Recording Options: Codecs and Containers

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From Analog to Digital to HD

- Explosion of new formats with the start of standard-definition digital video and an even broader array of options for high–definition recording.

Not easy to compare recorders

- With few exceptions manufactures don’t use codec names in brands, making it difficult to compare.
- Some of the needed information is not in the datasheets.

Current DTV Standards

Resolution			
Vertical	Horizontal	Scanning	Frame rate (Hz)
720	1280	Progressive	23.976 24 25 29.97 30 50 59.94 60
1080	1920	Interlace	25 (50 fields) 29.97 (59.94 fields) 30 (60 fields)
		Progressive	23.976 24 25 29.97 30

High Definition Section of ATSC A/53, Table 3

Each choice has consequences

- Do I shoot Progressive or Interlaced?
- Do I use 24p because it looks more like film?
- What about the PBS Redbook which says delivery is HDCAM 1080i/29.97?

Lots of Data to Collect

- The Math:
  - 1920 horizontal pixels x 1080 vertical lines x 30fps x 3 samples/pixel x 8-10 bits/sample = >1.2 **billion** bits per second.

Techniques for Data Reduction:

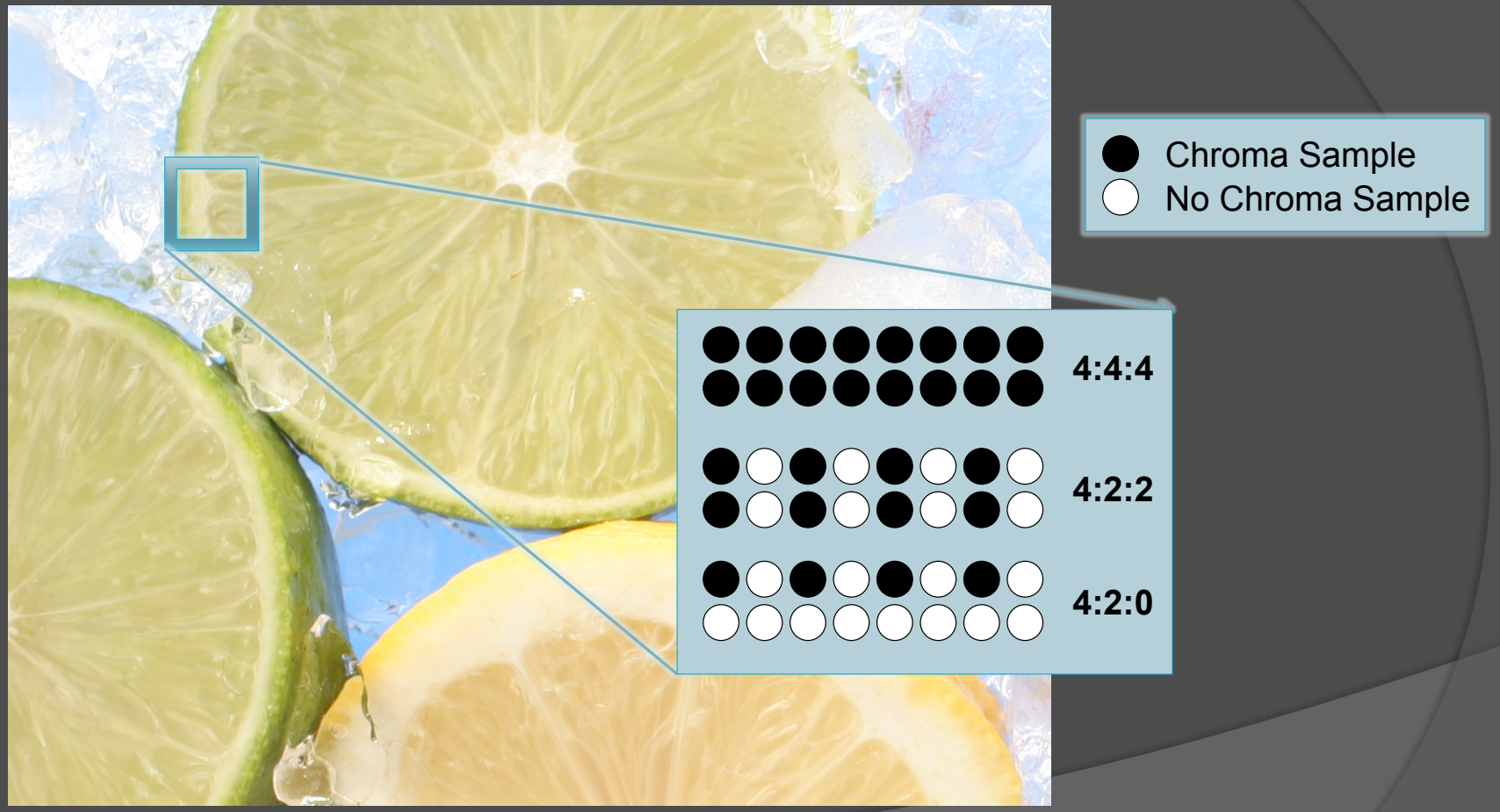
- Resolution Sub-sampling
- Video Encoding/Sampling
- Video Compression

