

Digital Video 101 - Part I

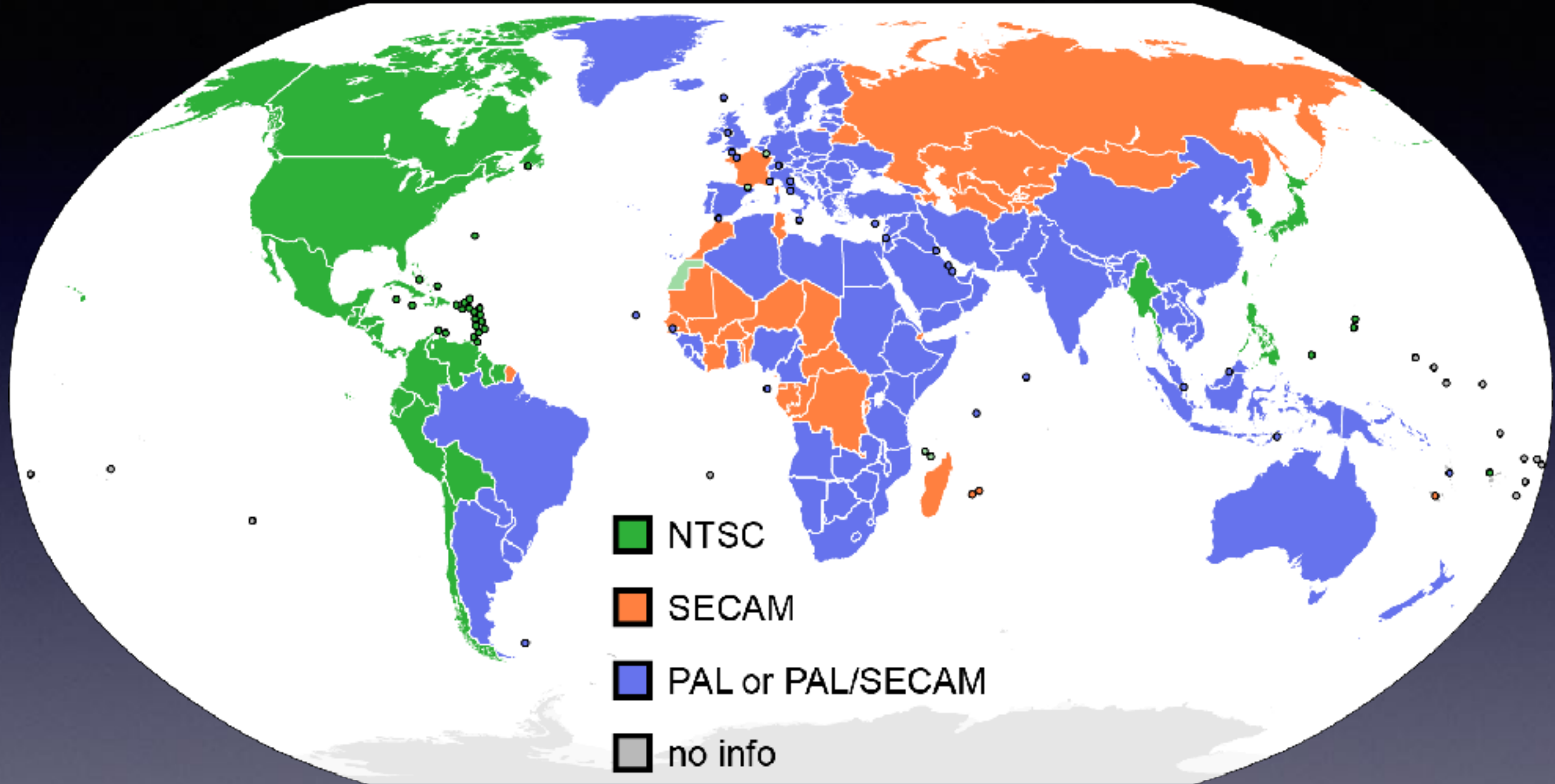
Video Standards

Video Standards

- NTSC
- NTSC-J
- PAL
- PAL-M
- SECAM

Video Standards

- NTSC
- NTSC-J
- PAL
- PAL-M
- SECAM



source: wikipedia

NTSC

- Began as analog format
- 525 h-scan lines / frame
- 30 fps (29.97 fps)
- North/Central America, Philippines, South Korea, Taiwan

NTSC-J

- 525 h-scan lines / frame
- 30 fps (29.97 fps)
- Used in Japan
- Darker black than NTSC (0% vs. 7.5% IRE)

PAL

- 625 scanlines
- 25 fps
- Europe, Scandinavia, parts of Asia, Pacific Islands, S.Africa
- Currently being replaced by DVB, ISDB or DTMB (European digital TV standards)

PAL-M

- Used in Brazil
- 525 scanlines
- PAL color palette
- 30 fps

SECAM

- 625 scanlines
- 25 fps
- Different color palette
- France, Middle East, Russia, N.Africa
- Currently being phased out and replaced by DVB (European DTV standard)

Incompatible

- Most formats are incompatible.
- Some TVs can play multiple formats
- Some professional gear can rec/playback NTSC & PAL

World is Getting Smaller

- Onset of DTV in Rest of World makes universal playback possible
- YouTube, Vimeo, Social networks = online video sites

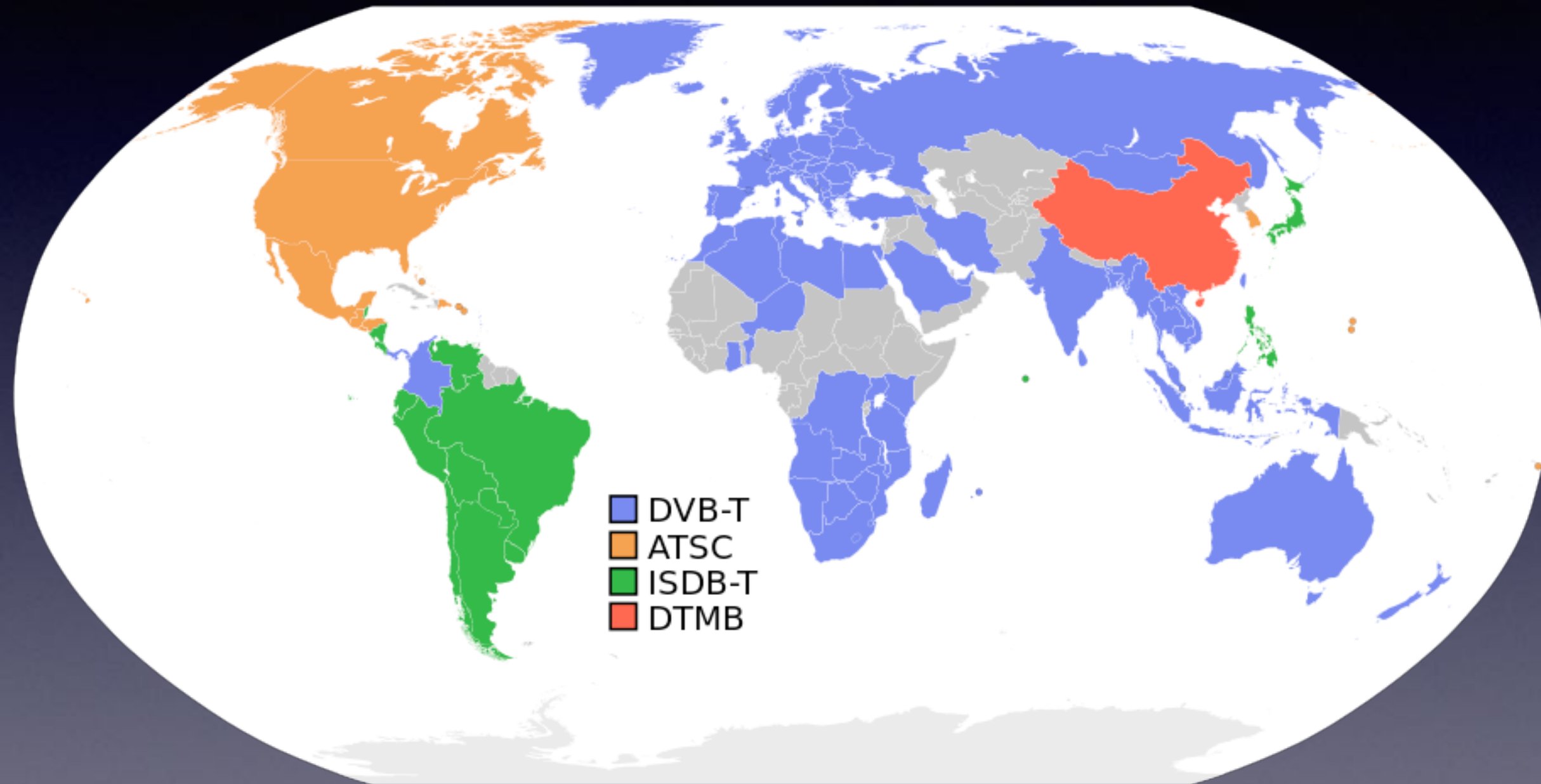
Which standard to use?

