Bild: Rotor Film, Berlin Babelsberg

DCP-Mastering

Advanced LITE Workshop

Index (Page)

D-Cinema Server (Linux System, USB2)

CRU DX115 Carrier Interface with HDD

Open graphics

Myth-Busting

BluRay is experimental in Cinemas, needs its own projection system. Completely different formats:

BluRay	DCP
Home Cinema	**Cinema**
Optical Disc (may stutter)	HDD with Buffering
Differences by Brand	Specified/Standardised Hardware
1920x1080*, FHD (3D)	min. 1998x1080, 2K or 4K** (3D)
8 bits, 4:2:0	12 bits, 4:4:4
Lossy h264 compression	Lossless Wavelet J2K
Compressed Audio (single stream) (Dolby)-Audio Server may separate/ignores it	Uncompressed Audio (discreet Channels) (Dolby)-Audio Server understands
HDMI, 60i standard (Conforming needed)	HD-SDI truly Progressive
mostly 23,98/24p (*25p technically possible though)	24/48p IOP standard (SMPTE also 25/30 but still experimental)
RGB, rec709 Gamma 2.4	XYZ, P3 Gamma 2.6
Consumer media, functional	Quality matches archival master copy
Delay of spanned content, loading times	instant playback of Reels and Playlists

***** 4K BluRay uses the same specs, just higher resolution – Player/burner has to support it
****** 4K in Cinemas only distinguishable from 2K until row 8–> 2K still standard

COMMON DCP TOOLS COMPARED TO RESOLVE 15 STUDIO

ADDITIONAL TOOLS

	DCP-o-Matic	openDCP	Wraptor (lite)	easyDCP Creator	Resolve Studio	easyDCP Player	DCP Transfer
System	Win/Mac/Linux	Win/Mac/Linux	Win/Mac	Win/Mac	Win/Mac/Linux	Win/Mac (Trial)	Mac only
Price	free	free *(discontinued)*	Adobe CC (AME)	very expensive*	mid-range	very expensive*	subscription**
Speed* **	very slow	very slow	very fast	very fast	very fast	–	fast
Quality, FPS	very good, any	very good, any	very good, 24/25	great, any	great, any	hardware dependent	–
Potential Shifts	usually no	color/gamma	gamma	usually no	usually no	–	–
Syntax (playability)	full pass****	warnings/errors	warnings/errors	full pass****	full pass****	–	–
Input Formats	most	TIFF/J2K/DPX	most	most	most	DCP/Stills	DCP only
Interface	extended	simple	simple	professional	professional	professional	extended
Options, 4K	advanced, yes	basic, yes	limited, no (lite)	advanced, yes	advanced, yes	advanced, yes	–
Subtitles (soft)	SRT/XML	SMPTE XML only	–	SMPTE XML only	–	on/off/list	–
Audio	up to 7.1	up to 7.1	2.0/5.1	up to 7.1	up to 7.1	hardware dependent	–
Source Color	set manually	set manually	no options (auto)	set manually	set manually/LUTs	color simulations	–
Validation	*yes (in ext. Player)*	–	–	yes	–	yes *(also in trial)*	yes
Hash-Check	*yes (in ext. Player)*	–	–		–	yes *(also in trial)*	yes
EXT2 Clone	–	–	–	–	–	–	yes
Limitations	no color/gamma preview, limited prefs	no crop/refit, **dead,** subs buggy	2K, no 3D/encryption/ reels, 250mbit only	–	no reels, no encryption or subs	15s playback in trial only	drives up to 2TB for EXT2
Specials	Timeline, retime, versioning, subs, DCP **re-wrap**	re-pack possible, good title tool, reads MXF	Uses Adobe MediaEncoder***** pipeline & features	Timeline, versioning, subs, color/gamma preview, **reels**, re-wrap	new in v15: KAKADU J2K parallel to easyDCP	ProRes export (paid), **color-check**, audio tool	Paragon ExtFS included, inode size of 128KB

* also available as “Publisher” for FCP X with a **pay-as-you-go** model (about the same price as other online services, needs internet connection) - *expensive*
** monthly or yearly available, meaning 1 month (license deactivates after) or 1 year with the option to renew – *expensive*
*** depending on hardware configuration (GPU/CPU), **** interOP (24p) passes DCI validation as well as SMPTE (25p+)
***** also available for AME: **cuteDCP** (Win/Mac) – cheaper, professional options (color/gamma/subtitles/surround) but also syntax warnings

Preface

DCI Digital Cinema Initiatives, LLC

http://www.dcimovies.com
Latest Specs (**Errata**) and **certified** equipment*

How to set up a fully certified DCI system for playback and mastering:
http://www.dcimovies.com/compliance_test_plan/DCI_CTP_v12.pdf

STOP!

This is the **LITE** version of my e-book,
many chapters and topics are not included or restricted.

For the full instructions and content: Purchase the PRO version of the e-book *(also on Kindle)*

You can also **hire me** for 1on1 training or seminars **OR**
GET MY NEW COMPLETE ENGLISH ONLINE VIDEO COURSE
AND LEARN EVERYTHING IN 6 HOURS
⇓
www.sebastianleitner.com

* also note: http://www.cinemaequip.com

History Lesson

Year 2000: 15 digital cinemas in the US, 11 in Europe — showing MPEG2 content (first DCP-format)

In **2002**: Digital Cinema Initiatives, LLC (**DCI**) was founded by Metro-Goldwyn-Mayer (MGM), Paramount Pictures, Sony Pictures Entertainment, 20th Century Fox, Universal Studios, The Walt Disney Company, Warner Bros. und Lionsgate. They wanted to introduce a new global digital cinema standard.

Strict, uniform specifications set (creation and playback) –> **interOP standard is born**

They hoped for more people in theaters (yes, cinema started dying since VHS came out), quality control, easy handling and less piracy through closed systems and 128 bit encryption. Also: cost reduction.

First official DCP releases (Universal): “Serenity”, 2005 and “Inside Man”, 2006 — MGM leaves the DCI in 2005 for not believing in it even before they had set new specs.

They set all specs in the DCI regulations (“errata”) for creation and playback, as well as equipment in cinemas. Only sticking to those specs grants you the status “certified”.

2008-2012: Revision of DCI regulations (Errata 1.2) to add 3D and more FPS –> **SMPTE standard** (25p, 30p) which is still optional to date, certification without it is possible. Brand-dependent (firmware) features.

Cinema equipment only needs to meet the interOP definitions (DCI Errata 1.0), anything else is still considered “experimental” and “optional”. Pro DCPs are therefore mastered in those “legacy specs”.

Cinema is very slow (expensive equipment), only in 2017 the DCI issued first trials of 25/30p trailers.

Technicalities

The **safe** “legacy specs” (**interOP**) of DCI (2D) are the base values (**globally to date**):

Resolution: 2048×1080 (2K) at 24/48 fps or 4096×2160 (4K) at 24 fps

- In 2K, for Scope (2.39:1*) presentation, 2048×858 pixels of the image is used
- In 2K, for Flat (1.85:1) presentation, 1998×1080 pixels of the image is used

- In 4K, for Scope (2.39:1*) presentation, 4096×1716 pixels of the image is used
- In 4K, for Flat (1.85:1) presentation, 3996×2160 pixels of the image is used

Bit depth: 12 bits per color component (36 bit total) in 4:4:4 via dual HD-SDI (encrypted)
Color space: CIE XYZ, P3 (Gamma 2.6, **D63** white point = **6300K**)
Compression: JPEG 2000 (single picture per frame), 4.71 bits/pixel (2K @ 24 fps)
Image bit rate: variable, max (4K) of 250 Mbit/s (31 MB/s) – **stay under 200 (2K) for compatibility!**

Audio: 24 bits per sample, 48/96 kHz, up to 16 channels, broadcast WAV with uncompressed PCM (Surround channels need to be mapped accordingly –> cinema mix needed, e.g. Dolby-Curve)

Additionally for many festivals*: Minimum of 3 audio channels (L-R-C, 3.0 mix), un-encrypted (“open”), EXT2, usually IOP 24p, 1920x1080 (with Padding) allowed but not recommended (uneven borders).

Format	Resolution	Aspect Ratio	Pixels
DCI 2K (native resolution)	2048 × 1080	1.90:1 “Full frame”	2,2 MP
DCI 2K (flat cropped)	1998 × 1080	1.85:1 “Academy”	2,1MP
DCI 2K (CinemaScope cropped)	2048 × 858	2.39:1 “Scope”	1,7MP

aka 2,35:1 – actually 2,40:1

* **Official best practice recommendation about DCP at BERLINALE**: https://www.berlinale.de/media/pdf_word/service/ifb/DCP_Best_Practice.pdf

Synchronicity

Picture and sound are separate files (containers). Audio channels are played back parallel to an image sequence. To avoid running out of sync, metadata and special header information needed:

Audio: Indication of first sample of audio data, relative and total frame count, sample rate
Image: Frame count number (duration), frame rate, resolution and aspect ratio

Both streams feature a “unique ID”, a clear reference, used by a map file called VOLINDEX.

Audio metadata also includes the global specs for channel mapping. E.g. for 5.1: **L-R-C-LFE-Ls-Rs**

Digital Cinema Package (DCP)

Not a single file or stream but a set of assets for picture, sound, subtitles and metadata.
MXF for audio/video and **XML** for index and subtitle files, following SMPTE-TT specs.

Sometimes the content is split into **reels** (of arbitrary length), depending on the post-production process.
The “**asset map**” lists all content (+ reels) as kind of a map, VOLINDEX defines the order of assets.

Note: All those files are important for cinema playback and form the DCP together, do not interfere.

The “**package list**” file (PKL) includes generated **hash values**. The cinema server checks if a DCP has been altered or damaged using those. E.g. corruption due to unsuitable copy process (–> cloning).