Resolution Sub-sampling

- 1920 horizontal pixels reduced to 1280
  - DVCProHD-1080i
- 1920 reduced to 1440
  - HDCam, HDV, XDCamHD, XDCamEX (25Mbps), AVCIntra (50Mbps – 1080i)
- 1280 reduced to 960
  - DVCProHD-720p, AVCIntra (50Mbps – 720p)

Video Sampling

- Each pixel is sampled once for the luma component (Y') and once for each of the chroma difference components (Cb' and Cr').
- The samples are expressed as a ratio.
- Reducing chroma samples reduces data.
- Examples: 4:4:4, 4:2:2, 4:2:0 and 3:1:1


Chroma Sample
No Chroma Sample
4:4:4
4:2:2
4:2:0

4:2:2 Sampling

- DVCProHD, Avid DNxHD, Apple ProRes, Red, XDCam422, GFCam50, AVCIntra (100Mbps), HDCamSR

4:2:0 Sampling

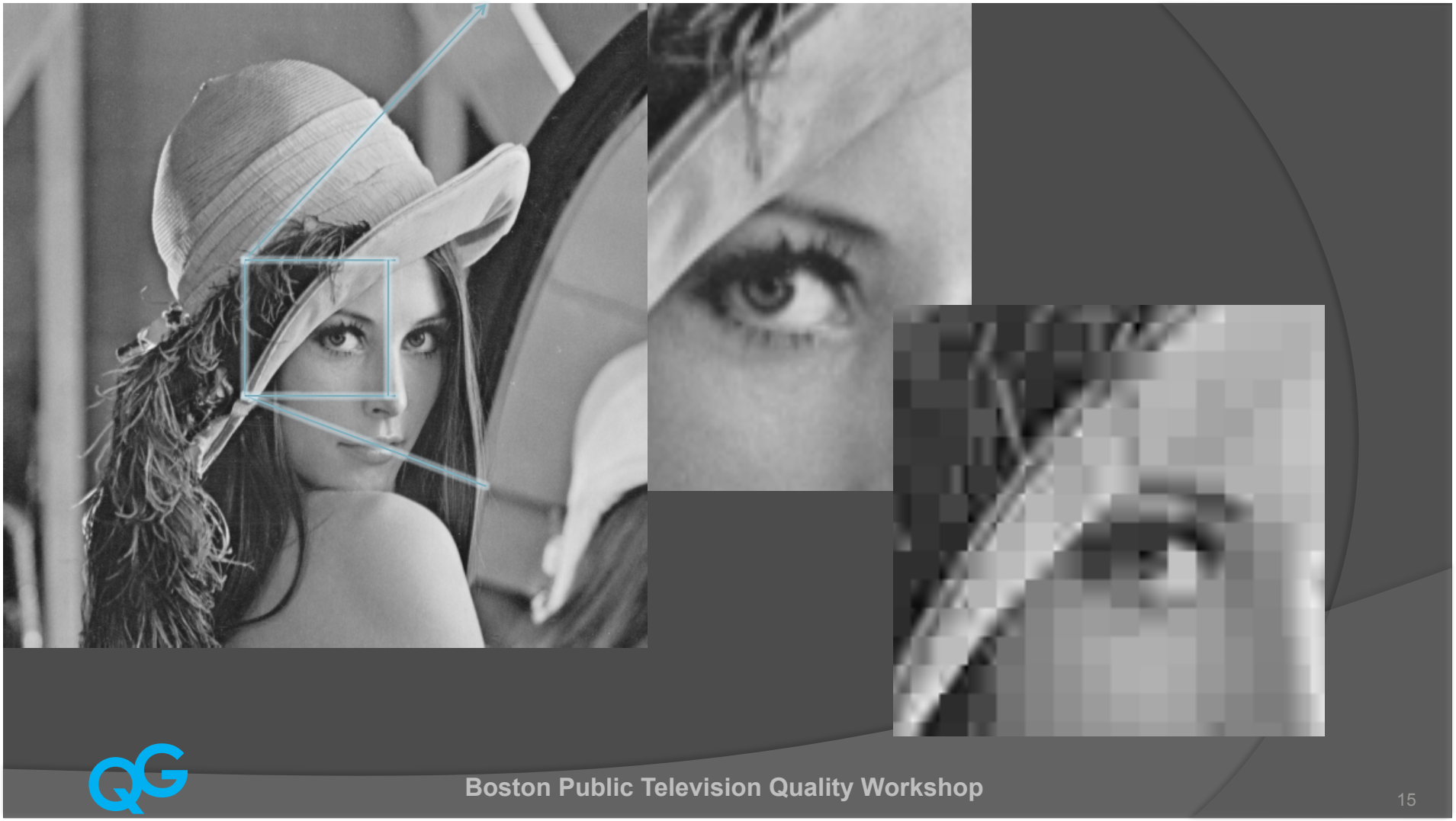
- HDV, XDCamHD, XDCamEX, AVCHD, Canon 5DMKII and AVCIntra(50Mbps)

