

Digital Delivery from Cinema to the web

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Deliverable formats, big to small

- Film (Digital Intermediates)
- DCI spec digital cinema distribution package
- Festival masters
- Broadcast delivery masters
- Shiny plastic deliverables (DVD, HD-DVD, Blu-ray)
- Online deliverables (huge range)

Film (via DI)

- not a digital deliverable in and of itself
- but de facto standard is a DI - Digital Intermediate, is a digital pipeline
- film scanned at 2K (2048x1556) or now 4K (4096x3112) or Super2K
- 10 bit log is standard (compression)
- DPX or Cineon files are the standard
- High end tools - daVinci, Pablo, Scratch, etc. (Color?)

Digital Intermediate Workflow

- film is telecined to offline format (SD or HD)
- offline edit is done until picture lock (sorta)
- film selects are scanned at high resolution
- VFX work done at high res from those files
- edit is conformed at 2K/4K on high end box
- color grading done in a DI theater w/LUTs
- digital files then transferred to film

Digital Cinema Initiative

- started by the major studios
- wanted to have one standard for digital distribution
- wanted it to be secure to reduce piracy, or at least identify the source
- meet or exceed the current projection standard
- otherwise why bother

DCI's Goals

- stop making lots of expensive film prints
- stop shipping heavy film prints
- stop having film prints get worn out & look bad
- stop having to make so many briefly needed prints (opening weekends)
- have ONE standard, SECURE for digital distribution
- VERY concerned about security/piracy, as you'll see
 - don't copy, don't alter upon display

The DCI spec: Resolution

- Since going digital, decided to go with square pixels
- Unlike traditional digital film work (non-square pixel aspect ratio)
- Not 2048x1556 (2K) or 4096x3112 (4K), 2048x1080 (2K) and 4096x2160 (4K)
- note how close 2K is to 1920x1080 HD
- See? is “higher resolution”