- Use whatever format your destination needs.
- Keep in mind your target audience...
- Americas = NTSC, Europe = PAL
- Internet = Any format/size depending on content distribution network

Digital TV Worldwide

- Rest of world slow to implement DTV (as we were)
 - 2011-2020 most countries will have DTV!
- US: 2010 switchover complete
- Analog SD still meaningful until worldwide switchover (almost there in 2017).

Digital TV Worldwide



Why does it matter?

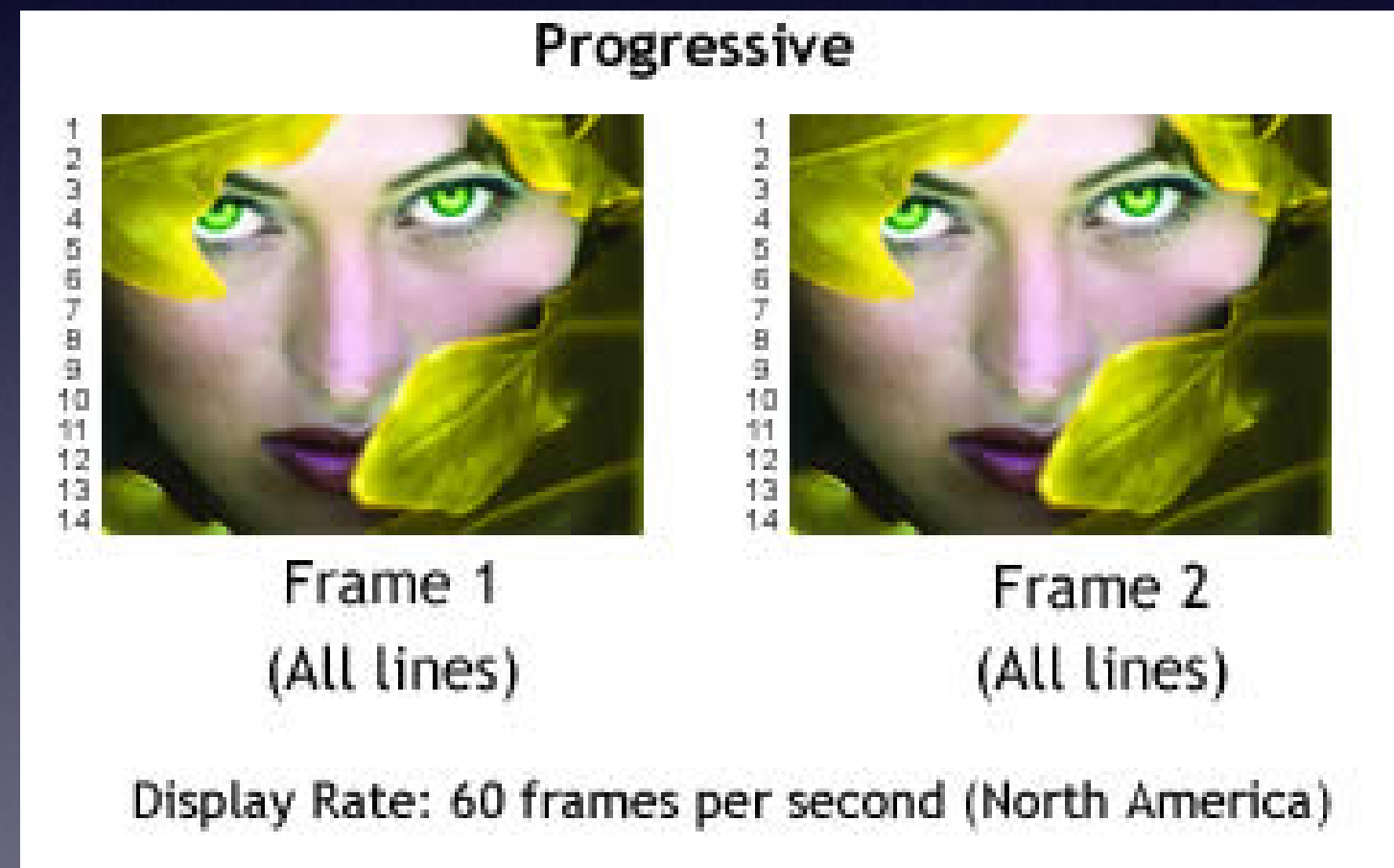
- Your projects should adhere to broadcast standards and frame rates, even on streaming platforms.
- Standards ensure future compatibility.
- Ease of distribution to wider venues.

