Media Players
  - Video iPOD, Cell Phones
- HD-DVD
- Blu-Ray
- Video Games
- Digital Cable

AVC/H.264 Commercial Deployment

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- Products
  - NAB 2006 : 125+ companies
    - Services
    - Encoders
    - Decoders
    - STB
    - ICs
    - Cores
    - Software
    - …

AVC/H.264 Standard

- Extensions
  - Higher resolution and quality
    - Studios, D-cinema
    - Very High Definition to home?

AVC/H.264 Profiles

- Higher Resolution and Quality
  - 4:2:0/10bits – High 10 bit (Hi10P)
  - 4:2:2/10bits – High 4:2:2 (Hi422)

AVC/H.264 Standard - Next Steps

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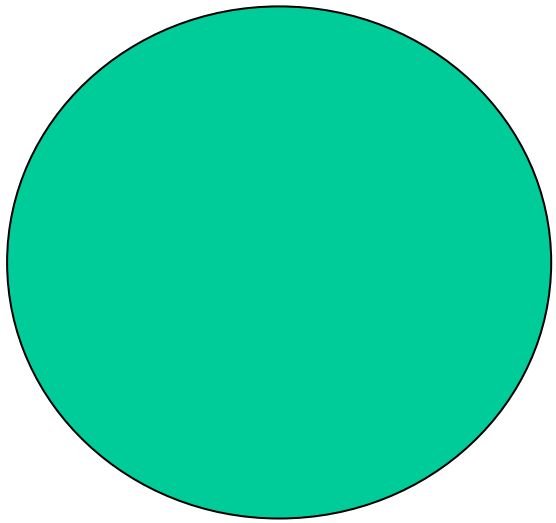
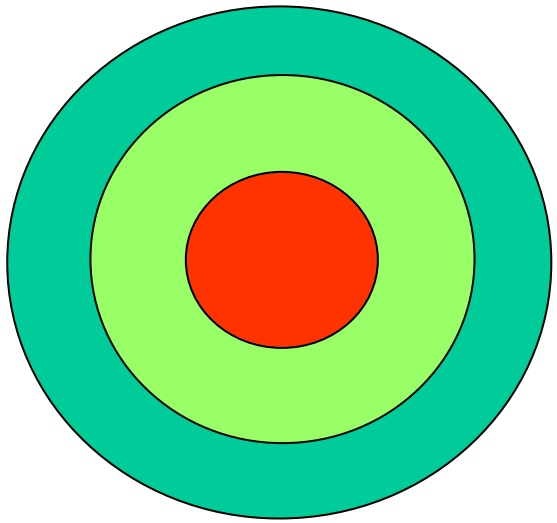
- Extensions
  - Higher resolution and quality
    - Studios, D-cinema
    - Very High Definition to home?
  - Scalable Video Coding (SVC)
    - Multiple layers
    - Potential alternative for seamless mobility
      - Across networks
      - Across devices
      - Across applications

Scalability



Single Layer



Multiple Layers

Scalability

- Temporal
- Spatial
- SNR
- Fine Granular (FGS)

AVC/H.264 Standard - Next Steps

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- Extensions
  - Higher resolution and quality
    - Studios, D-cinema
    - Very High Definition to home?
  - Scalable Video Coding (SVC)
    - Multiple layers
    - Potential alternative for seamless mobility
      - Across networks
      - Across devices
      - Across applications
  - Multi-View Coding

AVC/H.264 Standard - Next Steps

ITU-T

- Extensions
  - Higher resolution and quality
    - Studios, D-cinema
    - Very High Definition to home?
  - Scalable Video Coding (SVC)
    - Multiple layers
    - Potential alternative for seamless mobility
      - Across networks
      - Across devices
      - Across applications
  - Multi-View Coding
- Next standard
  - Significant improvement over AVC/H.264 ?
    - H.265?
    - MPEG-x ?
  - Hunt is ON