**bci digital**   **White Paper on DCP**

What is a Digital Cinema Package (DCP)?

A: Simply put, a DCP is the digital equivalent of a 35mm film print. It is what you give to a commercial theatre so they can screen your movie on a digital (also known as "D-Cinema") projector. Like a 35mm print, a DCP is a world-wide standard. If you walk into any Digital Cinema (DC), anywhere in the world, they can play your DCP without any problems.

A picture paints a thousand words. Here in a nut shell is how the system works:
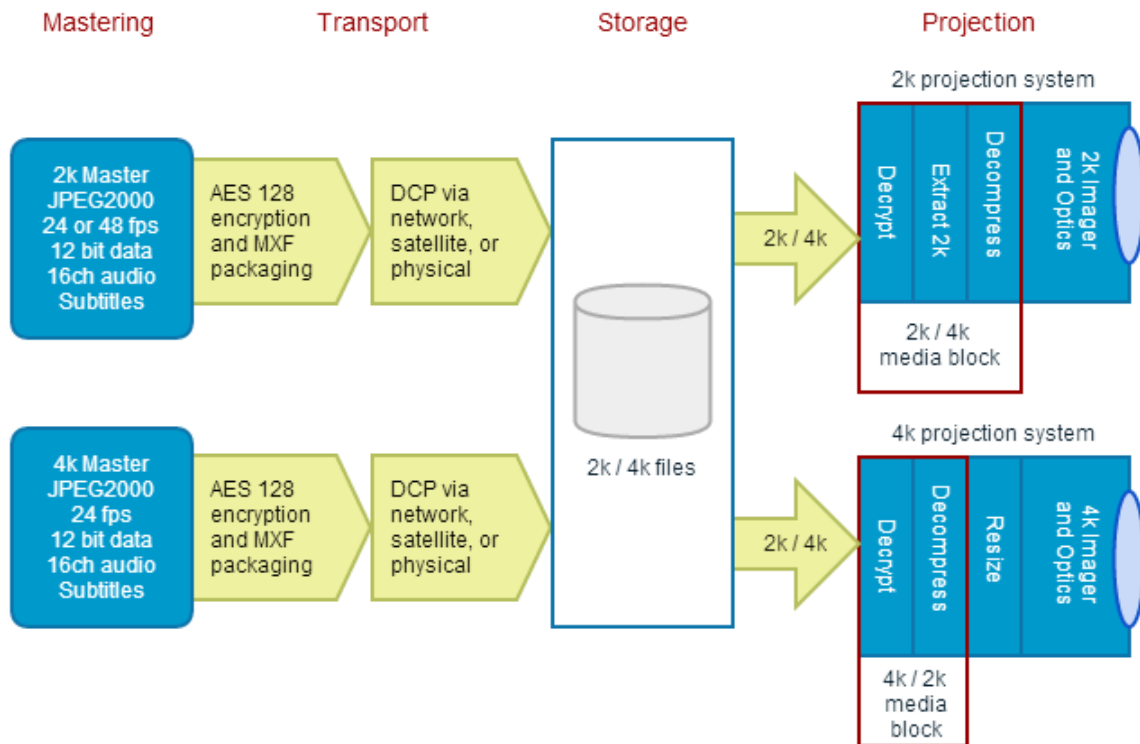
Mastering is the generation of the original video / audio material, the essence as it's termed. Parameters defined include bit depth, sample rate, minimum channel count, channel mapping and reference levels, and the format of a Digital Cinema subtitle track file. A subtitle track file contains a set of instructions for placing rendered text or graphical overlays at precise locations on distinct groups of motion picture frames. The resolution can be either 2k or 4k but the DCP must allow for the content to be playable on either 2k or 4k projection systems.

Transport is the process of packaging up the essence in such a way that it can be easily and securely transported be this via an Internet network, satellite or some type of physical media such as a hard disk drive

Storage refers to the file format required for storage to disk or other physical media

Projection is the actual 'unpacking' of the DCP files for ultimate display at a theatre with consistent and repeatable colour image quality

The components of the DCP are MXF, CPL, PKL and optionally KDM files.

Q: How Does a DCP Work?
A: A DCP usually arrives at a cinema theater on a CRU hard-drive or USB Flash drive. The DCP is ingested into the theatre's Digital Cinema Server. Once verified, it is played off the server through a Digital Cinema Projector.

Q: What are MXF Files?
A: MXF is an acronym for Material Exchange Format. It is a file wrapper enclosing both the content and associated metadata. Picture and sound content may be stored as one or more MXF files. Each file contains JPEG2000 compressed image information and corresponding 12-channel, 24-bit, 48/96 kbps audio information.

Q: What is a CPL?
A: CPL is an acronym for Composition Playlist. A Composition Playlist consists of an ordered sequence of reels each referencing sound or picture files. Each reel is analogous to a film reel. The CPL controls the order and timing of the play-out of the reels.