Video Compression

- DCT (discrete cosine transform)
- Wavelet transform
- MPEG
- H.264 (AVC)
- MPEG4 Studio Profile

DCT

- Compresses each frame of video, frame by frame.
- Frame boundaries mean each compressed frame is not dependent upon any other frame.
- Blocking artifacts with high compression.
- Used by HDCam, DVCProHD, Avid DNxHD and Apple ProRes.

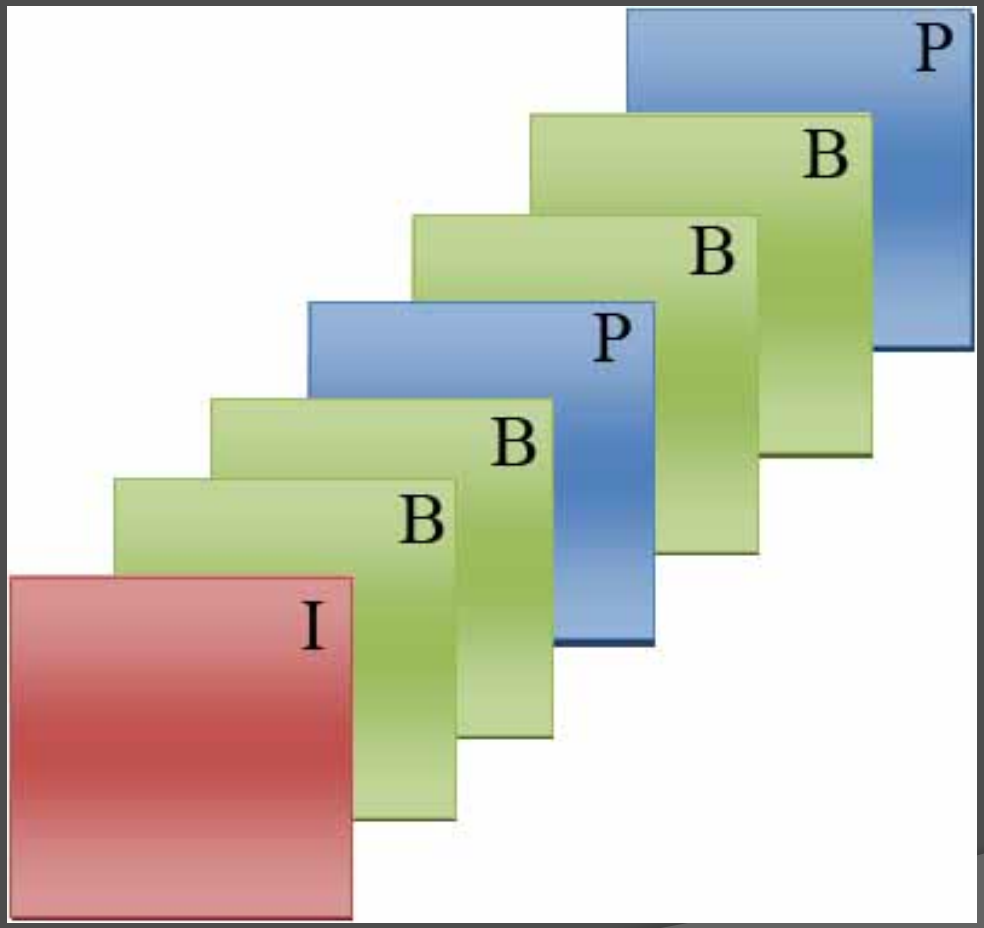


Wavelet

- Relatively new and promising technique.
- Early in the adoption cycle.
- Frame-based.
- Artifacts across multiple frames at high compression levels.
- Softer artifacts.
- Used by Red Camera.