Format Resolutions: Traditional Scans vs DCI spec

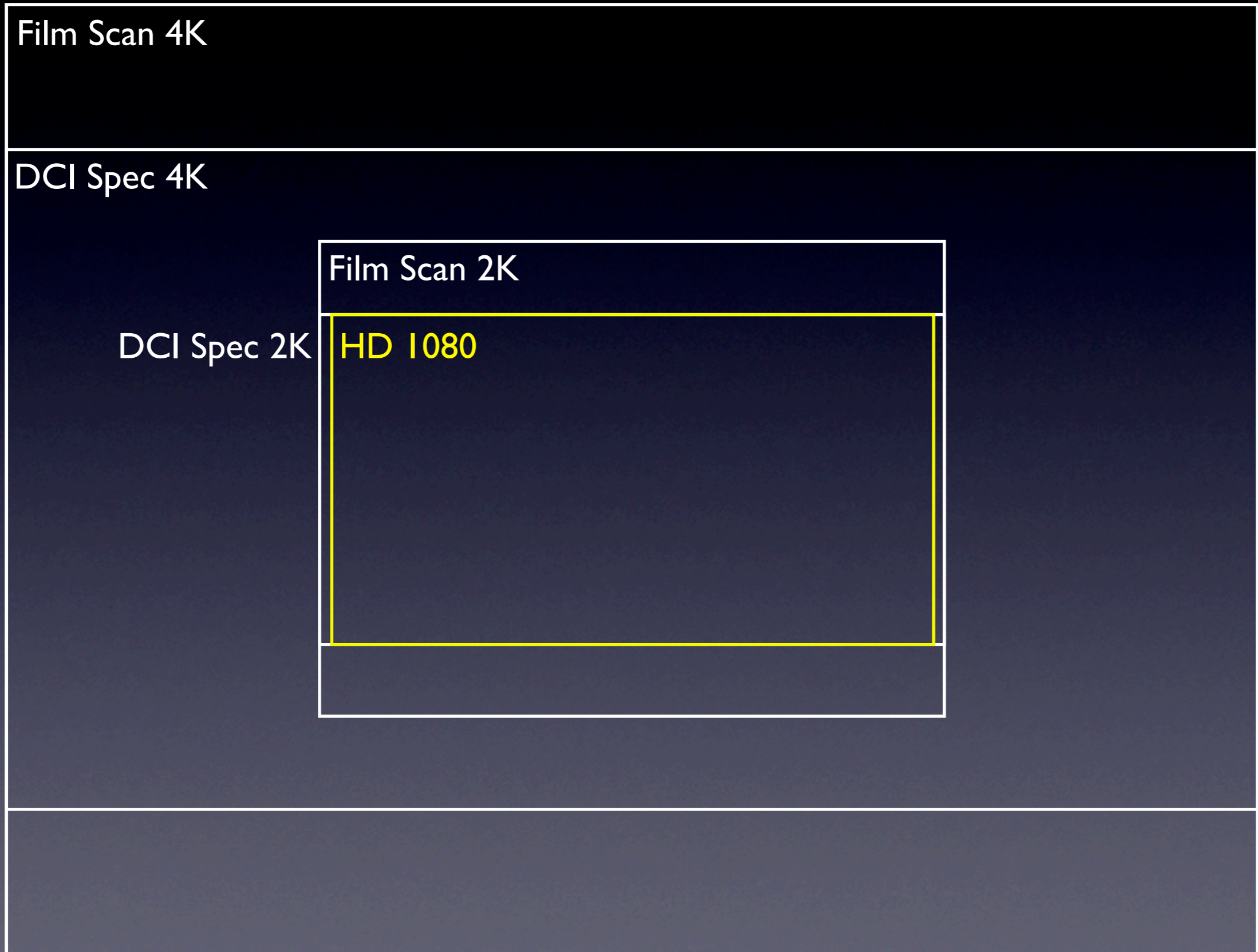
Film Scan 4K

DCI Spec 4K

Film Scan 2K

DCI Spec 2K

HD 1080



DCI Spec: Color

- CIE 1931 XYZ Color space - said at Digital Cinema Summit in 2005:
“Right now doing XYZ is like trying to stand up in a hammock.”
- DCI gamut is MUCH bigger than Rec 709
- LOTS more green in DCI, blue is about the same, DCI has more red
- Gamma is 2.6, not same as SD/HD standard

DCI Spec: Bit Depth

- 12 bits/channel, linear
- most video formats have 8 bits
- higher end formats (Digibeta, D-5, HDCAM SR) have 10 bits, film scans usually 10bit log
- so instead of 256 gradations from black to white (8 bits), or 1024 (10 bits), have 4096 steps from black to white
- need that for smooth gradations on large screens
-what is smooth on 60 inch not 60 feet

DCI Spec: Display Conditions

- corner to corner uniformity of 85%
- 14 ft-L brightness
- white point of .414x,.351y
- 2000:1 minimum contrast ratio (on/off)
- 150:1 intra-frame contrast ratio
- gamma of 2.6
- and big screen w/black surround to avoid eyestrain

DCI Spec: Compression

- JPEG2000
- wavelet based, therefore is from DCT which we're used to - used in JPEG, DV, etc.
- when DCT is too low in bandwidth, get mosquito noise and blocking
- when wavelet is starved, image just gets soft - details begin to get fuzzy
- VERY processor intensive to encode/decode

DCI Spec: Data Rates

- 2K @ 250 mbps (=31.25 MB/sec)
- 4K @ 250 mbps (=31.25 MB/sec)
- 3D 2K @ 48 fps @ 250 mbps - good not great, and so is 4K @ 24p @ 250 mbits
- matched to single drive speed capabilities
- while looks good, some complaints about picking that number as merely what the current hardware could do

the workflow for DCI

- very similar to DI, just adds more steps at the end, needs to be done by a high end post place
- need a DSM - Digital Source Master - this is the high quality files from which deliverables are made
- that is converted to a DCDM-Digital Cinema Distribution Master, is in XYZ color
- then make a DCP - Digital Cinema Package

mention security – there's LOTS, so much so that theaters are worried about dark screens – something doesn't get a verification, and the movie won't play – one of the biggest concerns after cost & complexity

DCI security & distro

- EACH version sent out has its own encryption keys
- keys are sent separately
- content is watermarked
- at each theater, is complex infrastructure to handle playback etc.
- playback servers VERY physically secure
- DCP can be sent as hard drive, satellite, via cable, etc. - just data, designed to be agnostic

Festival Masters

- Major festivals are moving towards two deliverables to show:
 - 35mm film print
 - HDCAM 1080i60

- since I specialize in digital tech for independent filmmakers, thought worth mentioning