Optional: DCPs can be encrypted (128 bits) and the cinema server needs a “master key” to play.

```
<?xml version="1.0" encoding="UTF-8"?>
<AssetMap xmlns="http://www.digicine.com/PROTO-ASDCP-AM-20040311#" xmlns:xsi
www.digicine.com/PROTO-ASDCP-AM-20040311# asset_map.xsd">
  <Id>urn:uuid:bb191251-b7cd-4322-88d1-641544de5da3</Id>
  <VolumeCount>1</VolumeCount>
  <IssueDate>2018-08-12T13:21:07+02:00</IssueDate>
  <Issuer>SLFILM</Issuer>
  <Creator>easyDCP</Creator>
  <AssetList>
    <Asset>
      <Id>urn:uuid:1fcbf0ea-975b-4f05-b0bb-a33857bb1f2b</Id>
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        <Chunk>
          <Path>CPL_1fcbf0ea-975b-4f05-b0bb-a33857bb1f2b.xml</Path>
        </Chunk>
      </ChunkList>
    </Asset>
    <Asset>
      <Id>urn:uuid:69ea9186-8b68-4ed0-9fe2-fcb517febf30</Id>
      <PackingList/>
      <ChunkList>
        <Chunk>
          <Path>PKL_69ea9186-8b68-4ed0-9fe2-fcb517febf30.xml</Path>
        </Chunk>
      </ChunkList>
    </Asset>
    <Asset>
      <Id>urn:uuid:ac605839-0f1e-448a-b5e8-28bb48d6f6ef</Id>
      <ChunkList>
        <Chunk>
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        </Chunk>
      </ChunkList>
    </Asset>
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        <Chunk>
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        </Chunk>
      </ChunkList>
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  </AssetList>
</AssetMap>
<!--Created by Fraunhofer DCP API Version 1.0.301-->
```

Asset Map

```
<?xml version="1.0" encoding="UTF-8"?>
<PackingList xmlns="http://www.digicine.com/PROTO-ASDCP-PKL-20040311#" xmlns:xsi="http://
xsi:schemaLocation="http://www.digicine.com/PROTO-ASDCP-PKL-20040311# PackingList.xsd">
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  <AnnotationText>SkodaArrow</AnnotationText>
  <IssueDate>2018-08-12T13:21:07+02:00</IssueDate>
  <Issuer>SLFILM</Issuer>
  <Creator>easyDCP</Creator>
  <AssetList>
    <Asset>
      <Id>urn:uuid:1fcbf0ea-975b-4f05-b0bb-a33857bb1f2b</Id>
      <AnnotationText>SkodaArrow_ADV_S-239_51_2K_20180812_IOP</AnnotationText>
      <Hash>m8DsZFdhWAIAbUNkdSp5Jj+X3ow=</Hash>
      <Size>10669</Size>
      <Type>text/xml;asdcpKind=CPL</Type>
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    </Asset>
    <Asset>
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      <AnnotationText>id_6571367.8600024108</AnnotationText>
      <Hash>px7kTUE9kGrBOE91/yfhq5aZpmg=</Hash>
      <Size>352661681</Size>
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      <Hash>P11RvjmsrIsSCdgsVjymIafKhf0=</Hash>
      <Size>39638694</Size>
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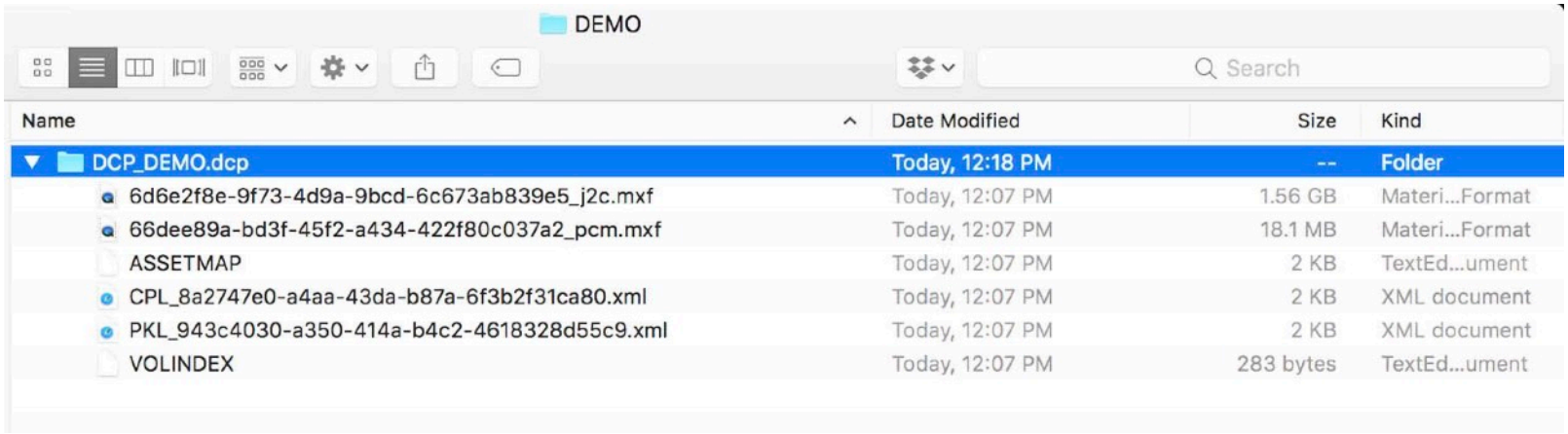
PKL



CPL

```
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<CompositionPlaylist xmlns="http://www.digicine.com/PROTO-ASDCP-CPL-20040511#">
  <Id>urn:uuid:1fcbf0ea-975b-4f05-b0bb-a33857bb1f2b</Id>
  <AnnotationText>SkodaArrow_ADV_S-239_51_2K_20180812_IOP</AnnotationText>
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  <Issuer>SLFILM</Issuer>
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          <IntrinsicDuration>1100</IntrinsicDuration>
          <EntryPoint>0</EntryPoint>
          <Duration>1100</Duration>
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        <MainSound>
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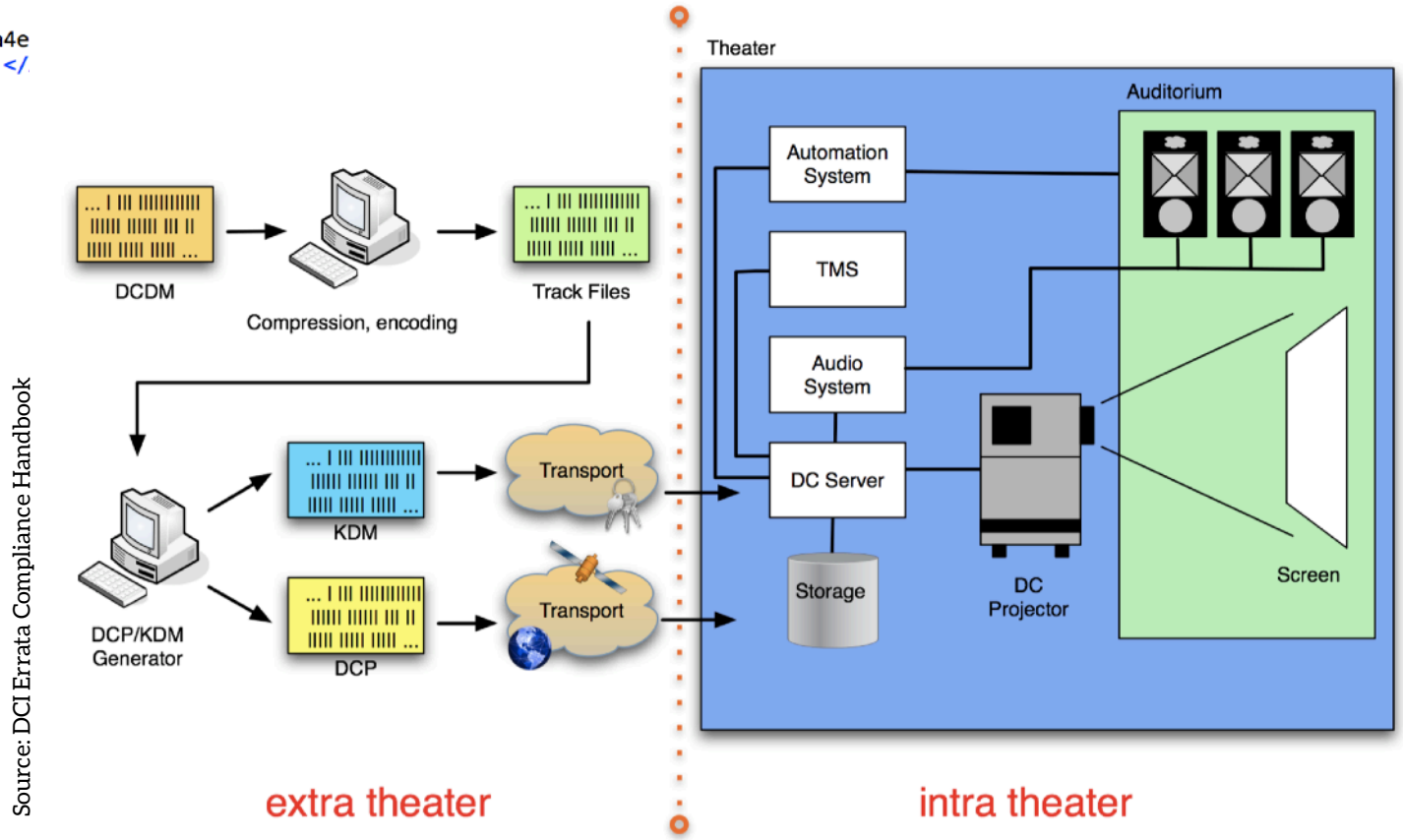


Source: DCI Errata Compliance Handbook

SMPTE

It defines technical specifications of a DCP, on the other hand it's used for naming the "new" DCI regulations of 2008, which allow for more FPS values (internationally not binding):

24, 25, 30, 48, 50, 60 fps @ 2K — 24, 25, 30 fps @ 4K

Depending on brand, type and firmware version of the cinema server, SMPTE might not be supported. **Professional DCPs are always interOP to guarantee global compliance and 100% playability.**

Subtitles

SMPTE also defines the subtitle standard (a cinema server decides on formatting) **even when interOP:** CineCanvas XML is a strict standard and aka DLP Texas Instruments in **UTF-8**:

```
<SubtitleID>97fd79ed-b2ff-468c-b11f-1a3792fc90dc</SubtitleID>
<MovieTitle>Example Movie Title</MovieTitle>
<ReelNumber>1</ReelNumber><Language>English</Language>
<LoadFont Id="arial" URI="arial.ttf"/>
<Font Id="arial" Color="FFFFFFFF" Effect="shadow" EffectColor="FF000000" Size="42">

    <Subtitle SpotNumber="1" TimeIn="00:00:00:000" TimeOut="00:00:07:000" FadeUpTime="2" FadeDownTime="2">
    <Text HAlign="center" VAlign="bottom" VPosition="10.00">Example Subtitle Text One with LoadFont.</Text>
    </Subtitle> (…)
```

More about CineCanvas subtitles and UTF-8 packaging: http://www.knuterikevensen.com/?p=573

D-Cinema Server

A cinema server is based on **Linux**. Only certified DLP projectors accepted: *Nec, Barco, Christie, Sony.* Usually only **CRU Dataport DX115** interface available for an **Ext2** Filesysteme (**inode size 128KB**) or alternatively data fed via **USB2** oder **eSata** (external power needed). NTFS, USB3 only on few models.

100% DCI conformity only if delivered as CRU on Ext2! Alternatively: eSata + USB2 power with 2.5” HDD

It’s a closed system, only minimal manual control possible: Audio levels, Delay (2 ms = 4 frames) and projector adjustments are measured and set once a year. Firmware updates are not always free –> many small cinemas don't have it and only support the legacy specs with minimal “wiggle room”.

Human Readable Information (HRI)

A DCP identifies itself **only** through an “attribute tag” in all metadata assets, aka “composition name”: *Title_Kind-FPS_Ratio_Language-Subs_Sound_Resolution_Date_Standard_Version*

NAME_FTR-24_F_DE-XX_51_2K_20141130_IOP (use the **Title Tool** and always refer to the whole set) Wraptor (Adobe) does not have it for instance, Filename = DCP Name –> un-professional.

You should also use this composition name for “reference/attribute” and the final folder name!

J2k compression (JPEG 2000)

Open source **Wavelet**–Library on Linux which is only party available (and outdated) on Win/Mac. Pricey licenses needed for accuracy and high speed conversion. No realtime playback of XYZ P3 –> rec709.