Digital Video 101

Progressive vs. Interlaced

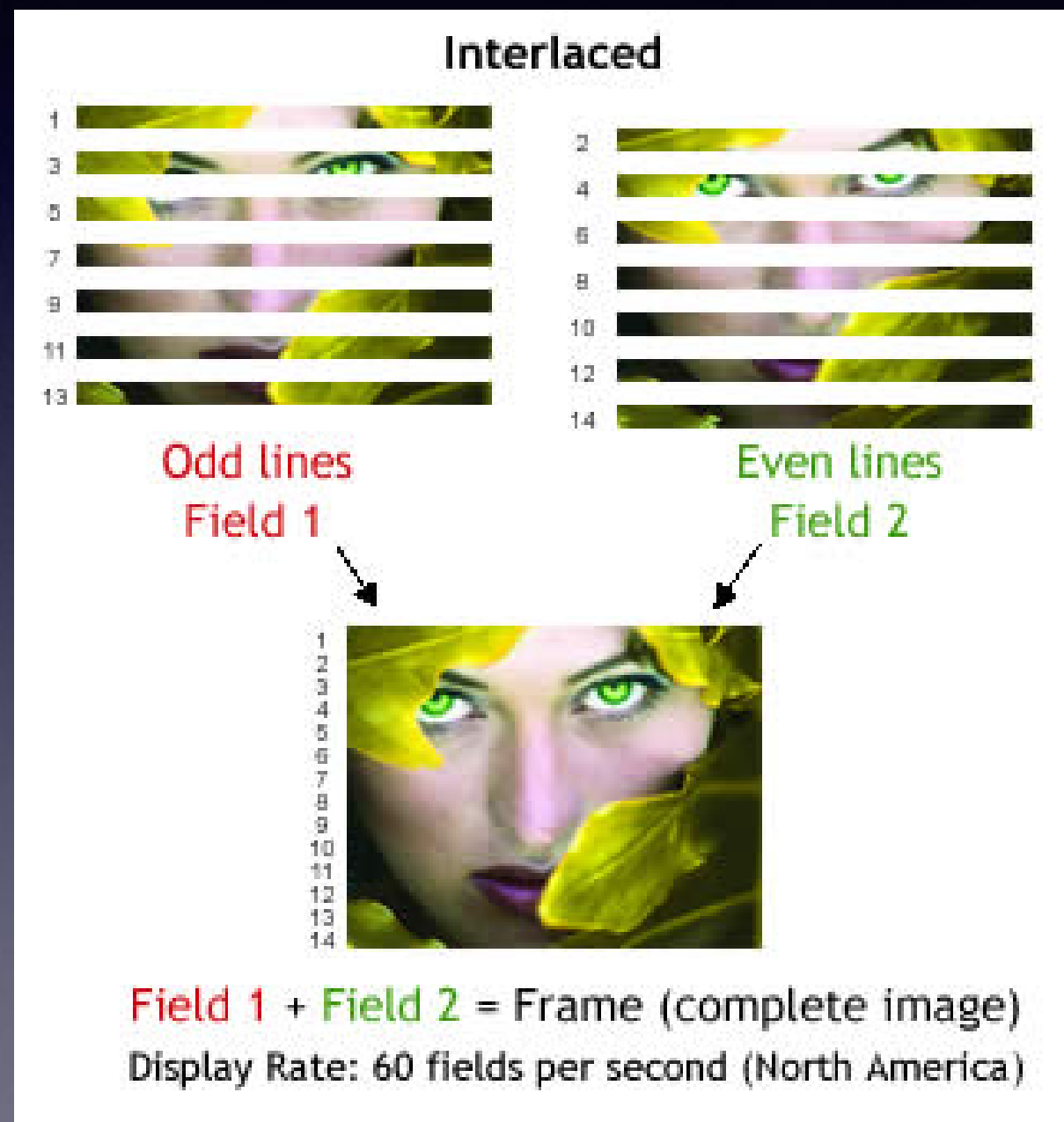
Progressive

- Each scan-line is displayed in sequence from top to bottom



Interlaced

- The complete image is encoded as two fields...

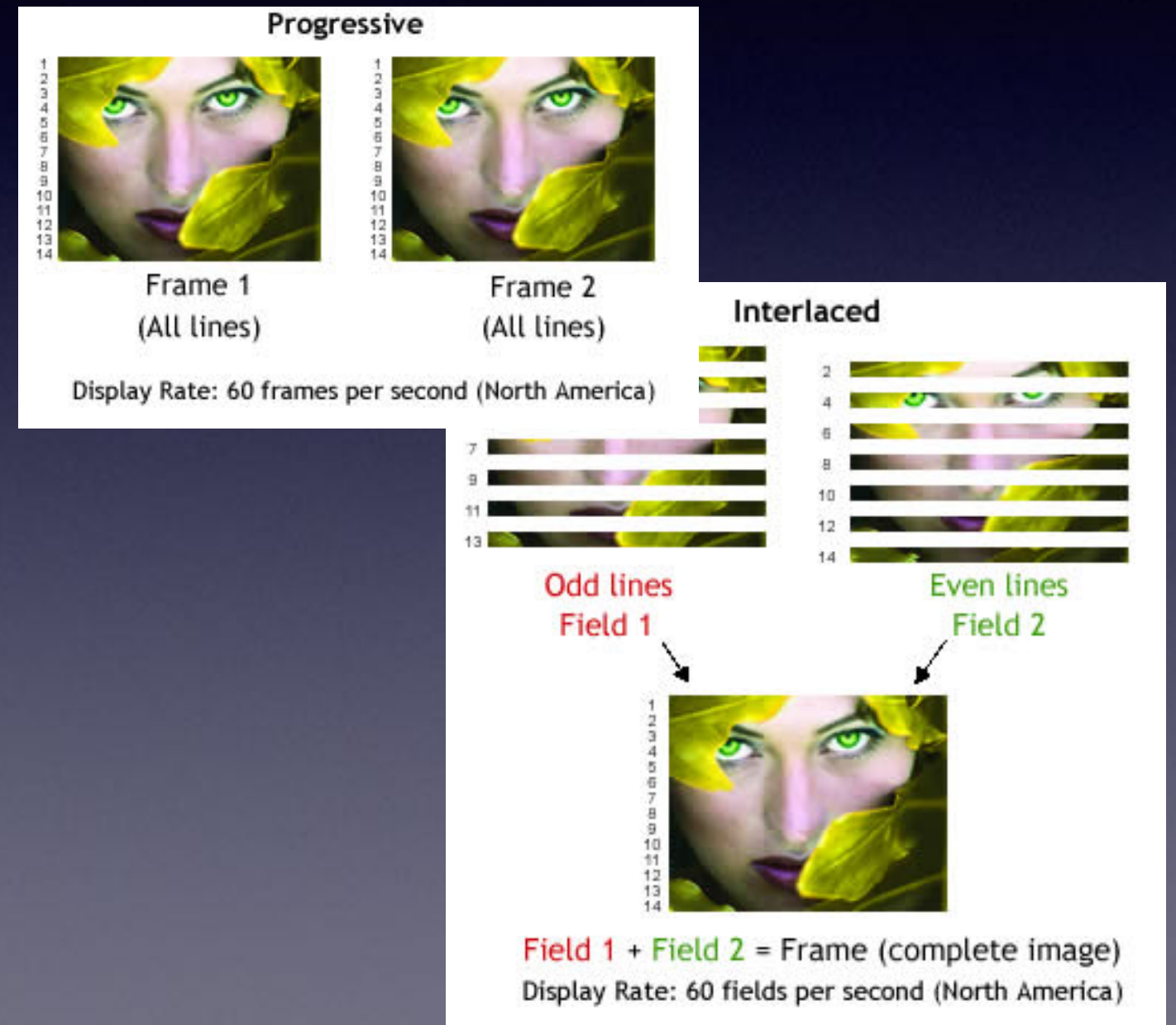


Progressive vs. Interlaced

- Computers use progressive displays.
- Televisions (NTSC/PAL) use interlaced displays.
 - Interlacing artifacts (flickering)
 - Computers display interlacing wierd (forks)
- Film is progressive by nature.

Progressive vs. Interlaced

- Progressive = higher image quality.
- Interlaced scan = less bandwidth
- Progressive scan = more bandwidth
- 720p60 only HD broadcast right now



Interlace vs Progressive: Who's Who?

1080i	720p
Warner Bros. Discovery Comcast Paramount Global	Fox Disney MLB A+E Networks

What to use what?

- Filmic narrative
 - “24p” most commonly used
- Reality TV, Network News, Sports
 - Interlaced formats - 60i
 - Some networks use 720/60p
 - Action / blogging use 60p on streaming platforms