Why A Festival Specific Master

- if you're making an indie movie without guaranteed distribution, why go to the \$30-\$60K (minimum) additional expense unless you know it is needed?
- Only need film if DEFINITELY going theatrical
- Consider making a good festival master instead
- Doesn't necessarily have to be broadcast safe - therefore can have richer blacks, brighter whites, and more saturated colors - but check fest specs

oh - and don't forget to make a good 24p master for yourself - if mastered 4:2:2, get at least a D-5 master, and if mastered 4:4:4, get an HDCAM SR 4:4:4 24p master as well

Broadcast Masters: Video Formats

- Tape is still king
- used to be a simpler world: NTSC vs PAL
- with HD, have more video formats to contend with:
 - 720p at 23.76, 24.0, 25, 29.97, 50, & 59.94
 - 1080p for acquisition at 23.976, 24.0, 25, 29.97, and not 59.94 & 60fps
 - 1080i50 & 1080i59.94 (aka 1080i25&1080i29.97)
- but for broadcast, 720p50, 720p60, 1080i50/59.94

I've adopted this nomenclature because the advent of 60p production made it possible to get into vague and ambiguous definitions – “Is that tape 30 fps?” used to be sufficient, but it could be NTSC 29.97, 720p29.97, 720p30.0, 1080 progressive 29.97 or 30, 1080 interlaced 29.97 or 30, etc.

Broadcast Masters: Tape Formats

- In the SD world we have DV, DVCAM, DVCPRO, DVCPRO50, XDCAM, IMX, Digibeta, BetaSP, etc.
- In the HD world, we have AVCHD, HDV, XDCAM HD , DVCPRO HD, HDCAM, D-5, and HDCAM SR

Tape Formats: How to evaluate

- Recorded vs. Displayed pixel resolution
- Color sampling
- Bit depth
- Compression type
- Compression amount

things like “prefiltering” or “subsampling” are used as kind metaphors for “we threw your pixels away, have a nice day”

Tape Formats: Record vs Display Res

- used to be pixels was pixels - 720x480, 720x486, 720x576, etc.
- with the advent of HD, manufacturers tried to stuff up to 6 times more pixels onto the same tapes
- so one compromise was to horizontally shrink the frame before compression

used to be, pixels was pixels – with the advent of HD,

Shrinkage: when 1920x1080 or 1280x720 isn't

- HDV 720p is “honest” - 1280x720
- DVCPRO HD 720p - 960x720
- thus Varicam is only “double res SD” to tape - compare to 720x576 for PAL in terms of pixels
- DVCPRO HD 1080i/p - 1280x1080
- HDV, XDCAM HD, HDCAM - 1440x1080

Tape Formats: Color Sampling

- Color sampling is simply how much of the color are you throwing away before recording:
 - 4:4:4 is all of it (HDCAM SR)
 - 4:2:2 throws out half the color info
(DVCPRO HD, HDCAM, Digibeta, D-5)
 - 4:1:1 and 4:2:0 throw out 3/4 of the color
(DV, HDV, XDCAM HD)
 - 3:1:1 ditches some luma and 3/4 of color

Tape Formats: Compression Type

- different frame compression styles: inter vs intra frame
- inter-frame compression is more efficient, but longer GOPs harder to decode/edit
- different styles - DCT vs. wavelet (wavelet more efficient, harder to decode)
- RAW vs RGB, etc. - 3 vs. 1 channel to compress

Tape Formats: Compression Amounts

- All other things being equal (which they rarely are), less compression is better
- therefore, as a general rule, higher data rates are generally preferable
- consider that the 10 bit HD-SDI off a 1080i camera is 160 MB/sec uncompressed...but HDV delivers that for 3.5 MB/sec

- That's a 45x difference - how much useful information do you think was lost?

Quick Comparison: Tape formats

- DV/CAM/Pro - 480i 8 bit 4:2:0 DCT based 3.5 MB/sec
- Digibeta - 486i 10 bit 4:2:2 10-12 (??) MB/sec
- HDV 720p - 8 bit 4:2:0 DCT based 2.4 MB/sec
- HDV 1080i - 1440x1080 8 bit 4:2:0 3.5 MB/sec
- XDCAM HD - 1440x1080 8 bit 4:2:0 2.3-4.4 MB/sec
- DVCPRO HD 720p60 - 960x720 8 bit 4:2:2, 15 MB/sec
- DVCPRO HD 1080i60 - 1280x1080 8 bit 4:2:2, 15 MB/s
- D-5 1080i60 - 1920x1080 10 bit 4:2:2, 54 MB/sec
- HDCAM SR 1080i60 - 1920x1080 10 bit 4:4:4, ≤110MB/s

these are arranged by rough order of quality/preference – you can quibble to bump up or down a notch, but this is generally how they stack up. Note this is just the formats ranked, not the cameras that shoot them