Prerequisites

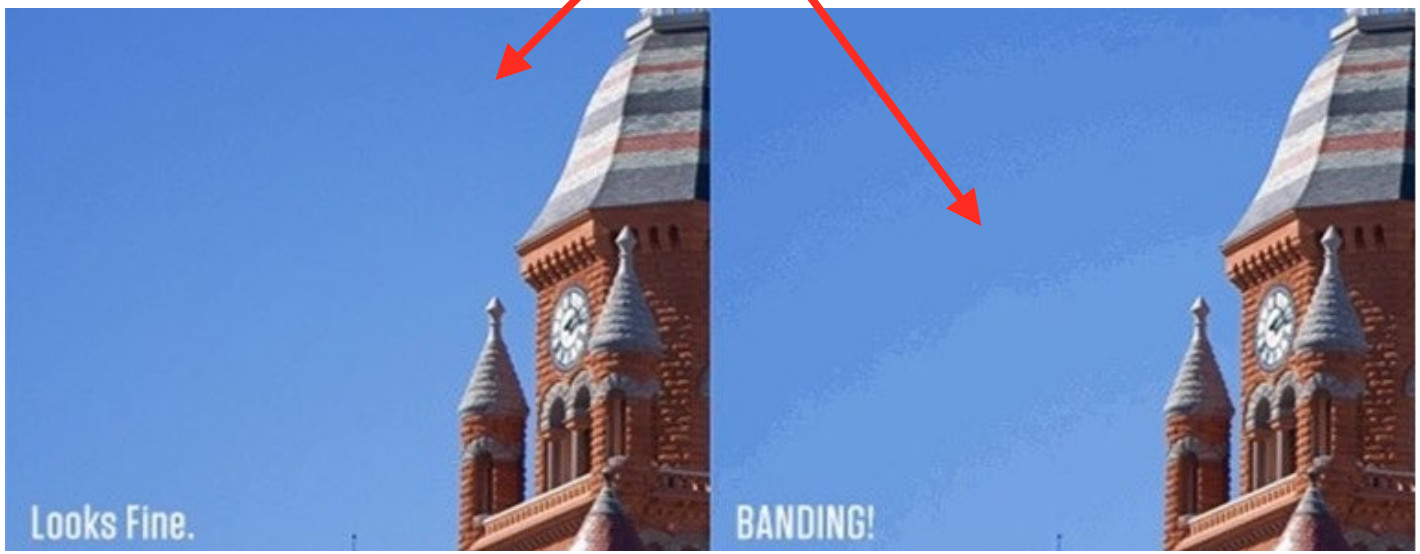
HQ master export at least in FHD and an industry standard (MOV/**MXF*** container):
ProRes, DNxHR*, **CineForm** (12 bits), **TIFF** (16 bits) or **DPX** Sequenz (LOG)

10 bits in 4:2:2 **chroma subsampling** recommended – **24p**, surround or 3.0 cinema mix, 120+ Mbit/s
Force Premiere/Avid to output HQ: “Render at Maximum Depth” and “Max Render Quality” *

Color Information

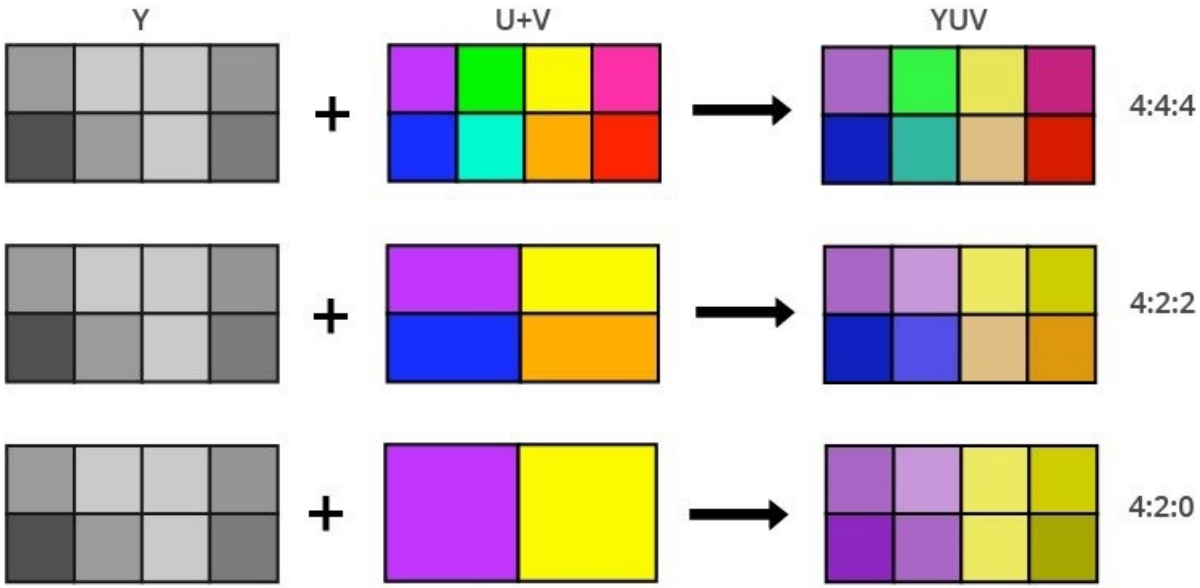
Your screen has to support 10 bits per channel as well!

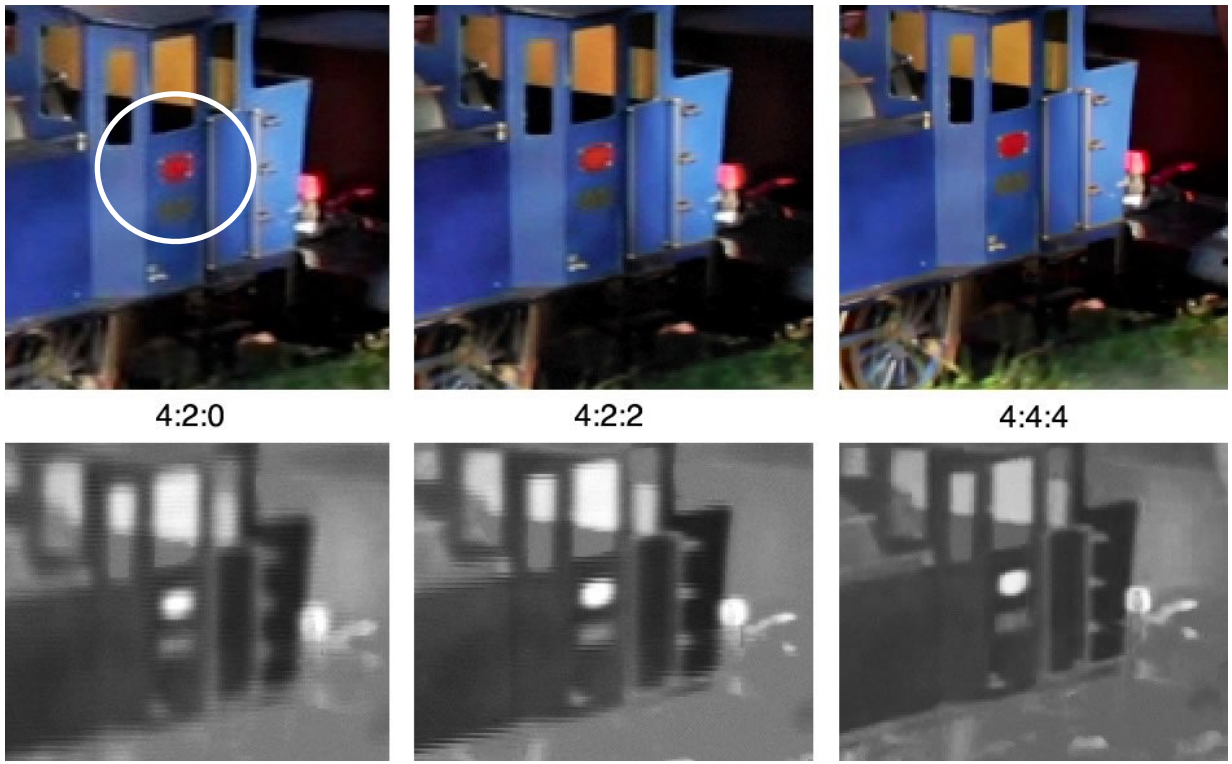
Color increments (**2^8 = 256 increents per color, 2^{10} = 1024**)
comparable to audio: 16bit/24bit: sound level increments



Source: wikipedia.org

* Internal render engines and color management: http://jonnyelwyn.co.uk/film-and-video-editing/colour-management-for-editors





Quelle: wikipedia.org

Chroma Subsampling

schematic, $Y'C_bC_r$ aka YUV

Y … Luma (Luminance = Brightness)
U+V … blue/red parts of light spectrum

realistic chroma subsampling
–> **influences sharpness** (color edges)

Example: Apple ProRes

Most used industry format (recording and processing) up to 8K, introduced 2007.

Lossy (422) 30:1 or lossless (4444) compression. New: ProRes RAW (hybrid).

Intra-Frame: Fast encoding/decoding, proprietary codec (macOS).

Automatic color space (gamma) adaptation under macOS via header flags (metadata)*

Native color matrix: YUV ($Y'C_bC_r$) – old analogue algorithm, in 10bit, white point **D65 = 6500K**

HDTV recorded in rec.709 gamma 2.4 “legal range”, but OS/screens are sRGB gamma 2.2 “full range”

variable bitrate: different max. values (e.g. at 1920x1080, 24p):

4444	HQ	422	LT	Proxy
264 Mbit/s	176 Mbit/s	117 Mbit/s	82 Mbit/s	36 Mbit/s

Cinema is: 12 bits per color, 4:4:4, color space XYZ P3 (**gamma 2.6**, more colors and white point **D63**)
“Gamma” describes the possible luminance levels between black/white –> brightness increments

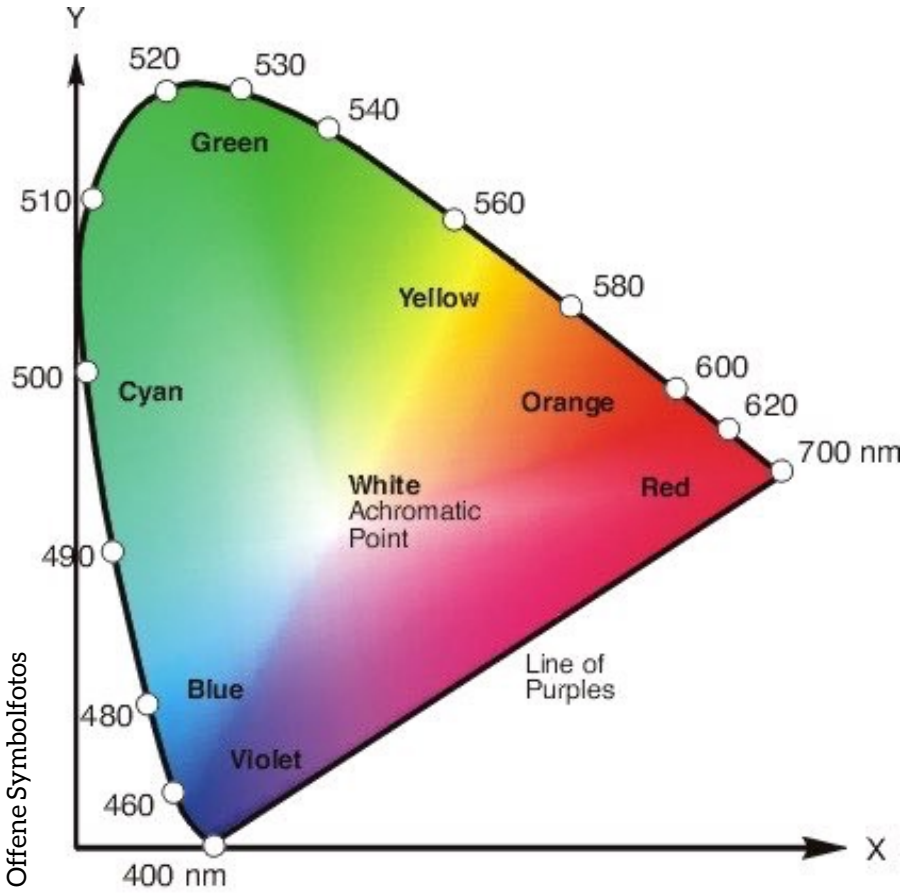
Windows: Use (GoPro) **Cineform** (Adobe, Resolve), especially for exchanging with macOS –> avoids gamma shift (also: DNxHD as **MXF**) and is RGB 12 bits Wavelet compression, nearly lossless

Overview of Intermediate Codecs (DNx, ProRes, Cineform): https://blog.frame.io/2017/02/13/50-intermediate-codecs-compared

Color Spaces

Define which colors can be recorded or shown. Bitdepth defines how many of them are available.
Usually only a small percentage of what the human eye can actually see (physical limit for technology).