Digital Video 101

Frame Rates

Frame Rates

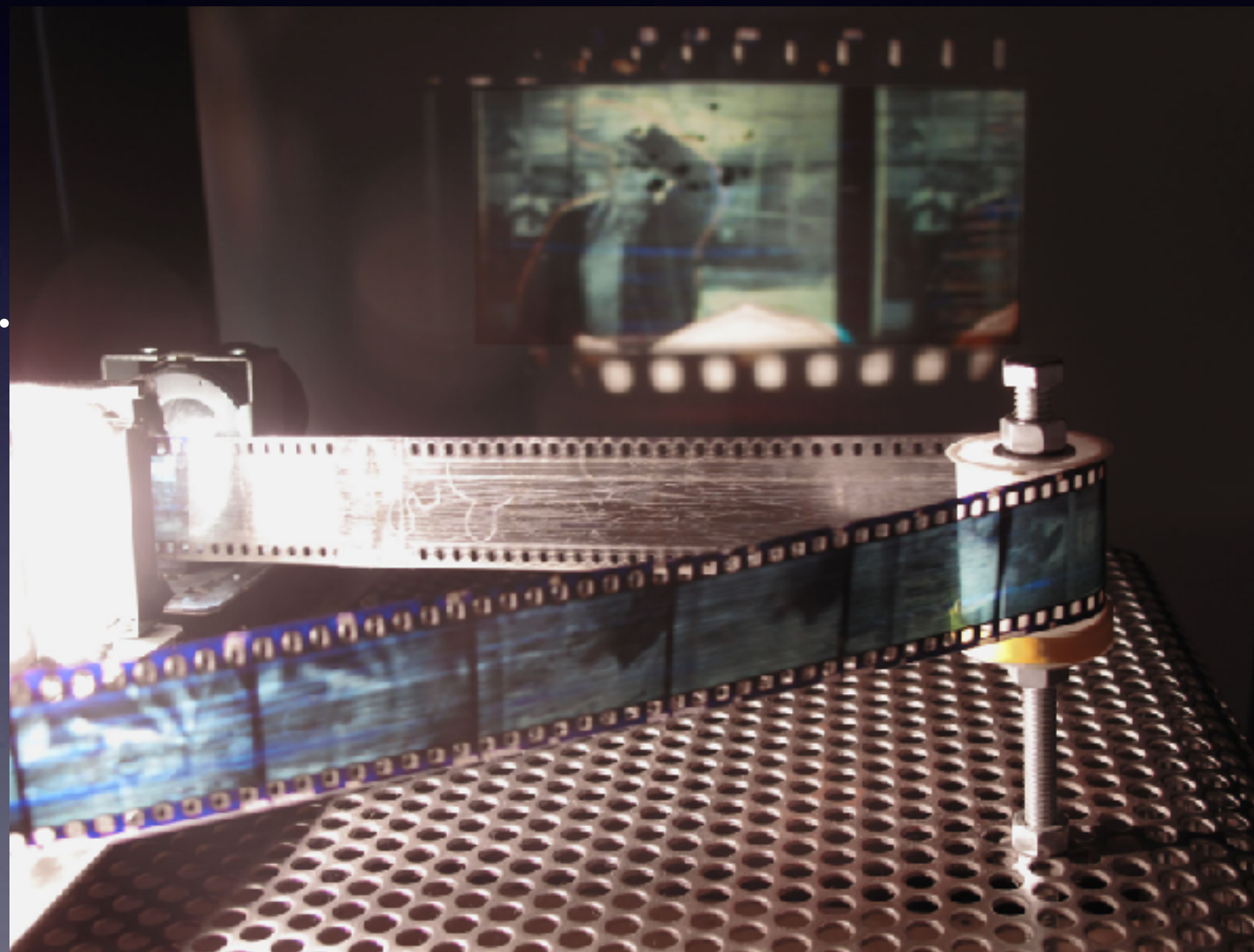
- Film: 24 fps
- PAL: 25 fps
- NTSC: 30 fps



Of these three,
PAL is the only one
that really runs
at 25 fps.

Film

- Film in US theaters - 24.0 fps.
- Europe - 25.0 fps.
- Digital theaters project multiple frame rates.



NTSC

- Theoretically 30 fps
- Actually runs at **29.97** fps.
 - Certain amount of time needed each second to transmit the color information (.03 sec)
 - Move from B&W to Color in the 50s necessitated the 29.97
 - Digital “Film” runs **23.976** or “23.98” to get all the math to work properly.

New Tech



- Some cameras shoot at 60 fields instead of frames.
 - Easier to convert to progressive frames... 30 or 23.98 “24p”
 - Variable frame rates possible now.

New Tech



- High Frame Rate Cameras
 - Sony FS7: 4k up to 60fps, HD up to 180fps
 - Panasonic GH6: 4k up to 60fps, HD up to 120fps
 - Sony FS700: HD up to 480fps!

Digital Video 101

Video Formats

Old Skool: Two main formats

- **DV** - low end / industrial / consumer / indie (SD)
 - Digital Video
 - Many parts of world still SD!
- **HD** - high end
 - High Definition

DV - “Ancient Times”

- Mini-DV
- DVCPPro-25
- DVCAM



DV

- DV, DVCPPro-25, DVCAM are all the same format!
 - They get written to tape differently (dep. on manufacturer)
 - All the math is the same.
 - All digital formats.

“Broadcast” SD

- DVCPRO - 50
- Betacam SP
- Digital betacam



SD

- Digital and analog
- Older than DV (analog versions)
- Used everyday in broadcast/cable networks, high-end corporate.
- Betacam (digi, sp) still widely used in industry!

HD

- HDV
- DVCPro-HD (DVCPro-100)
- HD (HDCam, XDCam HD, HDCam SR, ProRes, uncompressed)



DSLR Revolution (2008)



Robert Rodriguez

Why? Shallow DOF mimics 35mm film “look”

DSLR Revolution

- DSLRs shot “video” since 2008 (Nikon was first with D90)

- Canon

- EOS 5D series

- Rebel T3i

- EOS 7D MkII

- EOS 60D/70D/80D



DSLR Revolution

- Nikon
 - D90 *
 - Z6, Z9, Z30



DSLR Revolution

- Panasonic
- GH2/3/4/5/6



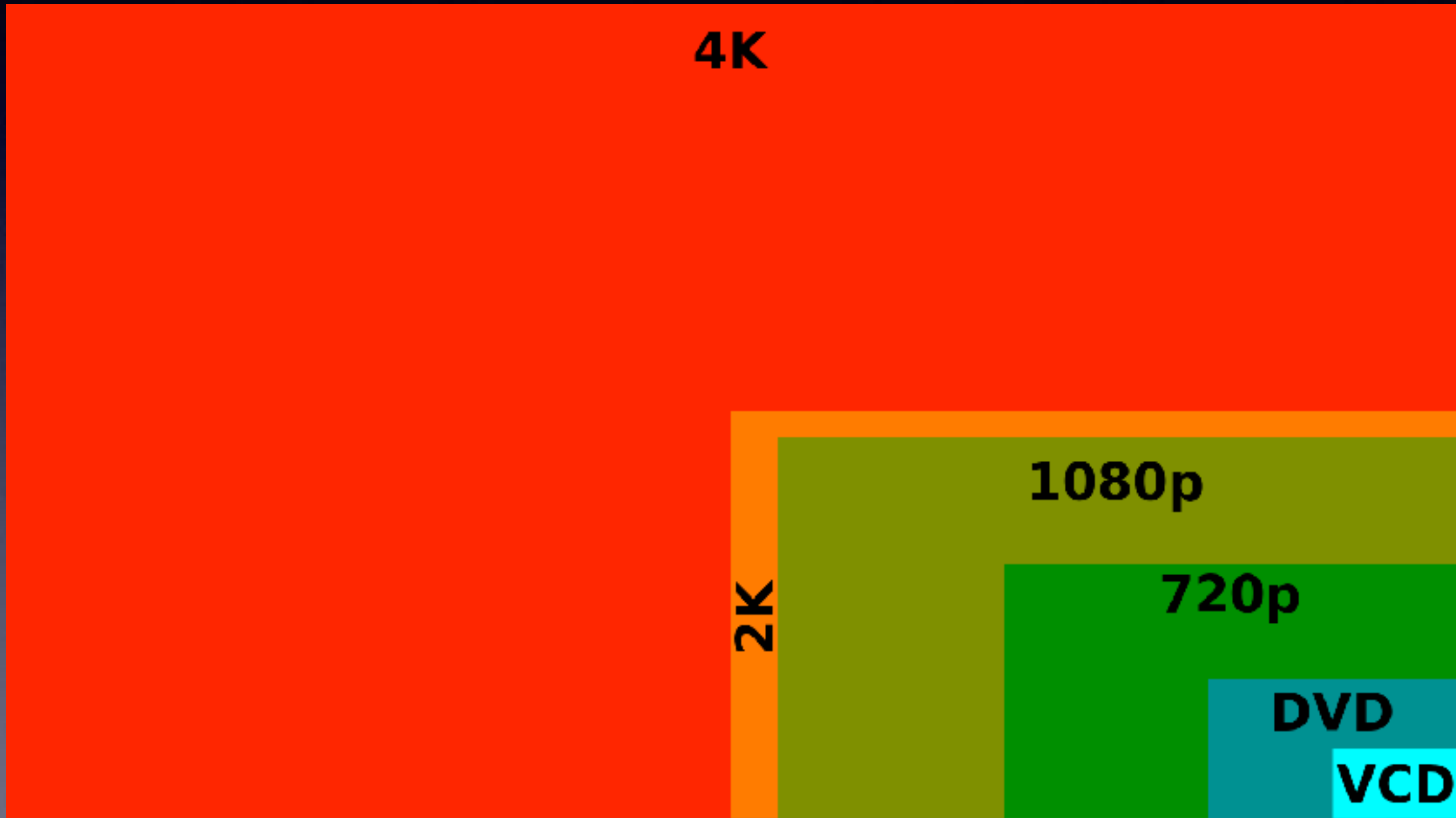
DSLR Video

- **AVCHD Codec**
 - MPEG-4
 - 480p/720p/1080i/p
 - 23.98p, 30p, 60p (480p)
 - Sony XAVC, Canon XFAVC

Large Format HD cameras

- Blackmagic 4K, URSA, URSA Mini
- Sony PMW-F3/F5/F55/FS700/FS7/FS5
- Canon C70/C100/300MkII/500
- Arri Alexa/Alexa XT/Amira/Mini
- Red One/Epic/Epic/Weapon/Helium (Dragon, Komodo = 6K!)
(Weapon/Raptor = 8K!)