Broadcast Acquisition: new formats

- a ton of new TYPES of acquisition stuff are coming as well
 - recording to hard drives or solid state media or optical discs or removable disc packs
 - a variety of ways and file formats -
DVCPRO HD, AVCHD, AVC-Intra, DPX,
Redcode, DNxHD, Cineform, QuickTime,
AVI, etc. etc. etc.
-
- while these aren't distribution formats, you'll have to deal with them in your workflows

So what makes a good image on tape?

- Sensor Size
- Sensor Resolution
- Good Glass

Sensor Size

- All things being equal, bigger is better (more light per pixel)
- don't forget fill factor - the house vs the lot
- bigger means better low light performance & better dynamic range/exposure latitude - more light per pixel
- bigger the sensor, the shallower depth of field can be attained (for film-like look)

Sensor Resolution

- Assuming you have big enough pixels & good light response, more resolution (more pixels) is preferable
- HD has two sizes (mention pixel shift):
720p (1280x720), and
1080p/1080i (1920x1080)
- Greater than HD is also possible now with
2K (2048x1080) and 4K (4096x2304) -
SI-2K, Red One, Dalsa Origin (& Origin II & Evolution), with more coming

Good Glass Counts

- It is obvious but it has to be said:
- The sensor can only record the information provided to it, and that depends on the glass
- If your camera came from the factory with a lens, you can get a better one, and you should if you can afford it

A note on Glass

- The smaller the sensor size gets, the BETTER the glass has to be to resolve an image of similar quality compared to a bigger sensor
- So it is technically HARDER to make a good image from the lens on a 1/3" sensor than a 2/3" or larger sensor - so use a bigger sensor if you can!
- Think about DSLR lens costs & the the image quality you get with still photography

Back to Deliverables: Shiny Plastic

- DVD
- High definition discs:

HD-DVD

Blu-ray

DVD

- 720x480
- 4:2:0 color sampling
- Rec 601 (SD) color space
- MPEG-2 long GOP
- max 10mbits for sound & picture, but 7ish more standard due to too many shoddy players on market - have to be compatible

High Definition Discs

- There are two competing formats:
HD-DVD from a Toshiba led group
Blu-ray from a Sony led group
- has been compared to the Beta/VHS wars...kinda right but not fully

HD-DVD

- Toshiba led group
- evolution of existing DVD tech
- blue laser (higher frequency) and focuses at similar depth in the media to DVD
- 15 GB single layer, 30 GB dual layer, 51 GB 3x*
- MPEG-2, H.264, VC-1 video codecs supported
- 5.1 & 7.1 audio formats supported, better quality than DVD
- interactivity based on Microsoft based tech

* – total, total specsmanship

Blu-ray

- Sony led effort
- more aggressive tech than HD-DVD, but \$\$
- also blue laser, but different frequency focusing closer to surface of disc-incompatible w/HD-DVD
- 25 GB single layer, 50 GB dual layer
- originally MPEG-2, but added VC-1 & H.264
- 5.1 & 7.1, but better audio options than HD-DVD
- interactivity layer based on Java, spec not finalized

Similarities:

- both blue laser
- both do high def video in 720p, 1080p, 1080i
- both do MPEG-2, VC-1, and H.264 video
- both do 5.1 and 7.1 audio
- both can connect to Internet

High Def Disc Differences

- Blu-ray holds more - 25 vs 15 single layer, 50 vs 30 dual layer
- Blu-ray can do some high end audio formats that HD-DVD does not
- Blu-ray built into PS3, \$200 HD-DVD module for Xbox360 adds up to same \$600

Market Factors

- Stealth Blu-ray factor - 94% of Blu-ray players are in Sony's PS3 game system
- HD-DVD players much less expensive - Amazon has HD-DVD for \$309, Blu-ray for \$500+
- Studio support - both are supported by most, either just by some, Sony owned studio factor
- porn as a factor
- my advice to consumers - WAIT...or punt

Which format will win?