Reference: Full spectrum of light (wavelength –> color) the human eye can see, aka **CIE XYZ** diagram.



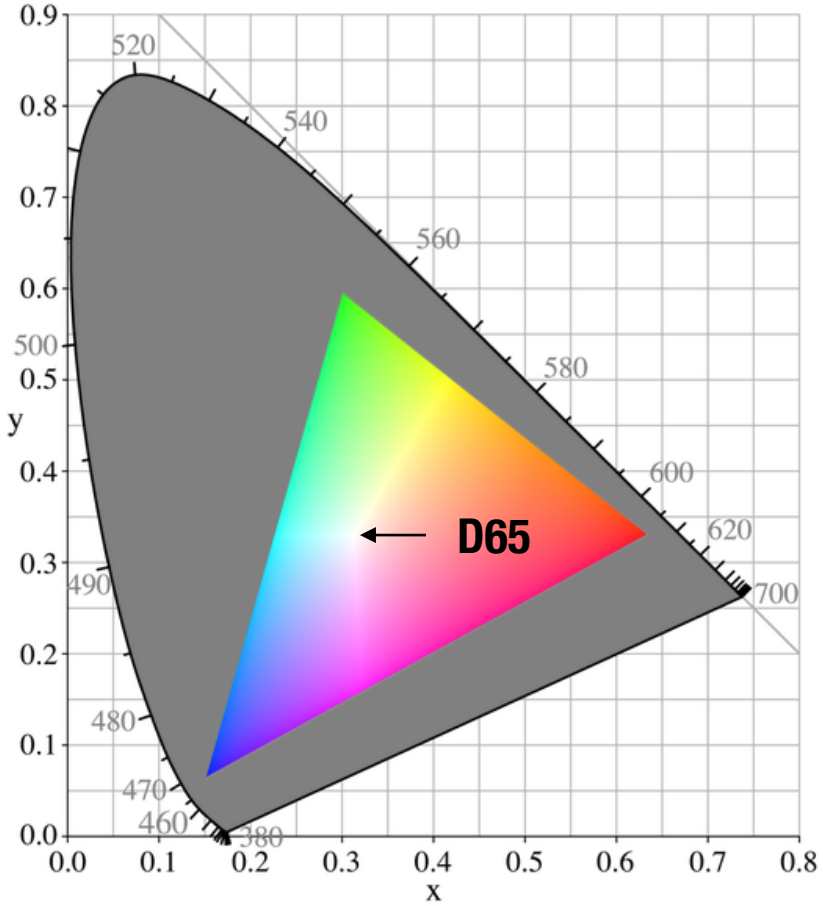
Offene Symbolfotos

- Cut through 3D at 50% brightness
- XYZ = spatial axis (2D –> Z ignored)
- already defined in 1931
- additive color mixing (sum of all colors = white)
- the more of this is covered the better the color space

Digital screen mix all colors from 3 primary colors (RGB):
The “extremest” colors, recorded or displayed by a device become the corner points.

If those corner points are connected you get the so-called **Gamut** (edges are color limits):
This way color spaces can be visualised as smaller triangles in the CIE for comparison.

A luminance response curve is defined per device and gives a rough understanding of display quality.

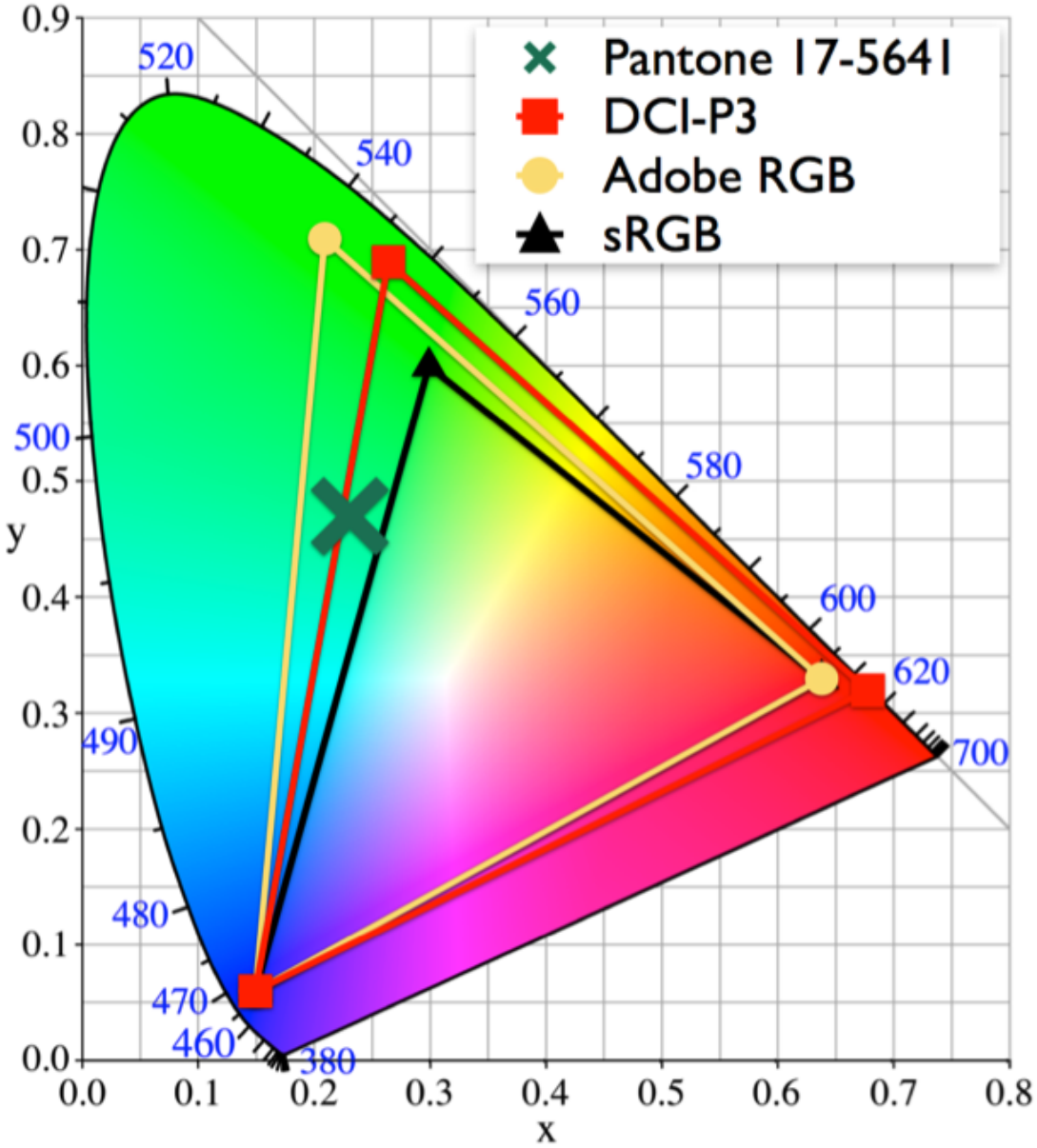


sRGB (rec.709) as a sub color space of CIE

White point at D65 (white Xenon light of a 35mm projectors)
DCI P3 defines it at D63 –> shift/transformation needed

Offene Symbolfotos

page in LITE version not available



Offene Symbolfotos

sRGB and DCI P3 compared
more greens (which regards contrast)

“Pantone” (Emerald) as reference value, which is not covered by sRGB (“super green”)

Adobe RGB makes sense for cinema, if your hardware (incl. camera) supports it!

rec709 VS sRGB

Use same primary colors, but usually different gamma (sRGB **g2.2** vs. HDTV rec709 **g2.4** –> 0.2 = **20%**)
Color space independent from bit depth (down-conversion possible, e.g. 10 –> 8, otherwise **Dithering***)

rec709 is smallest HD color space, every device has do be able to display/record it. Set as HDTV standard (D65) at gamma 2.35, following EBU/IBU (analogue CRT screens): Colloquial: “2.4”

Note: **rec709 features gamma 2.4 (HDTV standard) but web/OS/screens use 2.2 (sRGB)**

Legal (“video”, TV) and **Full** (“data”, raw) **Range** (“levels”) have nothing to do with gamma, but are often mistaken for a gamma-shift due to their similarities. Range defines min/max values of blacks/whites (luminance) – often the problem is wrong classification of levels and not gamma (“QT bug”).

S-Gamut3.Cine and Rec.2020

Gamut3.Cine by Sony’s FS7/F5: Enlarged DCI-P3 color space, even featuring colors beyond the limits of human perception. The reason being simple computational algorithms to convert to P3 without shifting colors. Instead colors get multiplied by a constant smaller than 1 only. Use it if possible.

Future: Rec.2020 for 4K displays and projectors. DCI-P3 successor but needs laser projectors (expensive and cinema evolution is slow). Until then use rec.709 g2.4 or P3 g2.6 in mastering depending on your monitoring capabilities.

* missing information interpolated (screens, NLEs, images but not in players): https://en.wikipedia.org/wiki/Dither

rec.2020 overview

page in LITE version not available

Example:

EIZO CS2730 Graphic Wide-Gamut 2560x1440 (16:9), 27”, 10 bits RGB
calibrated by factory-default + Software included

Color Space Coverage	
Adobe RGB	99,5 %
sRGB/rec709	100 %
DCI-P3	98 %

Buy it: https://amzn.to/2ookMvX –> *Calibrator*: https://amzn.to/2N9zoxn
Alternative **BenQ**: https://amzn.to/2PRBTTo or https://amzn.to/2Zvds6w
Cheapest professional Monitor by **AOC**: https://amzn.to/34mdyMJ

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white point/color cast: Is your display correctly set up for your work environment?

Apple iMac 4K/5K (or Retina Cinema Display) also features 10 bits P3 factory-calibrated. macOS knows about its luminance response curve, offers gamma/white point configuration.