Q: What do DCPs cost to make?

A: These seem to vary based on how much you wish to spend. The consensus on the internet is that a professionally encoded feature DCP typically costs between $1400-$3000 (depending on runtime and options), with additional copies running about $170-$300 each. When comparing prices, be sure all of the following are included in your quote:

Mastering - this is the actual process of converting your video/audio files into the format recognized by D-cinema systems.

Quality Check or 'QC' - this is where the final product is checked for glitches, drop-out, sync problems, gamma, colour, etc. by an experienced technician. This step is absolutely crucial. There is too much that can go wrong in the mastering process not to make sure the final product is as flawless as possible. Small mistakes look huge on a 30 foot theatre screen.

Transfer to USB or CRU drive. This is the final step when the mastered files (collectively called the DCP) are transferred to an EXT 2/3 formatted Linux hard drive. The actual drive can be a standard portable USB available in any computer store, or a professional "DX115" drive carrier, which is called a CRU. Both USB and CRU have the exact same information on them.

Q: How long do DCPs take to produce?

A: There does not seem to be a precedent. It takes as long as it takes; although obviously the shorter the better.

Q: What is DCI?
A: DCI is an acronym for Digital Cinema Initiatives. The DCI was created in 2002 as a joint venture between the major motion-picture studios (Disney, Fox, Metro-Goldwyn-Mayer, Paramount Pictures, Sony Pictures Entertainment, Universal Studios, and
Warner Bros. Studios) to establish and document specifications that would insure uniform, high-quality technical performance, reliability and quality control. The formal standardization of the DCI specifications is overseen by the Society of Motion Picture & Television Engineers (SMPTE).

Q: What is DCI Compliance?
A: DCI Compliance refers to products and services that conform to DCI specifications.

Q: What is a KDM?
A: KDM is an acronym for Key Delivery Message. A KDM is a special electronic key that contains a code which "unlocks" an encrypted film

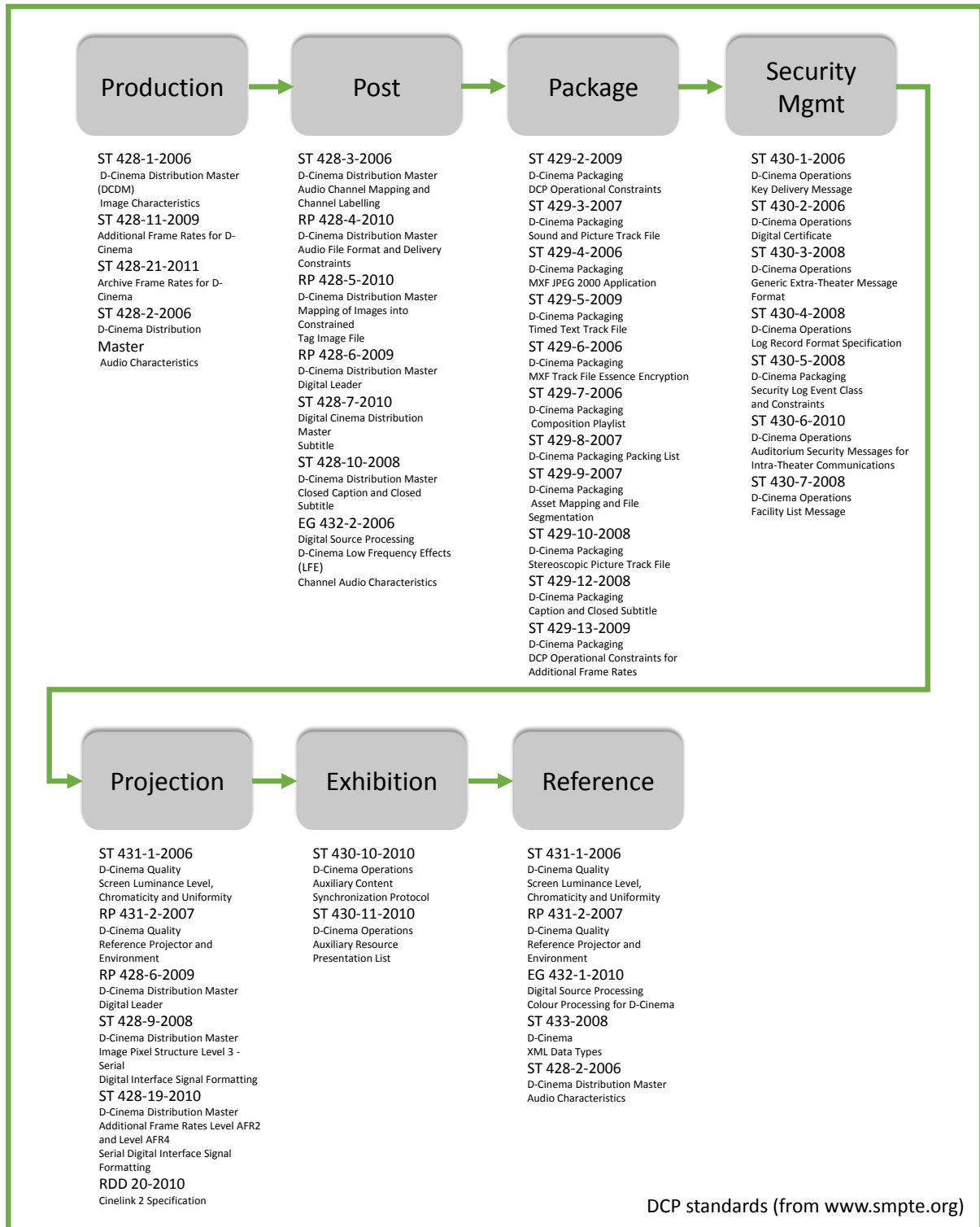### Q: What is a KDM encryption?
A: Encryption is a security measure used to prevent films from being stolen and duplicated. DCP's are encrypted in a manner that allows them to be played only on a specific Digital Cinema server at a predetermined time. A KDM is sent to the