- Too early to tell
- Sony will hold on for dear life, but other studios will follow the money - and that's consumers
- HD-DVD players \$200 less expensive @ \$310
- both sides engaging in specsmanship - Sony sales #s, HD-DVD 51GB disc
- combo players not the answer - cost more than buying PS3 & HD-DVD player
- consumer experience - if same quality and different movies on both, why not the less costly?

lies, damn lies, and benchmarks....then specsmanship

My advice - either wait or get a cheap HD-DVD player, unless there's specific movies that you can't live without that are on Blu-ray...then get a PS3 if you're a gamer too

The new options - “those Interweb tubes”

- Two broad categories:
 - on your computer screen
 - on your TV

whether to be watched on the computer, or new options to watch on your TV, the Internet is becoming a viable source of content for consumers

On your computer

- For watching on your computer, two broad categories as well:
 - free stuff that looks bad
 - for-pay content that varies in price, quality, and accessibility

“Free stuff” sites

- YouTube is the unquestioned king
- started in 2005, acquired by Google
- they convert all submitted video to Flash
- they ALL have different submission formats, so just start with a high quality master and go from there
- Google Video failed to get much traction - probably because you submitted content and then they converted it and it took a day (or two) to get online - so be EASY

Paid Content online

- Here's some companies that pay for content online: Atom, Revver, TurnHere, Metacafe, CustomFlix, Brightcove, CurrentTV, Greencine, Blip.tv, Lulu Eefoof, etc. etc. etc....and most pay poorly
- source: Scott Kirsner's excellent blog, CinemaTech (cinematech.blogspot.com): <http://www.scottkirsner.com/webvid/gettingpaid.htm>

Paid Content Online

- Most companies offering money for putting content online don't pay very well and keep the lion's share of it
- They all have differing standards on submission guidelines and technology used
 - Flash, H.264, WM9, MPEG-2, etc.
- Good idea to have a general purpose compression program, like Compressor, Cleaner XL, etc. to handle wide range

“Real” movie downloads

- Many players, small to big:
GUBA, BitTorrent, Joost, Wal-Mart, Netflix,
ClickStar, Movielink, MovieLink, Microsoft
Xbox Video Marketplace, Vongo,
CinemaNow, Amazon Unbox, and Apple’s
iTunes Store

source: <http://cinematech.blogspot.com/2007/04/internet-movie-marketplaces-whos-most.html>

The Big Five:

- From anticipated smallest to biggest:

Microsoft Xbox 360 Video Marketplace

Vongo

CinemaNow

Amazon Unbox

iTunes Store

Xbox 360 Video Marketplace

- MS has sold more than 10M Xbox 360s
- SD & HD content
- Warners, Lionsgate, Paramount, new Line
- Rental only
- HD rental is \$6, SD is \$4
- since already connected to TV, watch there

source: <http://cinematech.blogspot.com/2007/04/internet-movie-marketplaces-whos-most.html>

Microsoft has sold more than 10 million of its Xbox 360 gaming consoles, as of December 2006. The video marketplace offers standard-def and high-def features from Warner Bros., Paramount, Lionsgate, and New Line. (As of April 2007, Xbox and CinemaNow are the only of these services offering movies in high-definition.) Rentals only; no download-to-own. High-def new release movies cost \$6, and standard-def new releases cost \$4. Since the gaming console is already connected to a TV, viewing on the big screen is a breeze.

Vongo

- “all you can eat” for \$9.99/month
- about 1000 movies of rotating stock
- works with various MS products: Media Center, Vista Ultimate, Xbox 360 for TV
- CAN play on Windows friendly portables
- Live streaming Starz channel
- Rental only, PC only

source: <http://cinematech.blogspot.com/2007/04/internet-movie-marketplaces-whos-most.html>

Vongo is unique in offering an “all you can eat” movie service for a dirt-cheap \$9.99 monthly fee. About 1000 movies are available at any given time, but some titles rotate in and out of inventory. Works with various Windows systems (Media Center Edition, Vista Ultimate, Xbox 360) to display content on a TV. Content can also be synced with Windows-friendly portable media players. Vongo also offers a live, streaming version of the Starz TV channel. Rental only, PC only.