Buy it: https://amzn.to/2PTHYyD

Important: NLEs and Resolve ignore display color profile in the viewer (as does VLC). **Windows**: Note NVIDIA settings*, use professional Player –> Browser plugins problematic

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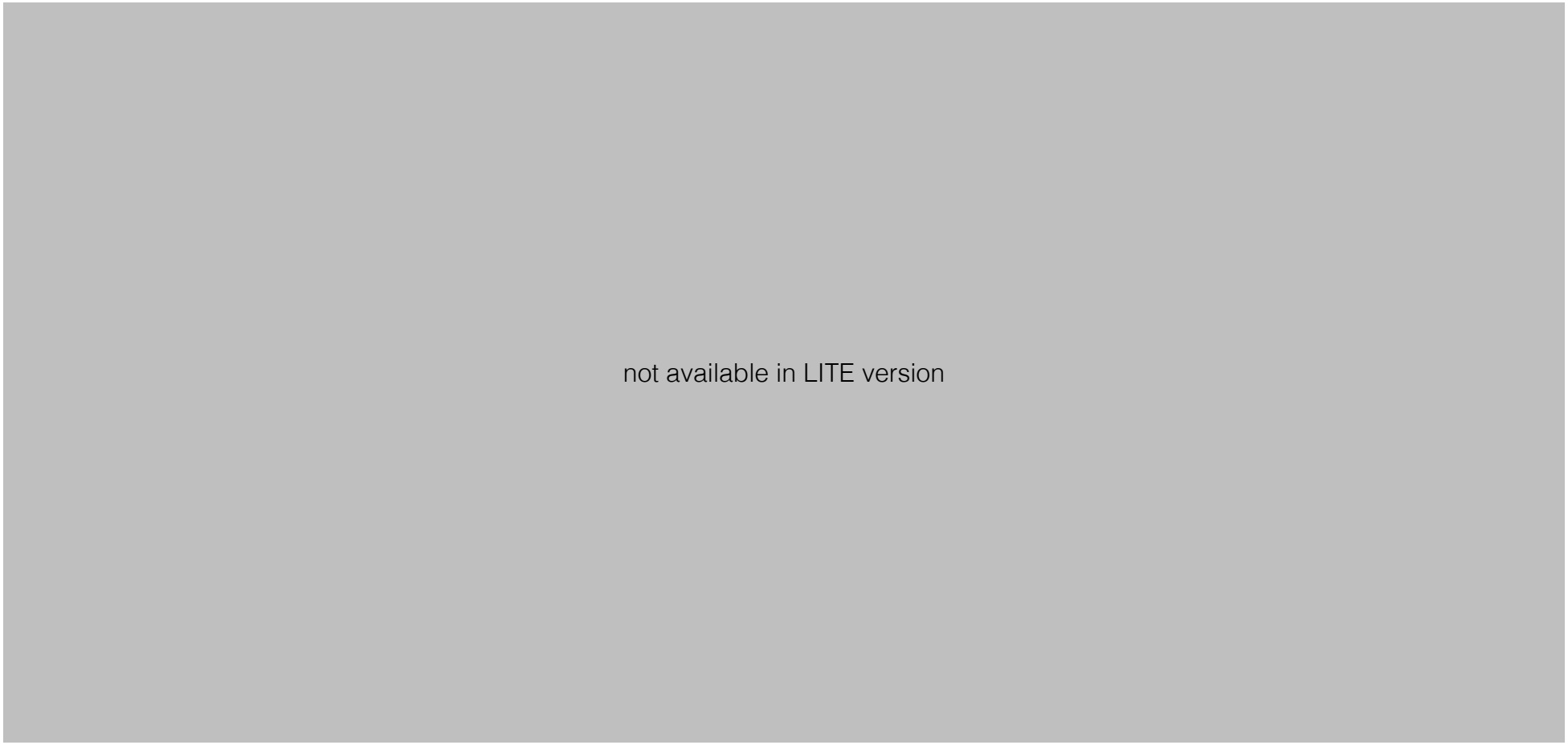
Monitor tests incl. color space-coverage: http://www.prad.de/new/monitore/testberichte.html
* Windows graphics settings: http://ntown.at/2016/07/03/how-to-set-youtube-or-vimeo-dynamic-range/

Cinema Mastering in Resolve Studio

Most screens are 8 bits in rec.709, professional devices offer 10 bits in P3 or Adobe RGB. Cinema: P3 Xenon projector in D63 (displays are D65 and use different luminance curve –> **Calibration** crucial).

Project Settings set to DCI (Scope/Flat) –> import **master file** (note “prerequisites”, page 13) –> create new timeline with it –> if needed conform to DCI specs within Resolve (FPS, resolution)



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Davinci Resolve 15+ features DCP-mastering using KAKADU J2K library in addition to expensive easyDCP – similar speed and quality!

Important: KAKADU is available in STUDIO version only.
Only „cheap“ **alternative**: Media Encoder's WRAPTOR (outdated, unsafe) together with DCP-o-matic to fix the syntax (re-wrapt without re-encoding: https://dcpomatic.com/manual/html/ch05s03.html

Master file in media pool, **right click –> "New Timeline"**
Under **"Delivery"** select the new DCP option even without an easyDCP license in IOP (24p only!) or SMPTE. Don't forget about the audio tab!

No closed captions with KAKADU (easyDCP only) though. Resolve takes **SRT** and can burn it in (load them into the media pool, add them to the timeline on a subtitle track).

Title Tool important (see **APPENDIX**), "composition name" should also be set for folder.

Resolves transforms color and gamma space automatically, no need for manual intervention –> preview during export

–> You can re-import a finished DCP just like any other video file to do a quick color and gamma check-up (estimated, does not replace QC!)

Audio

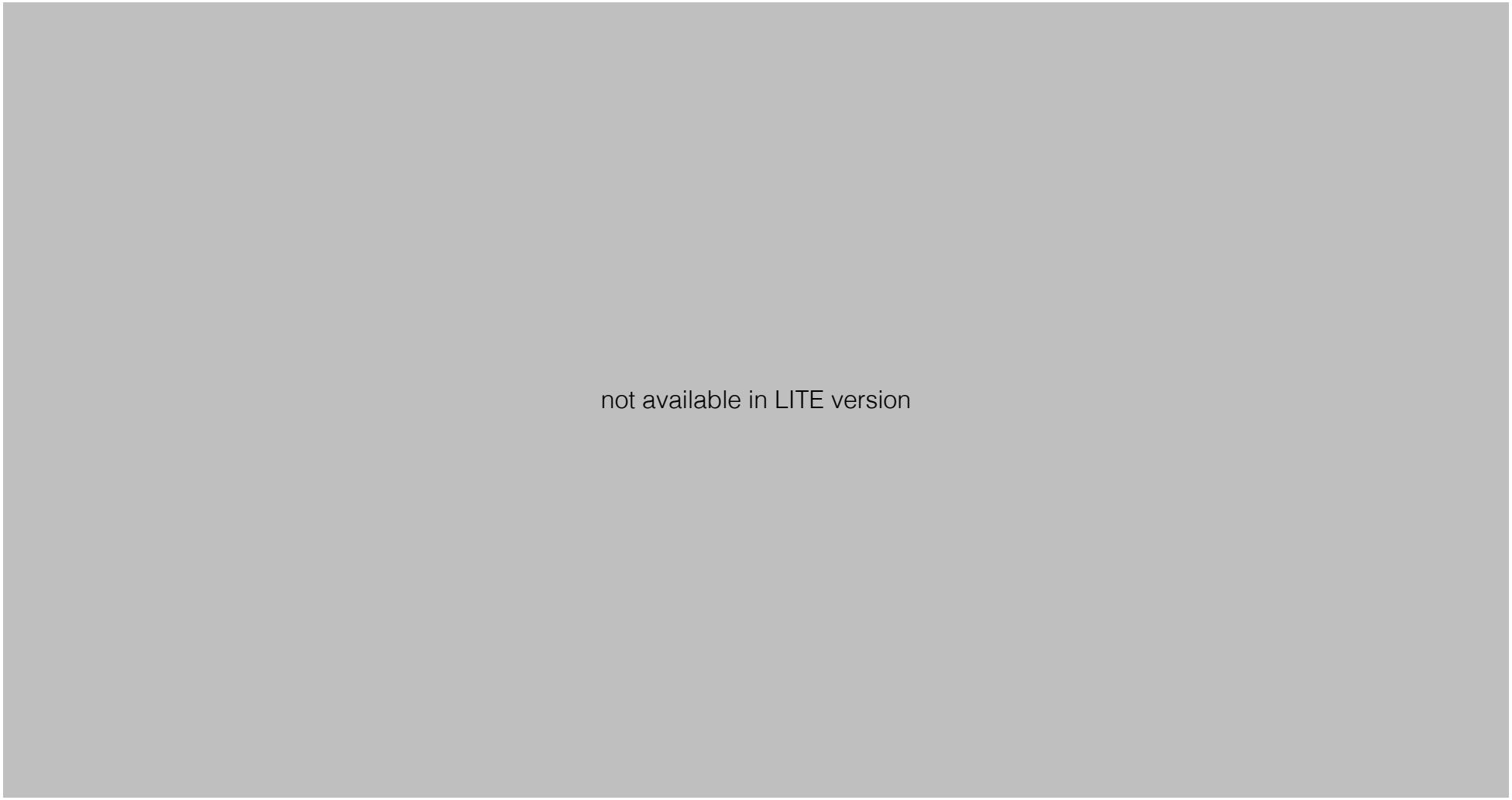
If master clip is already surround –> no further steps
A new timeline will already switch to it!

*Under "**Delivery**" choose "Timeline 5.1" as track format in 5.1*

If audio is added as separate mono files, channel mapping **L-R-C-LFE-Ls-Rs** for **tracks 1-6** respectively

If **FPS conforming** needed (25 –> 24, page 32), retime added audio by 4% (speed change)

If you want to take mixing actions: Menu “Fairlight” –> 5.1 setup, connect/group tracks –> **Audio meters are now surround**



Easier: Go to **“Delivery”**, configure mapping under tab “audio”.
Requirement: You already have a cinema mix (sound studio/engineer)
–> fastest way for discreet channels, also for 7.1 (8 tracks)!

Stereo should be treated as surround, empty channels will have silence added!
Better: 3.0 treated as 5.1 with dialogue on mono center track (3), music+FX on L, R (1, 2)

R128, aka: -23 LUFS for cinema fine, but not meant for features. Standard: **82 db leq(m)**
Use full dynamics, mix audio from -30 db to -12 or even -6 db (maximum)

ISDCF: „How Loud is a Movie? Measurement Methods“: https://isdcf.com/papers/...