projection site to unlock the DCP for the screening engagement. It is not a necessity to have a DCP encrypted

Q: Where can I find more complete technical specifications for DCPs?

A: Complete DCP specifications are contained in the following: SMPTE 428-1-2006 D-Cinema, ISO/IEC 15444-1, SMPTE 428-2-2006 D-Cinema, SMPTE 428-3-2006 D-Cinema. These standards documents are sold by SMPTE and other organizations such as ISO. See diagram here:

Production → Post → Package → Security Mgmt

Production

ST 428-1-2006
D-Cinema Distribution Master (DCDM)
Image Characteristics

ST 428-11-2009
Additional Frame Rates for D-Cinema

ST 428-21-2011
Archive Frame Rates for D-Cinema

ST 428-2-2006
D-Cinema Distribution Master
Audio Characteristics

Post

ST 428-3-2006
D-Cinema Distribution Master
Audio Channel Mapping and Channel Labelling

RP 428-4-2010
D-Cinema Distribution Master
Audio File Format and Delivery Constraints

RP 428-5-2010
D-Cinema Distribution Master
Mapping of Images into Constrained
Tag Image File

RP 428-6-2009
D-Cinema Distribution Master
Digital Leader

ST 428-7-2010
Digital Cinema Distribution Master
Subtitle

ST 428-10-2008
D-Cinema Distribution Master
Closed Caption and Closed Subtitle

EG 432-2-2006
Digital Source Processing
D-Cinema Low Frequency Effects (LFE)
Channel Audio Characteristics

Package

ST 429-2-2009
D-Cinema Packaging
DCP Operational Constraints

ST 429-3-2007
D-Cinema Packaging
Sound and Picture Track File

ST 429-4-2006
D-Cinema Packaging
MXF JPEG 2000 Application

ST 429-5-2009
D-Cinema Packaging
Timed Text Track File

ST 429-6-2006
D-Cinema Packaging
MXF Track File Essence Encryption

ST 429-7-2006
D-Cinema Packaging
Composition Playlist

ST 429-8-2007
D-Cinema Packaging Packing List

ST 429-9-2007
D-Cinema Packaging
Asset Mapping and File Segmentation

ST 429-10-2008
D-Cinema Packaging
Stereoscopic Picture Track File

ST 429-12-2008
D-Cinema Packaging
Caption and Closed Subtitle

ST 429-13-2009
D-Cinema Packaging
DCP Operational Constraints for Additional Frame Rates

Security Mgmt

ST 430-1-2006
D-Cinema Operations
Key Delivery Message

ST 430-2-2006
D-Cinema Operations
Digital Certificate

ST 430-3-2008
D-Cinema Operations
Generic Extra-Theater Message Format

ST 430-4-2008
D-Cinema Operations
Log Record Format Specification

ST 430-5-2008
D-Cinema Packaging
Security Log Event Class and Constraints

ST 430-6-2010
D-Cinema Operations
Auditorium Security Messages for Intra-Theater Communications

ST 430-7-2008
D-Cinema Operations
Facility List Message

Projection → Exhibition → Reference

Projection

ST 431-1-2006
D-Cinema Quality
Screen Luminance Level, Chromaticity and Uniformity

RP 431-2-2007
D-Cinema Quality
Reference Projector and Environment

RP 428-6-2009
D-Cinema Distribution Master
Digital Leader

ST 428-9-2008
D-Cinema Distribution Master
Image Pixel Structure Level 3 - Serial
Digital Interface Signal Formatting