CinemaNow

- in the market the longest, since '99
- download and burn to DVD
- > 100 titles, mostly older ones though
- does sell porn
- only service working w/all 6 major studios
- PC only, Win-friendly portables, MCE to TV

source: <http://cinematech.blogspot.com/2007/04/internet-movie-marketplaces-whos-most.html>

CinemaNow has been in the movie download business longer than most anybody else: since 1999. It helped pioneer technology to download a movie and then burn it to a DVD (more than 100 titles are now available, mostly older movies), and CinemaNow also hasn't been prudish about offering "mature content," working with porn providers like Vivid and Hustler. CinemaNow is the only service working with all six major Hollywood studios. Offers some movies for free, as ad-supported streams. Movies can get to TV with a Windows Media Center Edition PC, and to Windows-compatible portable players. PC only.

Amazon Unbox

- rent or buy, even directly to a TiVo (!!!)
- strong brand, probably already have your CC#
- recommendation engine
- indie content via CustomFlix for 50% revenue
- most of the major studios have content on it
- PC only, early complaints of bad user interface

source: <http://cinematech.blogspot.com/2007/04/internet-movie-marketplaces-whos-most.html>

Unlike iTunes, Amazon Unbox makes movies available for digital rental *and* purchase. Movies can be sent directly to an Internet-connected [TiVo device](#) for viewing on a TV. While Unbox hasn't yet built much momentum in the marketplace, Amazon has a built-in advantage over the other players on this list: hundreds of thousands of consumers already trust the company with their payment information, and have Amazon accounts already. Amazon can also make movie recommendations based on past purchases.

Indie producers can make their content available on Unbox using Amazon's [CustomFlix](#) service, and keep 50 percent of the revenues. That makes Unbox the most "long tail"-friendly movie service. Among the studios offering features: 20th Century Fox, Lionsgate, Universal, Paramount, Sony, MGM, and Warner Bros. Movies from Lionsgate, Sony, Warner Bros., and Fox. Works well with Windows-compatible portable devices like the Creative Zen Vision. PC only.

iTunes Store

- biggest player by far
- as of April already sold 50M TV shows and 2M movies
- new AppleTV works with wide & HDTVs
- decent TV show selection, but very limited movie selection
- computer, iPod, & AppleTV playback, Mac or PC, with super easy user interface

source: <http://cinematech.blogspot.com/2007/04/internet-movie-marketplaces-whos-most.html>

The big dog. Works for both Mac and PC users, and as of April 2007, had sold 50 million TV shows and two million feature films. New \$299 [Apple TV](#) device makes it easy to wirelessly transfer iTunes content to a television and view it there. The negatives: no rentals (only download-to-own, at \$9.99 and up), no way yet for indie producers to sell their content, no simple way to [burn shows or movies](#) from iTunes to a DVD. Also: only a few studios offer features on iTunes, including Disney, MGM, and Lionsgate. Paramount supplies older films -- not new releases. Others have so far been reluctant to cut deals with Apple CEO (and Disney board member) Steve Jobs.

AppleTV

- liked it enough I bought one
- essentially plays all your “authorized” iTunes content, as well as photos
- 33GB internal storage (can 3rd party more)
- video quality notably below DVD
- unit (barely) capable of HD content -
720p24 or 960x540 @24/25/30 fps
- pretty UI, but cumbersome for large libraries, and remote needs more buttons

On your TV

- Most likely there won't be serious adoption of Internet based premium content until there's an easy way to watch it on your TV
- ...and that is starting to happen. Two biggest ways - AppleTV and Xbox as a media extender
- Xbox offers better quality video, Apple offers easier experience, neither offer a great selection

One little thing...

DRM

...and there's one little thing...DRM – Digital Rights Management

DRM

- the idea is valid - don't let people rip off content the way CD & audio content is, protect content
- in execution however, it is massively too limiting - you:
 - can't watch content from most on TV
 - can't burn to DVD w/90% of these
 - can't watch on portable players most often
 - in general, can't wander out of their sandbox
- result is extremely limiting and frustrating for consumers

All adds up to...

- **F**ully
- **U**nrealistic
- **C**ontent
- **T**raps

you'll note that makes for a handy acronym...

The fix?