4K Future?



4K Future

Format ⚡	Resolution ⚡	Display aspect ratio ⚡	Pixels ⚡
4K Ultra high definition television	3840 x 2160	1.78:1 (16:9)	8,294,400
Digital Cinema Initiatives 4K (native resolution)	4096 x 2160	1.90:1 (256:135) ~17:9	8,847,360
4K Ultra wide television	5120 x 2160	2.37:1 (21:9)	11,059,200
4K WHXGA	5120 x 3200	1.60:1 (16:10)	16,384,000
DCI 4K (CinemaScope cropped)	4096 x 1716	2.39:1	7,020,544
DCI 4K (flat cropped)	3996 x 2160	1.85:1	8,631,360

4K Future

- Cameras
 - Blackmagic Production Camera 4K (8/2013), Ursa (2014)
 - Canon EOS C500 / IDC (2012), C300MkII (2015)
 - RED Raven / Epic / Scarlet / One (2006-13), Komodo, Raptor (2020)
 - Sony F5/F55/F65/AX1/AX100/X70/FS7 (2012-)

Move to 2K/4K and Beyond

- RED Komodo, Raptor
 - 6K/8K acquisition
 - Transcode to other formats
- ARRI Alexa/Mini
 - 3K max D-range
- Sony F65 (8K/4K), Venice (8K)



Digital Video 101

Image Size (DV / SD / HD and beyond)

Fixed Size

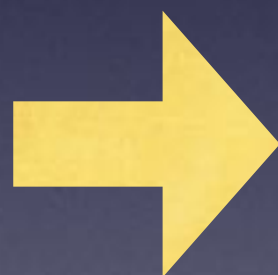
- All video (digital video) is fixed in size
 - Resolution is fixed at the moment they're created.
 - Bitmapped image.

Projected Images

- Video images do not expand as they get larger. The information stays the same because the resolution is fixed.
- The pixels get bigger.



3ft. screen



30ft. screen

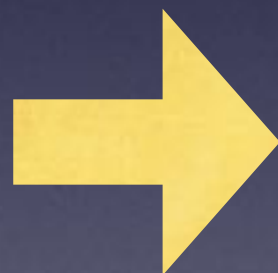


Projected Images

- Film displays more information as it gets larger.
- The pixels are smaller.
- More resolution



3ft. screen



30ft. screen

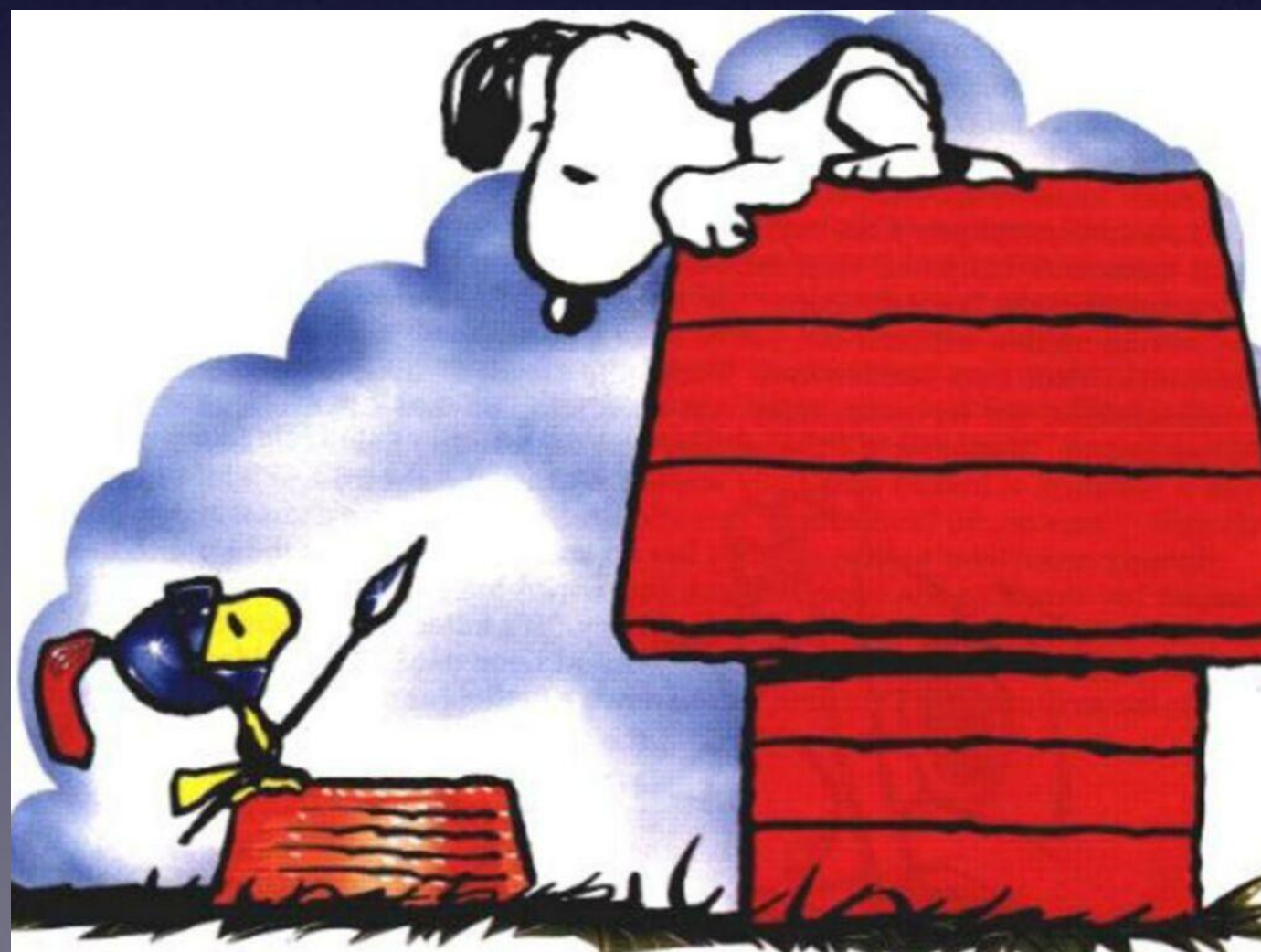


Image Size

- Video Resolution is fixed at 72 dpi.

DV NTSC

- 720 x 480

DV PAL

- 720 x 576

SD Video Sizes

- 720 x 486 NTSC
- 720 x 576 PAL

SD Video vs. DV ?