Dolby handbook: http://www.idea2ic.com/Manuals/dolbySuround.pdf
Details for surround mixing: http://www.thebeachhousestudios.com/mixing...
Also note: https://www.cinemasound.com/surround-mixing-free/

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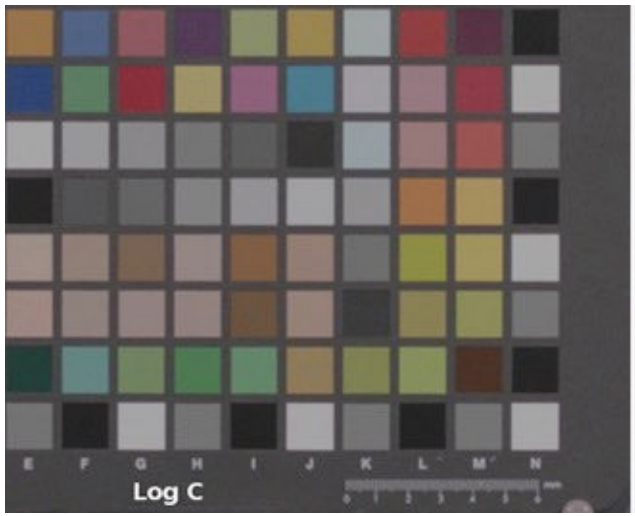
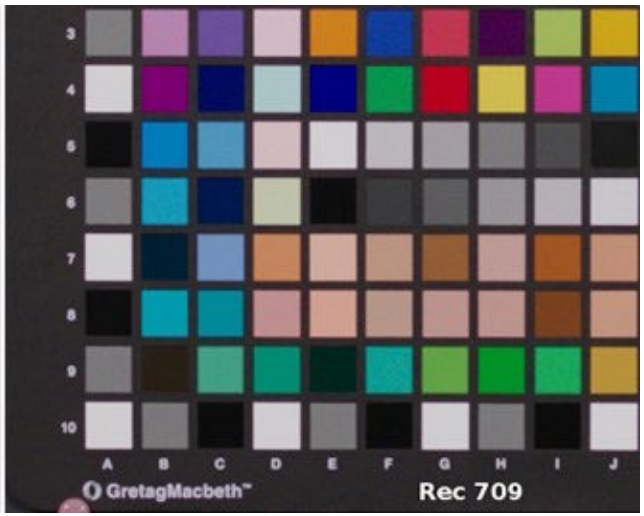
Log

Some cameras (Arri, RED,…) offer **log**arithmic formats (color values): **8 bit LOG means 12 bit linear**
Does not concern color space, just color information. LUTs are meant for preview only, transformation needed: Use interpretation algorithm for DCI-P3. Potential exchange formats include DPX, DNG, EXR





Offene Symbolfotos

rec.709: “What you see is what you get”

LOG offers more flexibility

LUTs simulate rec.709 in real time but do not fully conform color space (**LEGAL RANGE**)

Gamma Transformation

g2.2 for bright work environments (OS-native, office, living room,…) –> sRGB for web and PC

g2.4 for dark environments (and high-performance LED screens, studios,…) –> rec.709 (g2.35 HDTV)

g2.6 for “black” environments like cinemas, full dynamic range –> g2.2 and g2.4 too “soft” in cinemas

Optimise your working environment, calibrate gamma for it and keep it consistent. Don’t adjust gamma for target outlet but your studio! If you do not own a professional monitoring system, work in g2.2 only, **brighten up the room, calibrate screen**. Don’t change graphics card settings (only simulated via LUT).

Buy a **calibrator**: https://amzn.to/2N9zoxn *(same built as a Spyder, use freeware for any display)*

Gamma and color space have to fit **your** work environment, for other target environments transform gamma/color space as a last mastering step. Most apps ignore your display profile anyway –> professional displays offer hardware controls (knobs/buttons) to set it up and a special calibrator (EIZO).

Unique feature of **DaVinci Resolve**: Input, output & timeline gamma parameters are adjustable in project settings. Standard value is rec.709 g2.4 for timeline only, input/output is switched off – if unsure, don’t change it but it assumes you are in a dark room (see above) with the right calibrated display profile.

- **Beginner**: Use rec.709 **g2.2** only (= sRGB), crush blacks a little –> “What you see is what you get” is a safe way because all your devices and systems are g2.2 (sRGB)
- **Pro**: Project Settings –> Color Management –> Color Science –> “Color managed” and set values for In/Out/Timeline manually if known. This offers the most sophisticated workflow.

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Legal vs. Full Range

aka: video vs. data levels – has nothing to do with gamma, only shifts black/white points and not the transitions in between (mids). It's **codec/format dependent!**

Source: LightIllusion.com

Depending on position in processing chain, output may appear brighter/darker – display expects legal, but gets fed full or vice versa. Also software can mis-interpret signals. TV screens are legal, computer screens full range. Keep this in mind when buying, **gamma changable via LUTs (display profiles).**

After a certain point (value) absolute black or white are achieved, no further increments of greys. Scale shifted, information not lost! Signal can be stretched (legal –> full) or compressed (full –> legal aka. "Broadcast Safe", *caution for the latter: Information cropped!*)

Example: TIFF, ProRes 4444: **FULL** — h264, ProRes 422: **LEGAL**

In 98% of cases LEGAL is the right/better choice (depending on source and processing format). Usually software knows which formats use legal or full range and handle it correctly. Adobe tends to fail though.

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Frame Rate Conforming

Deinterlacing: Interlaced (“i”) to progressive (“p”) introduces loss of sharpness (motion blur).
24p have always been conformed “lossy” to 60i (Cinema –>DVD, TV) via **3:2 Pulldown*** with “judder”
LED/LCD screens work natively in 60Hz (HDMI standard 60i) –> 25p stutters, 24p/30p smoother

No NTSC/PAL anymore (was also referring to resolution), often incorrectly used for describing FPS.
General opinion: Ex-countries, which either used PAL (50i) or NTSC (59,98i).

- **USA**: Now 23,98p as BluRay and HDTV standard, often also 29,98p (ex-NTSC countries)

Lossless conforming 24p <–> 23,98 by **0,1% speed change** (also sound, neglect-able pitch shift)

- **Europe**: HDTV in 25p/50i (ex-PAL countries), also 23,98p for BluRay (or 24p, if player supports it)

Lossless conforming 25p <–> 24p by **4% Speed Change** (audio pitch shift of 0,7 half tones noticeable)

–> **Pitch correction** recommended, takes place automatically in FCP X and Resolve v14 or higher
“CinemaTools” built into FCP X*, e.g. ProRes speed change without render solely by header adjustments
(“Floor” setting). **Note**: Timecode changes –> subtitles/audio in sync? (**fps VS milliseconds**)

Rate **conversion:** No speed change, same length by **interpolation** (artificial frames added), e.g. 24 to 30
Quality of computed frames depends on algorithm used. Be careful with it!

E.g. **DaVinci Resolve**: Frame rate interpreted via “Clip Attributes” –>
Similar to Premiere and Avid (new timebase/timecode!)

FCP X: Add to new project with fps manually set, “Floor” on automatically.

*** Details**: https://documentation.apple.com/en/cinematools/usermanual/index.html#chapter=2%26section=5%26tasks=true

Quality Control

Only use IOP packaging, e.g. in DCP-o-Matic (syntax OK), **New:** Resolve 15 (lite)*, better & faster.
Also open, unencrypted DCPs should be “signed” (XML signature) – subsequent interference detected.

Test the DCPs on two different cinema servers, especially check for the right “cinema feeling” (surround)
A software player is great for technical testing but is a lot less restrictive (even plays non-conform DCPs):

- **easyDCP Player TRIAL** (Win/Mac) plays back 15s (good LUT), incl. **Hash-Check** & **Validation**
  Other software is available but does not feature trustworthy LUTs or the sophisticated test tools.

Finished DCPs are sensitive. Any interference (incorrect copy or renaming files,…) changes the hash!

- Use DCP_INSPECT (Linux) for syntax testing (incl. validation + hash check)*****
  Or via free **Docker** app Win/Mac****** – **DCP-Transfer** includes dcp_inspect (“Transfer”, page 37)

- Don’t interfere with the folder, ZIP it (e.g. with KEKA), careful with NTFS (copy assets separately)!

Most DCPs made with freeware or plugins like Wraptor (Adobe), openDCP or CuteFTP fail syntax/ compatibility testing (warnings can be enough). This means a worldwide playability guarantee is not assured but DCPs might still work in some cinemas –> not professional and kind of a gamble

Hash-check + validate master and every copy! **Clone** (1:1 with hardware or software) **instead of copy**!

* GUI for DCP_INSPECT on Linux: http://www.zweib.com/portfolio/medienproduktion/dcp-validator/
** DCP_INSPECT on Win/Mac: https://hub.docker.com/r/qubecinema/dcp_inspect/ (needs DOCKER: https://docs.docker.com)

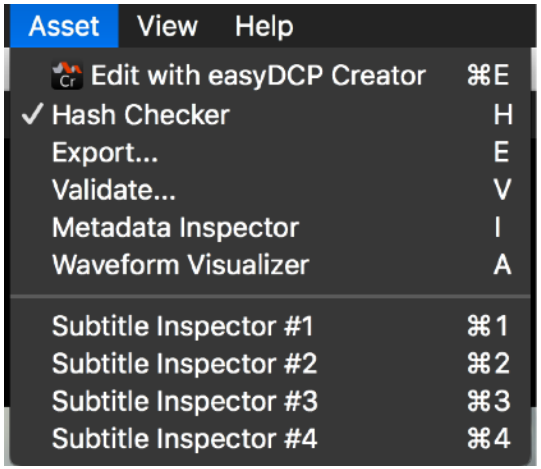
easyDCP Player Tutorial

page not available in LITE version

not available in LITE version

easyDCP Player (trial)

Assets menu



Validate: DCP_INSPECT integration, usually overkill. Important is the quick-check upon load, shows up in the **Log**.

Waveform: Visualize all audio channels
Subtitle Inspector: Subtitle list and more
Hash Checker: Use it often :)

< For most users this is the right color setting. If you have a calibrated DCI display, choose “P3”. Sometimes you need to switch to “Legal Range”.

Transfer & Cloning

Small DCPs (**shorts, ads**): Download* (ZIP, over 4GB use e.g. **KEKA**), USB pen drive (FAT32, 4GB max)
Big DCPs (**long content**): **eSata** + USB 2 HDD, **CRU DX115** (NTFS or EXT2/3), SSD not recommended

A digital copy is never 100%: Bits can "flip", DCP servers are very sensitive and restrictive. Even if the assets are uncorrupted after copying, generated hash values might have changed –> use **cloning**:
DCP Transfer, MAC (WIN soon), $50: www.dcp-transfer.com – **Ext2 i128, Hash Check + Validation**

NTFS (and Ext3) only sometimes supported (*Doremi, Sony,…*) — needs MBR (on new partition) – **buggy EXT2** international standard (**inode size 128KB** following DCI) — needs MBR (on new partition)

- Only use 1 partition, DCPs in root folder only, multiple versions possible (composition titles for ID!)
- **Don't use ExtFS plugins to format/write Linux drives** (wrong inode sizes and buggy)
- –> Linux Live Boot (www.linuxliveusb.com, **Win**) or **Virtual Machine** (VirtualBox free, Win/**Mac**)**:

Linux-Commands for EXT2 inode 128 – not available in LITE version

After transfer check hash and validate (easyDCP, dcp_inspect, DCP-Transfer does it automatically)
Mac: Paragon ExtFS ($) or OSX FUSE (buggy), Windows: EXT2FSD (free), **to read DCP only**

*I recommend FILEMAIL (only use desktop app, transfers faster & checksum-safe), 50GB for free (only 7 days + slower downloads)
Linux in Virtual Machine (Mac/Win): https://www.youtube.com/watch?v=n6rGDYoNXi0 (**USB devices need extra setup and driver**)
Windows Alternative: https://www.partitionwizard.com/free-partition-manager.html (**free**)
****Important**: Linux only reads NTFS drives, Live Boot only on Windows, on Mac use Virtual Machine with **Folder Sharing (SMB)**

DCP-Transfer Tutorial

not available in LITE version

Coming soon to Windows as well! Check their website!

Exclusive offer for my workshop clients and e-book readers:
Use voucher code “**SLFILM10**” when purchasing **DCP-Transfer** for **10% off**!