- Time
- Somebody's gotta relent
- Lotta money at stake, nobody wants to back down, everybody wants to own the market or process
- therefore, consumers getting hosed or driven away
- witness download DRM issues as well as the Blu-ray vs HD-DVD format war

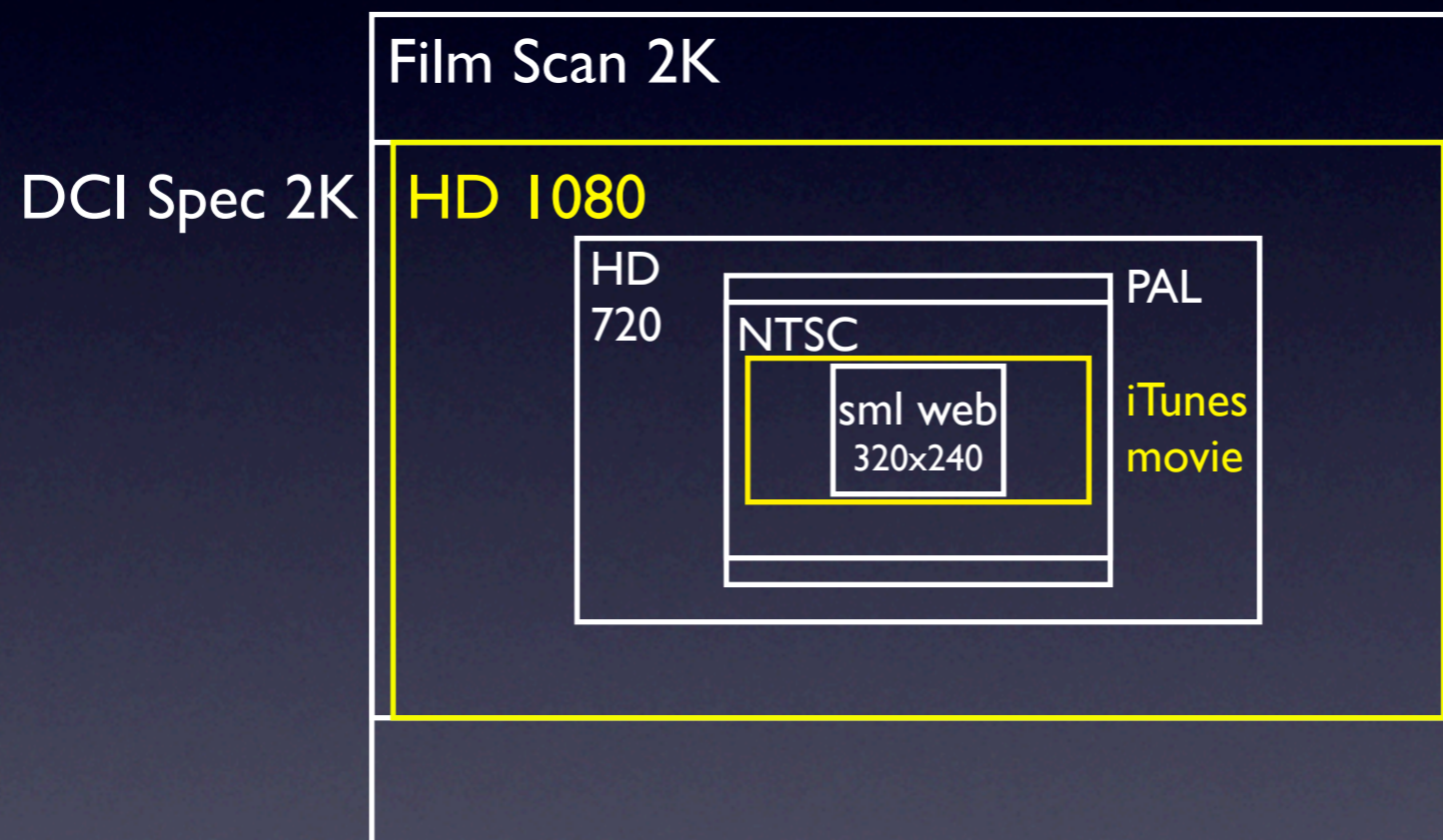
To review & sum up:

- the world of digital content is VERY wide
- many, MANY standards to keep track of
- difficult to keep track of yourself, find good resources to rely on
- we are, at least, getting closer to being able to acquire and post a single master to serve a variety of needs, or at least a master that serves the needs of all lesser deliverables
- start with deliverables and work way back