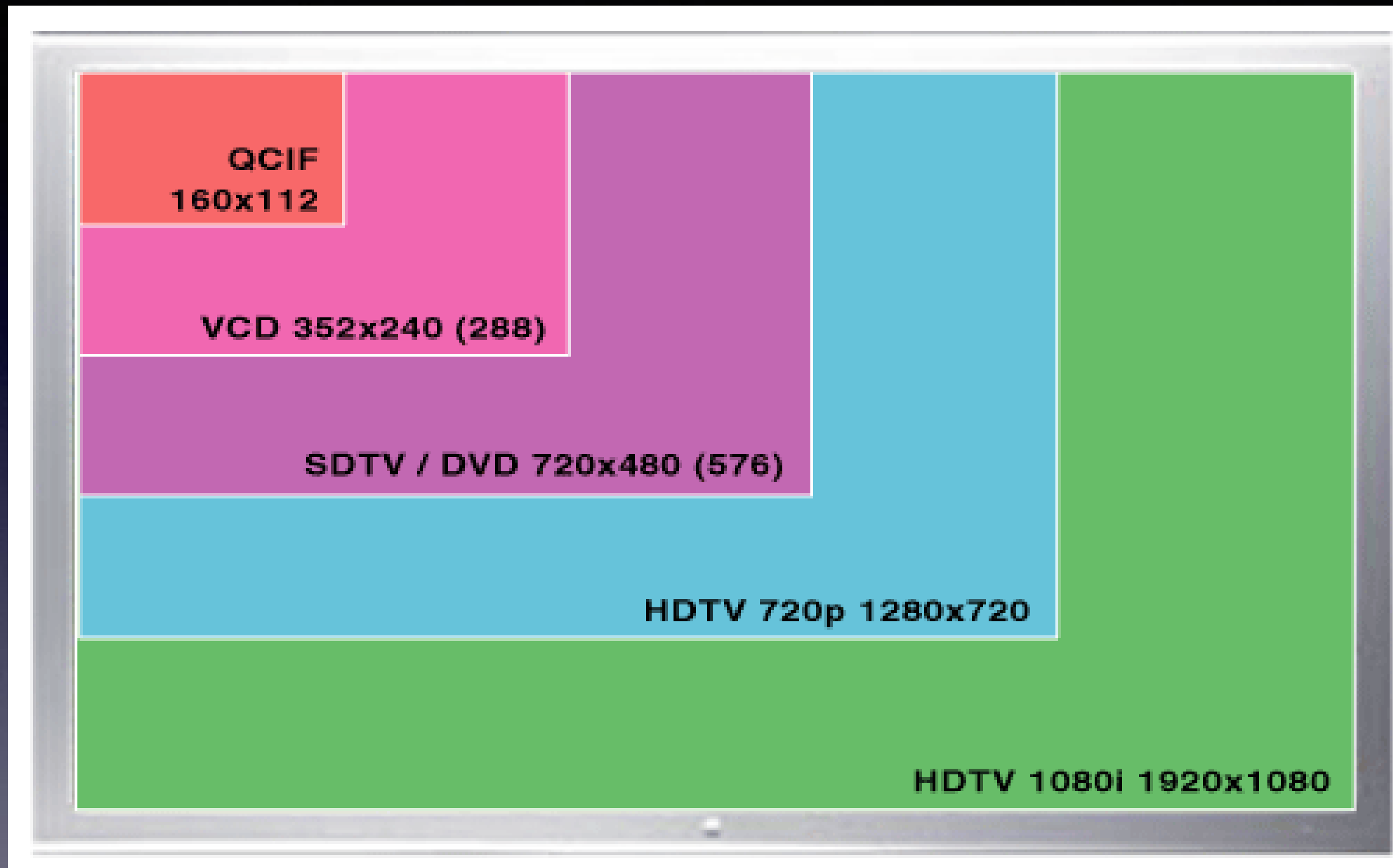
- 720 x 486 SD
- 720 x 480 DV ??????

UHD = 3840 x 2160

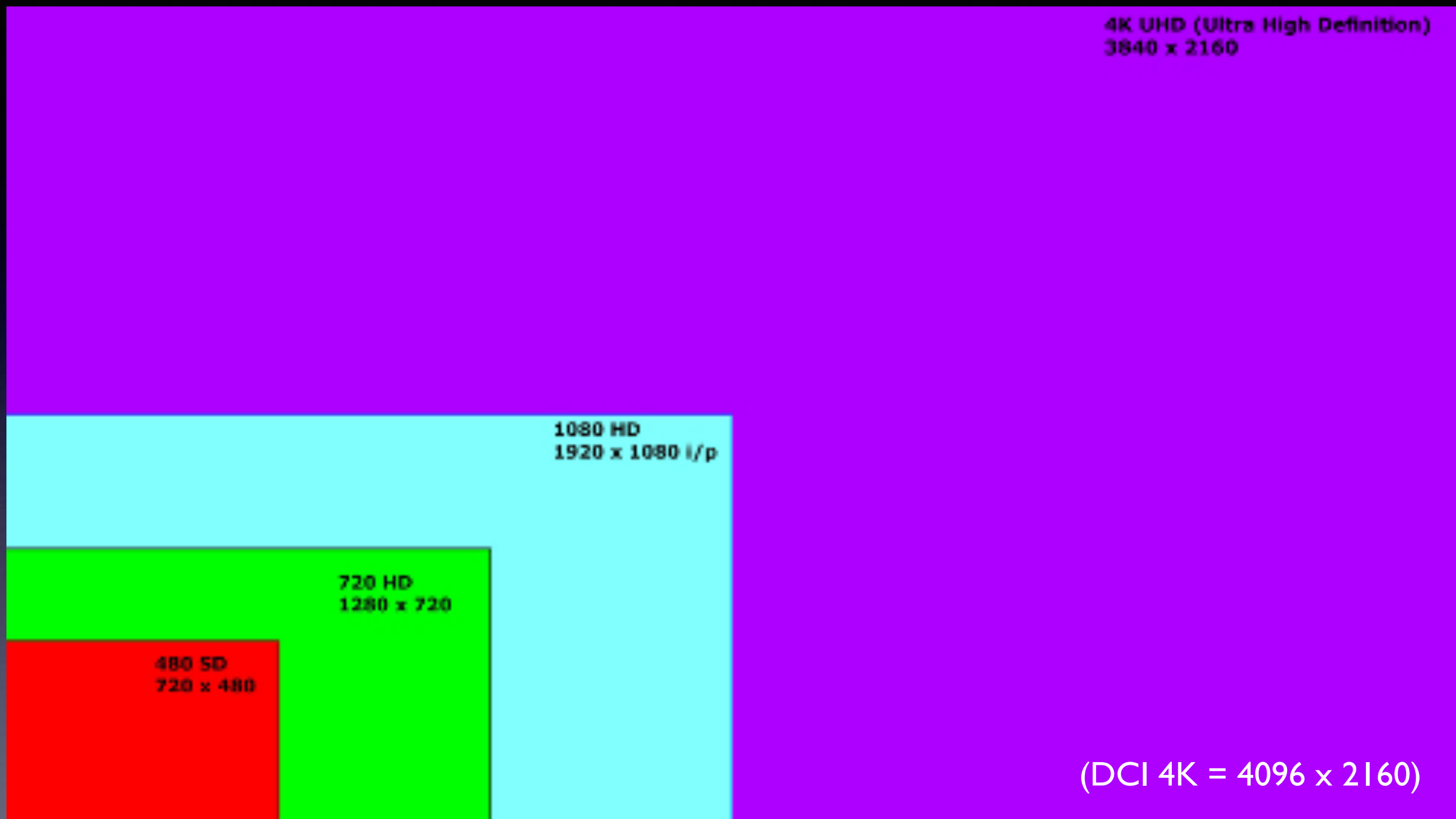
HD 1080i/p = 1920 x 1080

HD 720p = 1280 x 720

SD = 720 x 480



A 1080i HD frame has nearly Six times more pixels than a standard-definition (DV/DVD) frame



A UHD frame has nearly Four times more pixels than an HDTV frame!

Digital Cinema

- 38,000+ screens in USA
- 75% worldwide converted to digital by 2012
 - 93,000 as of 3/2015
- 35mm films rapidly decreasing as distribution format
 - ...But remains a solid production format. (Tarentino, Spielberg, Nolan, Anderson...)