Hardware

Open graphics

External USB 3.0 2.5” HDD with Case
Has to be USB 2 compatible! **(90% DCI compatible)**

Slim 2.5” HDD 120GB: https://amzn.to/2PPWZBm
Slim 2.5” HDD 160GB: https://amzn.to/2LGaDUo
Transport Case: https://amzn.to/2C0Yslt or https://amzn.to/2omDF27

USB pen drive in case, experimental
not recommended for DCI Ext2, only FAT32 or NTFS

Stay under 500GB for best compatibility and faster formatting!

Better: „Real“ USB 2.0 drive (Linux does not like USB 3, also less buggy for Paragon drivers)
Available in different sizes, e.g. 160GB: https://amzn.to/2ZxIgno – **(99% DCI compatible)**

CRU DX115 Carrier - Interface (100% DCI compatible)
Initially developed for the military – takes 3.5” SATA HDD
https://amzn.to/2MEW2On

needs **SATA HDD 3.5”:** https://amzn.to/2MP2Et2 or

Transport Case: https://amzn.to/2LNFBxg

alternatively **(99% DCI compatible)**:
External 2.5” USB 3 + eSata Interface
eSata takes power over USB
https://amzn.to/2N0R2TF
or https://amzn.to/2NwpUZU
USB2 only (**safer**): https://amzn.to/34vWFiO

–> **SATA HDD 2,5”:** https://amzn.to/2NsZnwq

Source: amazon.de

Thunderbolt to USB 3 + eSata (Mac)
TB1 (Display Port): https://amzn.to/2PDIvED
TB3 (USB-C): https://amzn.to/2LGaDUo

External Docking Station with USB 3.0
Incl. 1:1 hardware cloning feature (without PC)
for 2.5” and 3.5” SATA HDDs
https://amzn.to/2LsNh4R

SATA HDD 3.5”: https://amzn.to/2MP2Et2
SATA HDD 2,5”: https://amzn.to/2NsZnwq

Quelle: amazon.de

Subtitles (Belle Nuit Montage)

not available in LITE version

Caution: macOS Mojave last compatible OS (32bit), freeware (Mac only) but outdated
Can open basically any subtitle format!

Alternative: DCP-o-matic (SRT/XML only)
Uses source code by Belle Nuit, incl. formatting but no conform

< *Translates it in its own syntax*

not available in LITE version

"Spotting" can conform frame rate via TC
(Alternative: Free Online Tool https://subsyncer.com/)

Belle Nuit Montage Tutorial

not available in LITE version

Note: DCI subtitles position according to frame resolution. Will be translated into percent during export. Activate “monitor” for preview, values for *Scope* in image above. For *Flat* use **1998/960** with “Bottom”.

Strongly recommended: “Shadow” and 54pt Arial. Will be translated during export as well (actually 48pt). Belle Nuit automatically tweaks font tag for best and safest outcome in the cinema.

Re-Wrap: rendered DCP + subtitles SRT –> **combine/repair** in DCP-o-matic without re-encoding)

Subtitle formatting standards for burn-in

not available in LITE version

Summary for Burn-In:

“5% Title Safe” (audience heads!), max. 42 characters per line, max. 2 lines, Sans Serif Font 42-48pt

Source: http://translationjournal.net/journal/04stndrd.htm

Andreas Kiel's Subtitle Tool "TitleExchange" (Mac)

X-Title Importer (XTI) allows to create captions or titles for FCP X from Subrip SRT (font style, font color), WebVTT (font style, font color, voice tags), iTunes iTT and other DFXP/TTML formats, Spruce STL (font, font size, font style, horizontal alignment), Youtube SBV, Chapterlist, Final Cut Pro X XML (chapters extraction), untimed text from transcripts, Comma separated text CSV.
Download here

X-Title Exporter (XTE) allows to export titles from FCP X to WebVTT, Subrib SRT, Texas Instruments DCP and Spruce STL.
Download here

X-Title Caption Convert (XTCC) allows to convert captions to titles for FCP X It is fast and easy like XTCE and currently the only option to convert captions to titles.
Download here

X-Title Caption Export (XTCE) allows to convert captions from FCPX projects to SRT It is fast and easy like XTCC and currently the only option to convert captions to SRT directly.
Download here

X-Title Render which allows to create high quality rendered subttitles from Apple FCP X for Apple DVD Studio Pro, Abobe Encore, Avid, Autodesk Smoke/Flame and more apps.
Download here

Related applications (Adobe Premiere Pro):

premiereTitles currently is the most advanced and most affordable tool for subtilte import and export from Adobe Premiere Pro.

Quelle: www.spherico.com/filmtools

Windows alternatives:

Simply create DLP XML subtitles from SRT:

http://uross-digital-tools.appspot.com/dcptools?subpage=dcp_srtToDCPSubs (**free**)

Features similar positioning and formatting tools like Belle Nuit Montage!

Also: Editor/Converter (DLP and SMPTE):
http://www.nikse.dk/SubtitleEdit (**free**)

DCP-o-matic (free) converts SRT to XML (get the „beta" Test release) or creates „version files"

Also Resolve since v15 takes SRT and burns them in. Standard settings are already fine!

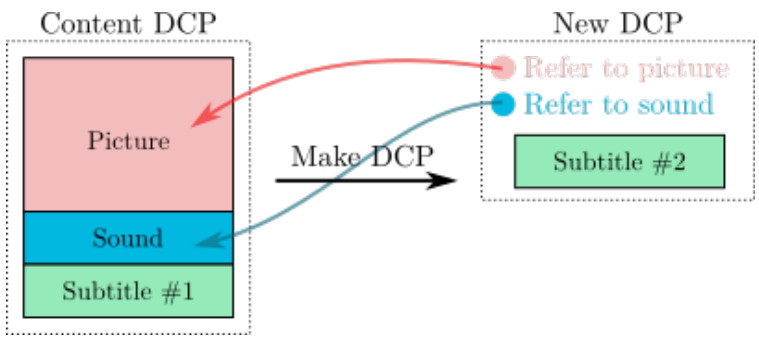
Online Converter (no formatting!)
several formats -> D-Cinema XML (IOP, SMPTE):
https://transcribefiles.net/other/pages/caption-subtitle-converter.htm

Complete Toolkit (paid) for Subtitle Creation & Conversion (incl. DCP): „Zeitanker Annotation Edit"
Create and download **SRT** (UTF-8) **via YouTube** (CC Editor): https://support.google.com/youtube/answer/2734796
Also note: SRT –> FCPX/Resolve via: https://resolver.tools/subsimple/ (online, **free**)

Subtitles & Versioning with DCP-o-matic

requires beta/test version 2.15.16 (02.09.2019) or later from https://dcpomatic.com/test-download

Creating multiple language versions of a DCP and adding multiple subtitles to a DCP or exchanging subtitle files.

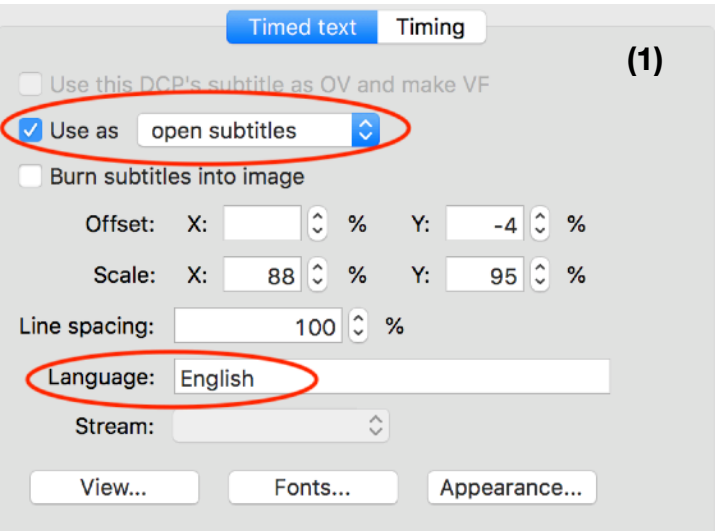


Where possible DCP-o-matic will re-use existing JPEG2000-compressed data from DCP content without modification. With its default settings (and no change to visual parameters) it will take DCP content (assets) and **copy** it.

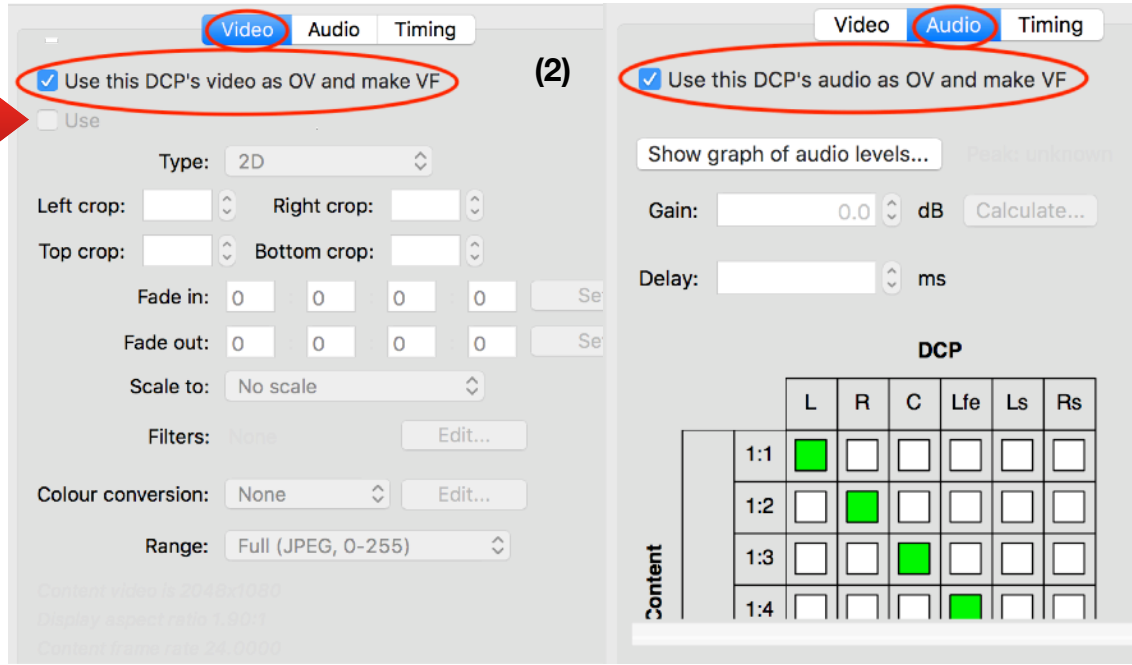
A **Supplemental-DCP** (aka **VF**, Version File) can refer to the 'assets' (picture, sound or subtitle) of another DCP. The source DCP is called **OV** (Original Version) and can be rendered with any software. E.g. Resolve or Wraptor (**re-package* first to fix faulty code**). See screenshots (2) below, select if you know the OV is healthy and validates (e.g. in easyDCP player, see Chapter „QC").

Then you can create any number of overlay DCPs (VF, Version Files) which *refer* to the base version and replace the original subtitles with their own – being just a few KB in size you can send them via email even. Given, the cinema Server has the OV already ingested!

Import a subtitle file (SRT or DLP XML) and use as „**open captions**". Adjust formatting, placement and **appearance**, enter language as shown in screenshot (1).