MPEG

- MPEG-2 is well known (DTV and DVD).
- Two types: I-frame and Long GOP.
  - LGOP is compression across multiple frames.
  - LGOP needs rendering when edited.
- I-frame used in GFCam (100 Mbps).
- LGOP used in HDV, XDCamHD, XDCam422, XDCamEX and GFCam (50Mbps).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H.264 (AVC)

- MPEG4 advanced video coding.
- Comparable quality to MPEG-2 at lower bit rates but requires more processing power.
- Used by AVCHD and Canon 5DMkII
- I-frame version used by AVCIntra.

MPEG4 Studio Profile

- Very high-bitrate system (400-800 Mbps)
- Uses both inter-frame and intra-frame coding
- Used by HDCamSR and HDCamSR-HQ
- Uses tape media but has a DPX file transfer mode.

Editing

- Most popular editing systems in the market today support all of these codecs natively.
- Editing and rendering can be relatively slow with computationally intensive codecs like H.264 and Wavelet.

Recording Media

- Optical disks
- Hard Drives
- Solid-State Memory Cards

Optical disks

- Pro
  - Inexpensive
- Con
  - Lower transfer rates.

Hard Drives

- Pro
  - Transfer very quickly.
- Con
  - Vulnerable to damage from a sharp impact.

Solid-State Memory Cards

- Pro
  - Robust, high transfer rates.
- Con
  - Recording time is limited and cost is high.

Backup

- Video Tape systems were more robust.
- Back up the media as soon as possible, in the field or on return to home base.

Long Term Storage

- Where and how do we store this data?
  - Solid state is too expense.
  - Hard drives are getting cheaper.
  - Data tape (LTO5)
- Common IT data storage practices prevail:
  - make two copies with one copy stored off-site

Summary

- Each recording system technology has its advantages and disadvantages. They have various trade-offs of cost, recording time, robustness, processing requirements and flexibility.

Summary

- Remember the 1.2 Gigabits per second of data you want to capture for every second of shooting?
  - How will you feel about compressing it to 25 Megabits per second in the recorder?

Discussion

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HD Acquisition Codecs

	Mbps	720p		1080i			1080p	Video Sample		Audio	
		960	1280	1280	1440	1920	1920	Sample	10 Bit	#	Bits
DCT											
HDCam [1]	140				√			3:1:1		4	20
DVCProHD@24p	40		√					4:2:2	√	8	16
DVCProHD-720p	100	√						4:2:2		8	16
DVCProHD-1080i	100			√				4:2:2		8	16
Avid DNxHD	145		√			√	√	4:2:2		4	16
Avid DNxHD	220		√			√	√	4:2:2	√	4	16
Apple ProRes	145		√			√	√	4:2:2	√	8	24
Apple ProRes HQ	220		√			√	√	4:2:2	√	8	24
Wavelet											
Red	224-336		√				√	RGB or 4:2:2	12	4	24
MPEG2 Long GOP											
HDV	25		√		√			4:2:0		2	MP1
XDCamHD	18-35				√			4:2:0		4	16
XDCam422	50		√			√		4:2:2		8	24
XDCamEX	25				√			4:2:0		2	16
XDCamEX	35		√			√		4:2:0		2	16
GFCam	50		√			√		4:2:2		4	16
MPEG2 I-frame											
GFCam	100		√			√		4:2:2		4	16
H.264											
AVCHD	24		√			√		4:2:0		2	AC3
AVCHD@24	24					√		4:2:0		2	AC3
Canon 5DMKII	38						√	4:2:0		2	16
H.264 I-frame											
AVCIntra	50	√			√			4:2:0	√	2	16
AVCIntra	100		√			√		4:2:2	√	2	16
MPEG4 Studio Profile											
HDCamSR [2]	440		√			√		4:2:2/4:4:4	√	12	24
HDCamSR-HQ [2]	880		√			√	√	4:2:2/4:4:4	√	12	24

[1] Tape format for comparison

[2] Tape with DPX file out