Digital Cinema

- <http://www.latimes.com/entertainment/envelope/cotown/la-et-ct-paramount-end-to-film-20140118,0,806855.story#axzz2rqj5reqH>

The Future

● 2K

Academy Standard 1828x1332 1.37:1 2.4 MP

Academy Flat 1998x1080 1.85:1 2.2 MP

Anamorphic Scope 2048x858 2.39:1 1.8 MP

DCI 2048 x 1080 2.2MP

● 4K

Academy Standard 3626x2664 1.37:1 9.7 MP

Academy Flat 3996x2160 1.85:1 8.6 MP

Anamorphic Scope 4096x1714 2.39:1 7.0 MP

DCI 4096 x 2160 8.8 MP

Digital Video 101

Aspect Ratios



Many Ratios over the years

- **1.33** (William Dickson, Edison 1909)
 - The original 4:3
- **1.37** (Academy Ratio) making room for optical sound
- **2.59:1** (Cinerama, 1957) “How the West was Won”
- **1.66** (Academy Ratio masked) “Shane”

Many Ratios over the years

- **2.35** (Cinemascope using 4 perf film, 1953) “The Robe”
- **1.85** (VistaVision) “White Christmas, Ten Commandments”
 - “Vertigo” etc...
 - 8-perf shot on side

Many Ratios over the years

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 - “Vertigo” etc...
 - 8-perf shot on side

Many Ratios over the years

- **2.20** (Todd-AO 70mm) “Oklahoma” 1945, “Patton” 1950
 - Panavision “Lawrence of Arabia” 1962
- **2.76** (MGM 65mm Camera) “Ben Hur” 1959

Advent of 16:9

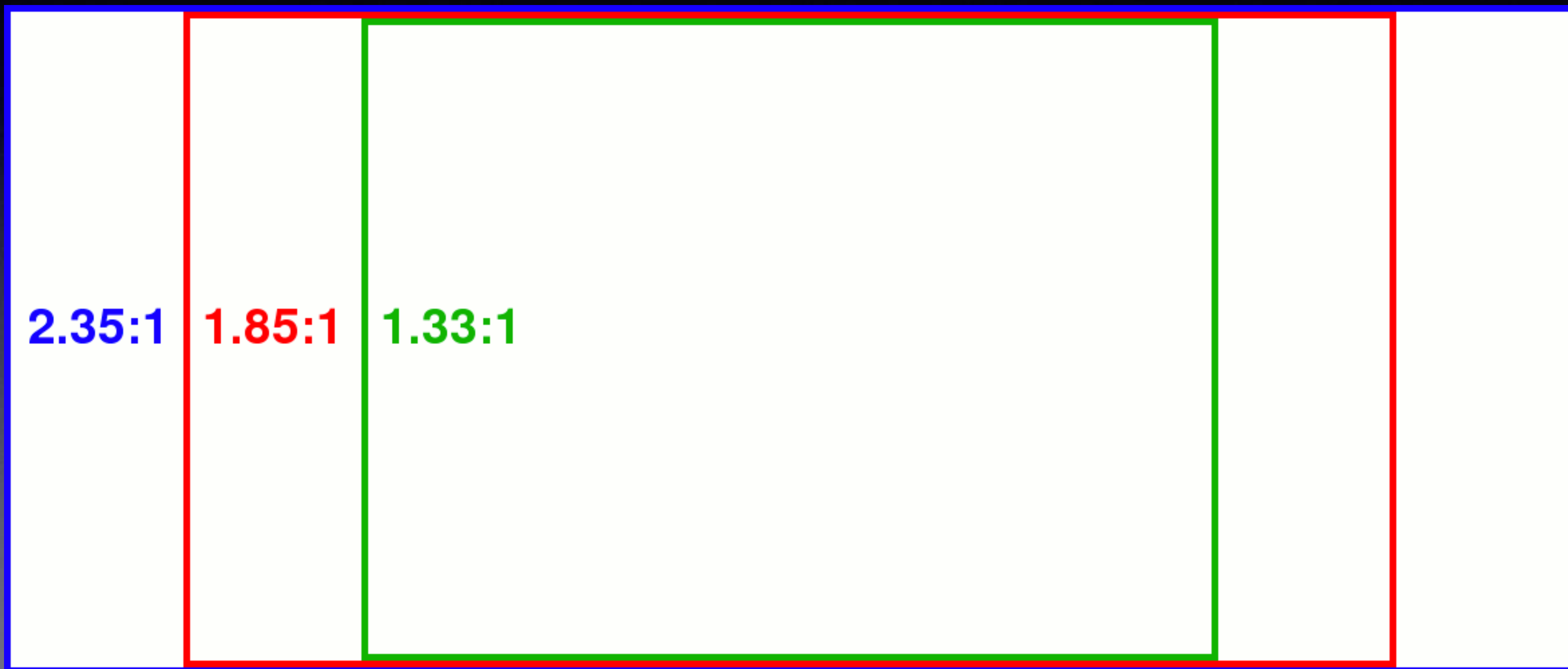
- **1.77** (Kerns H Powers) suggested 16:9
 - HDTV standard drawn up late 1980s
 - 16:9 compromise between 4:3 and 2.35
 - Both same screen area when formatted to 16:9

Aspect Ratios

2.35:1

1.85:1

1.33:1





I.33 - Edison



2.77 - Cinerama (3 cam/projectors)



2.35 - Panavision "The Sand Pebbles" (1966)



1.78 - HDTV - 16:9 (1966)

All HD formats are 16:9



HD production formats are 16:9

- What do you set your pixel ratio to?
 - **Pixel aspect 1.0 (square pixels)**
- Crop your canvas to proper shooting aspect
 - set guides/overlays for composition
 - manually set timeline settings to proper aspect

Digital Video 101

Video Connectors

Interfaces:
Analog
Digital



rear of srw-5500 HDCam SR deck

Analog Connections

Composite
(luma/chroma mixed)



S-Video
(luma/chroma separate)



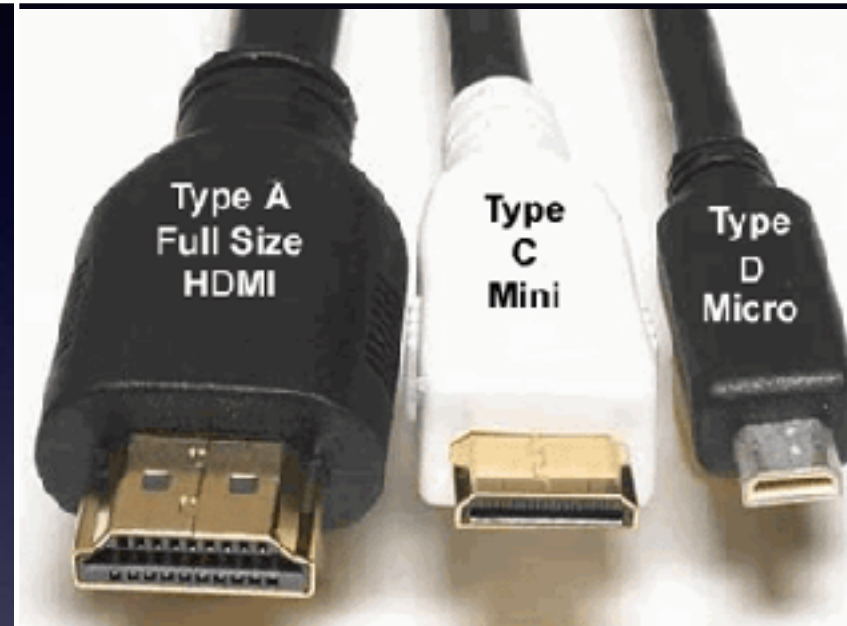
Component
(Y Cr Cb separate)