ST 428-19-2010
D-Cinema Distribution Master
Additional Frame Rates Level AFR2 and Level AFR4
Serial Digital Interface Signal Formatting

RDD 20-2010
Cinelink 2 Specification

Exhibition

ST 430-10-2010
D-Cinema Operations
Auxiliary Content Synchronization Protocol

ST 430-11-2010
D-Cinema Operations
Auxiliary Resource Presentation List

Reference

ST 431-1-2006
D-Cinema Quality
Screen Luminance Level, Chromaticity and Uniformity

RP 431-2-2007
D-Cinema Quality
Reference Projector and Environment

EG 432-1-2010
Digital Source Processing
Colour Processing for D-Cinema

ST 433-2008
D-Cinema
XML Data Types

ST 428-2-2006
D-Cinema Distribution Master
Audio Characteristics

DCP standards (from www.smpte.org)

Despite movies such as Christopher Nolan's 2014 blockbuster Interstellar being available on 35mm film over the last couple of years cinemas have transitioned almost completely to digital projection. Digital cinema offers content encryption protection, allowing for easy distribution, unlike film prints which required security personnel. Digital cinema can provide a cheaper route to the big screen but the distribution process requires post processing to ensure it is in the correct format.

A digital cinema package (DCP) is the standard convention accepted worldwide for distributing and projecting movies digitally (SMPTE 428-1-2006 D-Cinema, ISO/IEC 15444-1, SMPTE 428-2-2006 D-Cinema, SMPTE 428-3-2006 D-Cinema). Simply put, a DCP is a collection of image and audio files, plus some additional files used to organize and manage the whole playlist.

The DCP can be created either from the Digital Source Master (DSM) or for larger studio releases a Digital Cinema Distribution Master (DCDM). A DSM can be supplied in any number of formats and colour spaces and can require extensive transcoding to be in the correct format for DCP generation. Conversely since a DCDM already exists as a collection of XYZ TIFF format frames it can be encoded directly into the DCP. A DCP consists of a number of Material eXchange Format (MXF) container files, which are used to store separate audio & video streams and XML subtitles, plus auxiliary index files in XML format. The video container consists of JPEG 2000 DCI compliant pictures, with maximum frame sizes of 2048 x 1080 for 2k and 4096 x 2160 for 4k. The audio container consists of 24-bit uncompressed linear PCM, with up to 16 independent channels. Whilst the creation of separate audio and video files may seem unnecessarily complex, we can quickly see an advantage when considering distributing content worldwide to different language markets. In this example the video MXF would be the same for all markets and only the audio would be different. Once the asset files are created there are a number of XML files required for playing the content on a digital projector - the composition playlist (CPL), package list (PKL), assetmap, and volume index. The assetmap is a list of all files included in the DCP. The CPL defines the playback order and timing during presentation.

The PKL contains a hash of each of the MXF files and is used to verify the assets have not been corrupted or altered in the transit chain. Finally the volume index identifies the order in which content is retrieved from the storage medium (important when content is stored across multiple devices such as HDDs).

An optional portion of the DCP process is encryption to protect against piracy. The encryption standard is AES 128-bit in CBC mode but to achieve this requires additional processing during the DCP preparation. The AES encryption is applied to all MXF files during generation to ensure that only digital projectors with the key are able to decrypt the content. The key itself

is transmitted via a Key Delivery Message (KDM), which also defines the start and stop times for that DCP package.

To ensure security of the KDM, it is encrypted using public key encryption. To achieve this the DCP preparation process requires a library of public keys for each of the digital projectors which will be used to show the content. The KDM is encrypted using the public key of the intended digital projector and decrypted using the private key which is held securely within the digital projector. The end result is that even if the content is intercepted, it cannot be played on any other devices since the KDM and hence content cannot be decrypted.

Once QA has been completed on the prepared DCP, the final stage of the process is distribution of the content. The CRU DX115 hard drive is specifically designed for digital cinema use. ISDCF-Doc3 provides disk drive recommendations; the drives are usually formatted Linux ext2 format with the inode size set to 128 bits to avoid compatibility issues. The drives (in protective hard cases) are then shipped via courier.

The creation of these files is ideally suited to an automated workflow as part of an Asset Management System (AMS). This would manage the workflow, through encoding, MXF and associated XML generation and also encryption for those packages which require it.

AMSWare is BCi Digital's flagship asset management workflow product. The product combines best of breed components and custom modules and flows to provide an environment for the efficient and fast building of robust workflow solutions. Combined with BCi Digital's transcoding solution this provides all the tools necessary to generate DCP files.

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BCi is currently working with a major film distribution organization in creating cost effective high performance DCP generation tools. Please contact info@bcidigital.com for further information

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