*select USE instead if you want to **re-wrap** and write new package files (repair Wraptor's DCPs and give it proper HRI values/ naming convention) without re-rendering. The DCP will be copied, not referenced but also not re-encoded. The next page will takes you through the whole process step-by-step.



full Versioning guide DCP-o-matic

page not available in LITE version

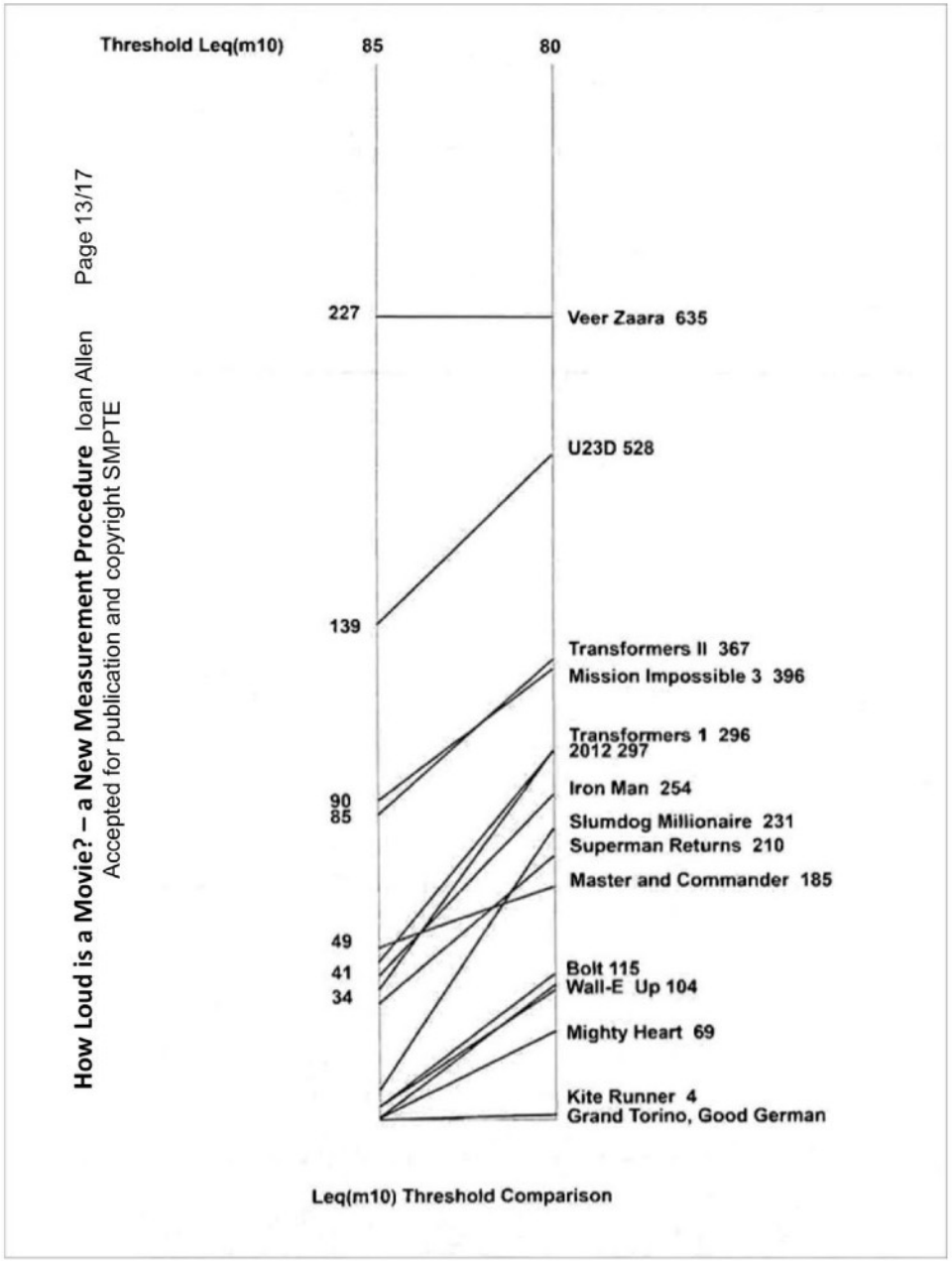


Figure 14 : Effect of changing threshold from 85 dB to 80 dB – normalized to *Veer Zara*, the loudest movie measured to date

Appendix: How loud is a Movie?

Outtake from: https://isdcf.com/papers/ISDCF-Doc11-MovieLoudnessMeasurement20160315.pdf

For the non-audio professionals: To be safe use the whole loudness scale up to -6 or -9db for each channel or channel pair (surround). a stereo down-mix will always be louder so take care there especially!

A cinema server detects (integrated/peak) loudness and the audio server might change the mix according to standards. You can always turn master volume up or down by about those above mentioned 6/9 db IN the screening hall (hidden button for projectionists to compensate for commercial, trailer and actual film).

Some cinemas even reject audio levels not according to the 82/84 leq. Get a good LOUDNESS METER* or trust a professional audio service/ engineer or studio. *Also dcp-o-matic gives some audio analyzation*.

The important value here is **LUFS**: This measurement is basically like RMS but with a twist. It takes into account how humans perceive loudness and it is currently the most accurate way of measuring loudness. Around -18 to -20 LUFS gives a proper level in the cinema.

You can mix and deliver a broadcast R128 (-23 LUFS) mix, which is safe but usually too low and lacking dynamics a little. „Loud“ in the cinema is LOUD and „faint“ can be whispery FAINT. You would still hear it and experience the whole scale. Also take a look at your LU (loudness range and try to maximise it if you can creatively)

***Free loudness meter VST plugin (accessible within Resolve)**:
https://youlean.co/download-youlean-loudness-meter/

loudness meter plugin values and best practice

page not available in LITE version

Appendix: Re-Wrap in DCP-o-matic

requires beta/test version 2.15.16 (02.09.2019) or later from https://dcpomatic.com/test-download

If you do have a DCP rendered and packaged by an either badly maintained, experimental or outdated tool like Wraptor, CuteDCP or similar you can **repair** it by re-building or re-wrapping it in the free DCP-o-matic.

Or you can deliberately use Wraptor for its convenience and speed, knowing you have to fix the bad code after but can just copy the assets. **The cheapest way for fast DCP mastering at the moment**!

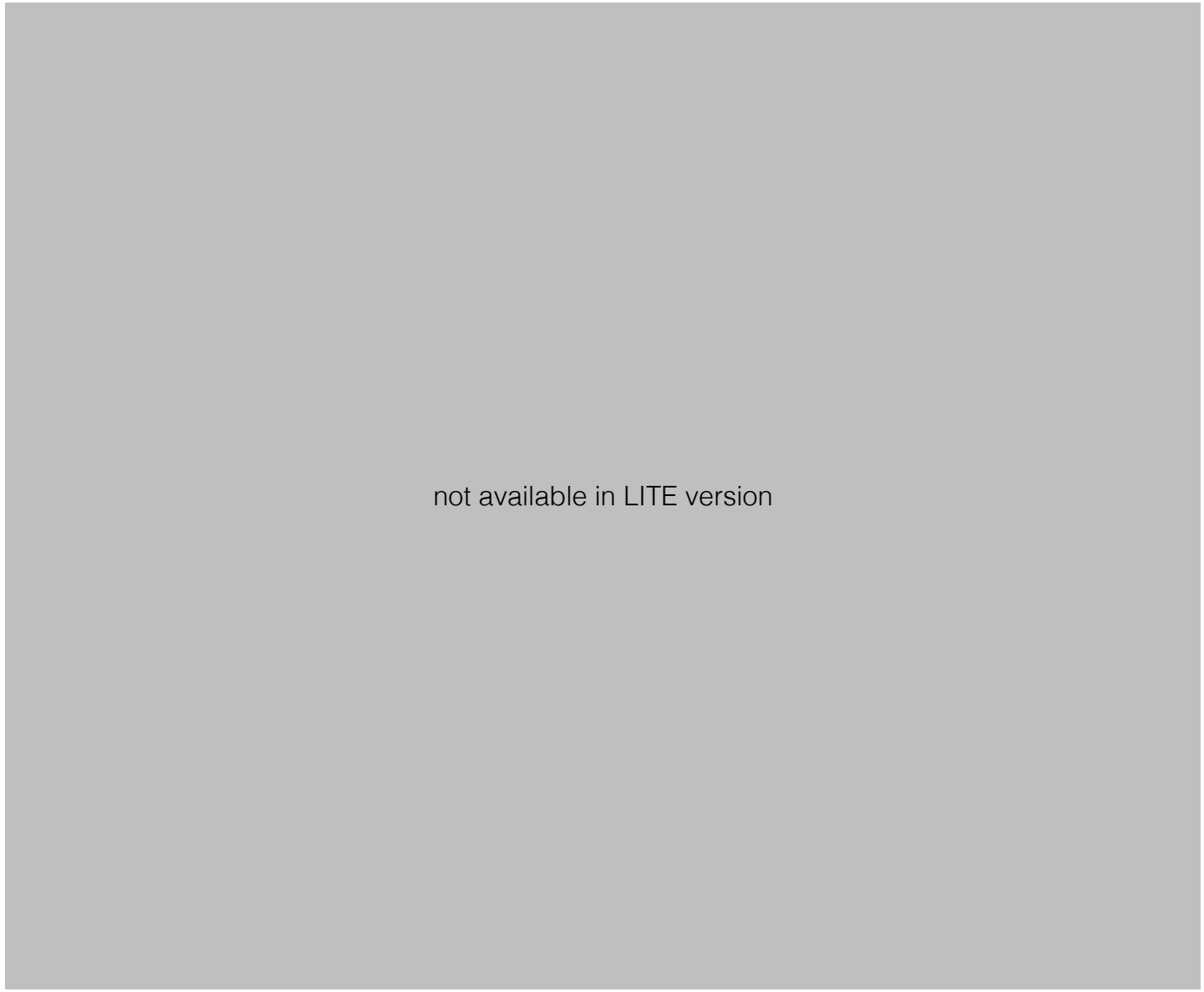
For example, Wraptor DCPs DO NOT validate fully (test it in in easyDCP player, see chapter „QC“) and are considered unsafe, HRI information is completely missing – but very important. If your movie file has the name „Final Version Final 2 new“ for instance, this would also show up in the cinema (as the only information) and no one but you would know what it is – it would also have important metadata missing. Set all of the **ISDCF** fields under „DCP“ first, it will also define if re-encoding is required (we don't want that) – specs should be the same as the source (audio and video).

DO NOT check the OV -> VF box but select the standard „USE“ instead, for picture and sound to be cloned.
At this point you could add subtitles as described before. „make DCP“ under „Jobs“ and get a repaired DCP with copied assets.

full guide re-wrapping in DCP-o-matic

not available in free version

Appendix: HRI Title Tool (Kakadu)



Put in all important parameters and specs here until you reach 42 characters (the maximum a cinema server displays at first glance during ingest).

Image and audio format, language and standard are the most important. **This does not change the project settings, it's just metadata.**

If you are planning on „Versioning“ be sure to set „OV“

If you have subtitles choose „Subtitle Language“. Please note that „captions“ are different and meant for hearing-impaired (every sound/noise is explained).

Also use this HRI as the folder name of the DCP and print it on a sticker for the drive. It contains all the important information for the projectionist.

– FIN –

Support: not available in LITE version
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This PDF is being under constant review and QC, check back in intervals to get updated info.

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