Digital Connections

HDMI

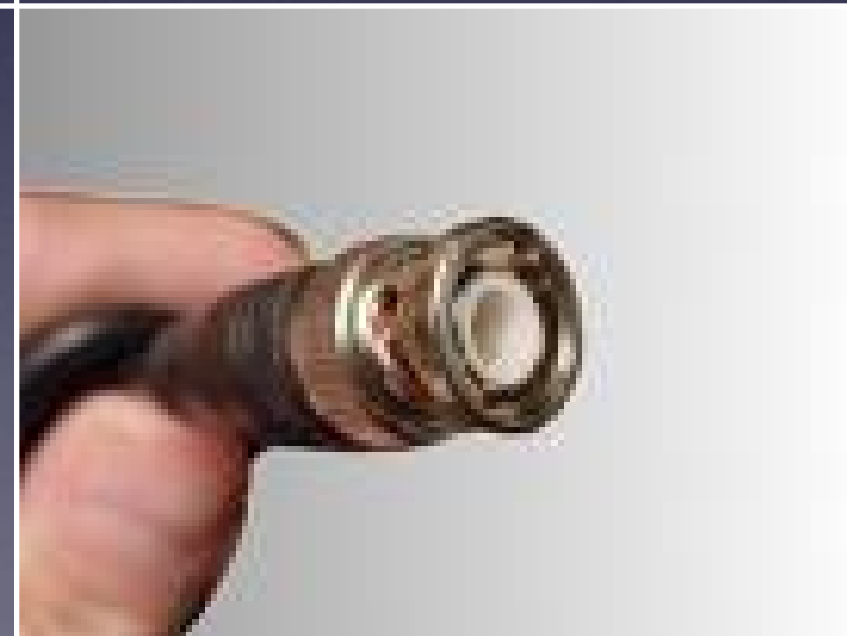
(High-Definition Multimedia Interface) is a compact audio/video interface for transferring uncompressed video data and compressed/uncompressed digital audio data)



best quality

SDI / HD-SDI

(SD and HD Video, can also carry embedded digital audio)



Digital Video 101

Video as Data Files

Tapeless Workflow

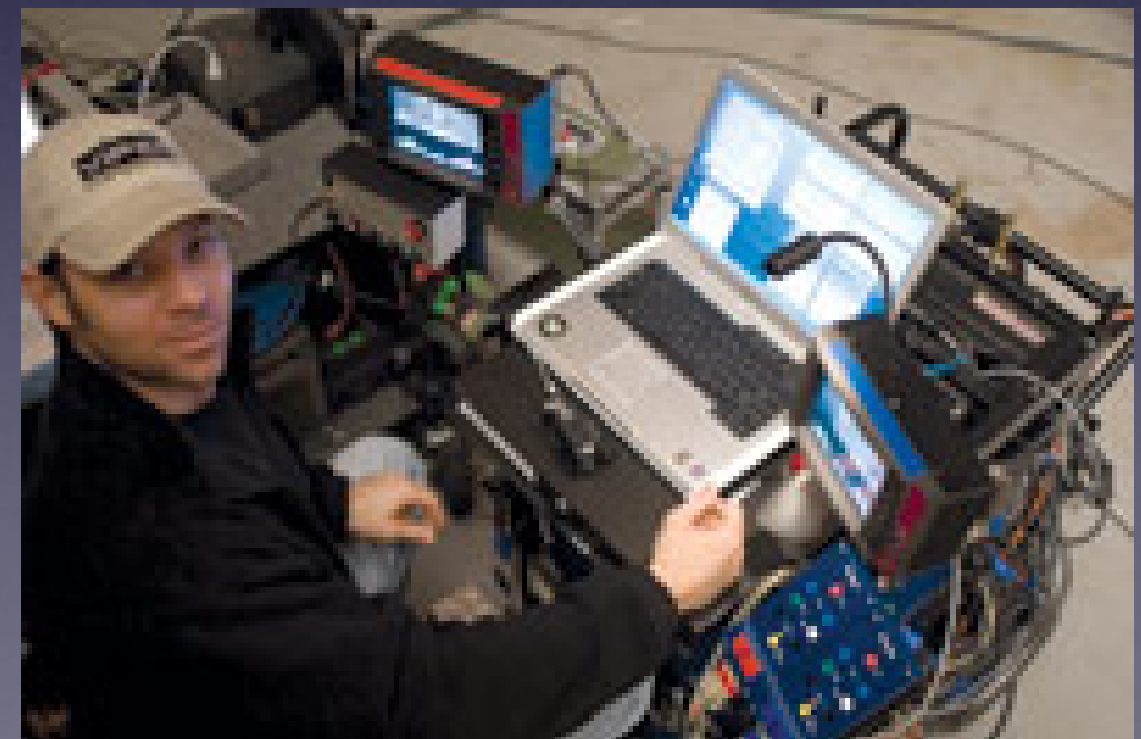
- Earlier, high quality digital video meant tethering computer to the camera.
 - Highest quality
 - Largest file sizes
 - Cumbersome

Tapeless Workflow



Camera operator Kim Marks (left), A camera first assistant Chris Blauvelt (center), and A camera second assistant Jason McCormick (right) line up a shot with a Thomson Viper FilmStream camera, configured to record directly to a hard drive, during production on David Fincher's movie Zodiac.

Wayne Tidwell, in charge of data capture for the Zodiac project, at his control station, which featured button pads that controlled two S.two digital hard drive recording systems used during production in lieu of tape. The laptop was used to manage files on the hard drive systems.



Tapeless Workflow



Tapeless Workflow



Panny P2 camcorders



Sony XDCam HD



Sony EX1,F3,F5/F55 camcorders

Tapeless Workflow



DSLR, Panasonic HMC-150, Canon XF series, Sony NX Series

Tapeless Workflow



Alexa uses SxS cards to record Apple ProRes

Tapeless Workflow



Red uses proprietary cards to record Redcode Raw data

Video Data Rates

- Higher data rates = higher resolution/quality

Video Data Rates

- CD Audio (16 bit / 44.1khz)
 - 176 KB/second.

Video Data Rates

- **DV**

- 3.75 MB/second.

- **SD uncompressed (8-bit)**

- 20.2 MB/second.

Video Data Rates

- **SD uncompressed (10-bit)**

- 26.7 MB/second.

- **HDV**

- 720p = 2.4 MB/second.

- 1080i = 3.2 MB/second.

Video Data Rates

- **Apple ProRes (industry standard as of now)**
 - 10 bits!
 - ProRes 422 LT = 100Mbits/sec *
 - ProRes 422 = 147 Mbits/sec *
 - ProRes 422 HQ = 220 Mbits/sec
 - ProRes 4444 = 330 Mbits/sec (yikes!)

Video Data Rates

- **HD uncompressed (8-bit)**

- 1080i/60 = 119 MB/second.

- 1080p/24 = 95 MB/second.

Video Data Rates

- **HD uncompressed (10-bit)**

- 1080i/60 = 237 MB/second.

- 1080p/24 = 190 MB/second.

Data Storage

- DV (NTSC/PAL)
 - 1 hour = 13 Gigabytes

Data Storage

- HDV
 - 720p: 1 hour = 8.7 GB
 - 1080i: 1 hour = 11.5 GB

Data Storage

- XDCam-HD for indie filmmakers
 - 1080p/24 (HQ mode): 1 hour = 23 GB

Data Storage

- ProRes 422
 - 720p/60: 1 hour = 66 GB
 - 1080p/24: 1 hour = 53 GB
 - 2160p/24: 1 hour = 212 GB!

Data Storage

- Uncompressed HD
 - 720p/60 (8-bit): 1 hour = 370 GB
 - 1080p/24 (8-bit): 1 hour = 334 GB
 - 1080p/24 (10-bit): 1 hour = 445 GB

Data Rates

- Internal hard drive of modern computer:
 - 70-150 MB/second
- External USB 3.0 drive:
 - 20-120 MB/second
- External Thunderbolt Drive (RAID)
 - 100-1200 MB/second!

Data Rates

- To edit uncompressed HD one needs a RAID
 - Redundant Array of Inexpensive Discs
 - 100-1200 MB/second!