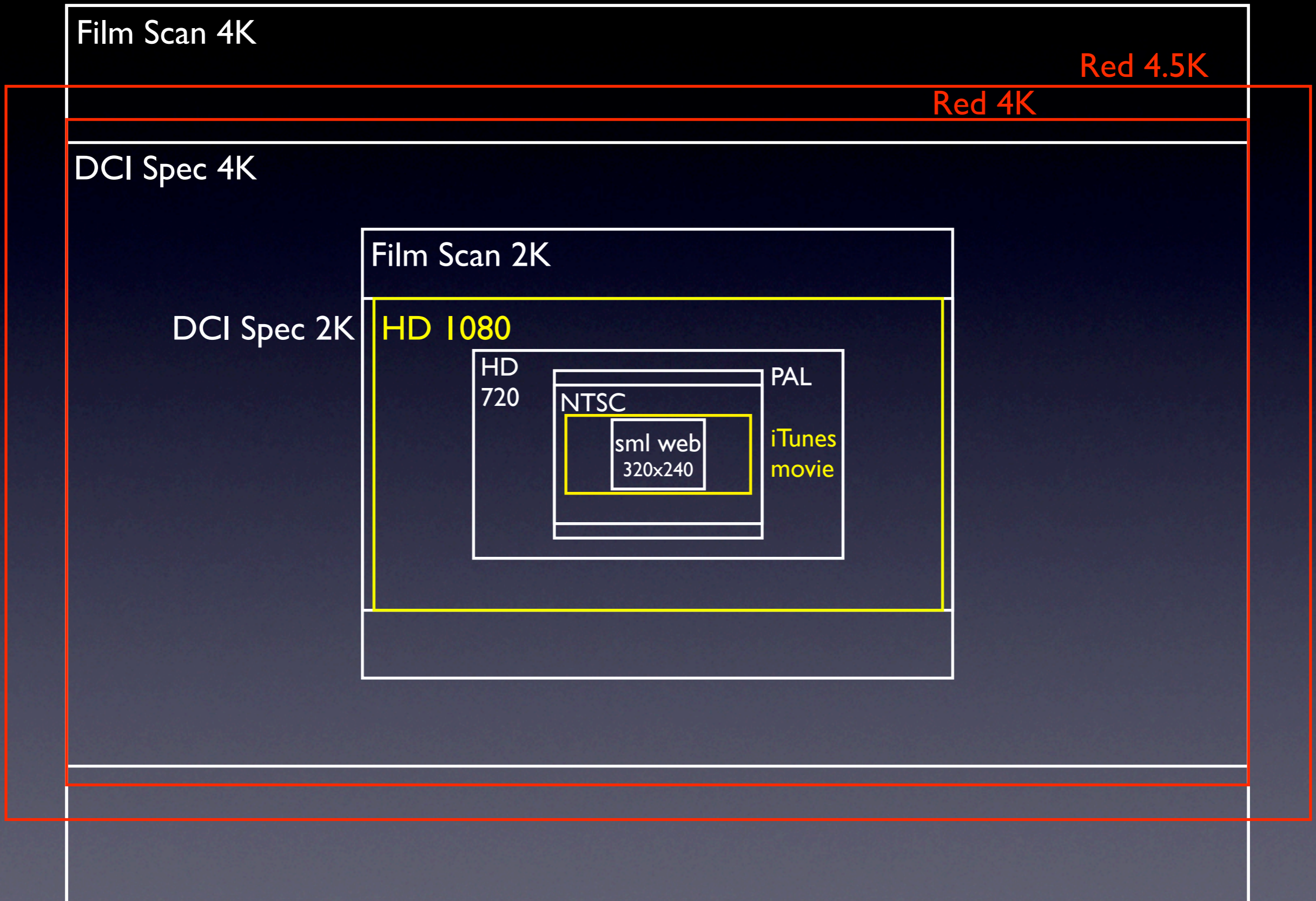
Format Resolutions: DI to YouTube

Film Scan 4K

DCI Spec 4K



Format Resolutions: where Red fits in



In closing....

- Thanks very much
- Please visit hdforindies.com for content creation info specific to HD
- the BEST place to keep up on digital delivery services and the business side of digital content distribution, especially on the web:
<http://www.cinemattech.blogspot.com>
- for more info on web video, buy his book, *The Future of Web Video*

Scott's book (ebook or Amazon.com) is the best, most up to date source I've found on the business side of

Fret not

- this entire presentation will be available on hdforindies.com in a day or two
(when I get a chance to post it as a PDF)