PREFACE

PREAMBULE

The purpose of this documentation is to describe the **Digital Cinema Package (DCP)** as comprehensively as possible.

Started naively in 2020, this documentation began as a collection of technical tips and information I have been using for years (probably since the early days of the DCI). This documentation aims to be, **at last**, a compilation of my own research on Digital Cinema, especially about DCP, all in one place.

Since the early release of the DCI specifications (2004-2005), getting information about DCP and its details is really complicated (above all because of standards not publicly available). Everyone who implements the standards has never explained to less knowledgeable people.

This documentation is intended for experts and beginners :

- **Beginners** : a quick and easy understanding of what a DCP is.
- **Experts** : avoid having to read thousands of pages of the SMPTE standards

This documentation doesn't claim to be perfect, its may have mistakes, omissions or lack of understanding :

- If you have technical or historical skills and you find mistakes or omissions, **do not hesitate to report them**.
- If you are a beginner and some paragraphs seem unclear, **do not hesitate to report them as well**
- If you have in mind a new potential subject or a missing one, do not hesitate to request it.

This documentation doesn't aim to be a translation of SMPTE standards or DCI specifications : They are too vast, it would be counterproductive to do that, especially because they often change.

This documentation aims to be evolving and updated over time : this is not a static documentation, it evolves to add new technological features and updates to the SMPTE standards. Keep an eye on changelog.

The Source code through this documentation doesn't aim to be "best practices of coding", they are intentionally oversimplified, in order to understand each step. I don't like documentation with complicated source code that only experts can understand. In my point of view, it's a bad way for the original author to prove their own expertise. If you find any unclear source code, report it, I will try to simplify further. This source code aims to have a second purpose : to be used and integrated into any other source code or project. It's like a library of ready-to-use source code, or snippets.

TOOLS AND PROTOTYPES

During the writing of this documentation, I needed some tools, so I wrote them concurrently. You may see their outputs throughout some chapters. In addition, you may find some lighter versions of these tools to help with understanding. You can take a look in the assets directory, you will find small software and source code.

Below, a brief description of these main tools.

> To be clear, at this time, these tools are only proof-of-concept, they need a complete rewriting. However, they are functional for the purpose of this documentation.

MXF ANALYZER

It's a MXF analyzer, it provides several options, such as analyzing and extracting data and metadata from MXF

files.

The project is now available in the github repository : https://github.com/sherpadown/mxf-reader/

```
$ mxf_analyzer.py --help
  -h, --help               show this help message and exit
  -f FILENAME, --filename FILENAME = mxf filename
  -x EXTRACT, --extract EXTRACT  = extract each KLV into files
  -k KEY, --key KEY        AES Key, ex. --key 00000000000000000000000000000000
  -v, --verbose            increase output verbosity
  -n, --no-resolv          Do not resolv UL (speed)
  --filter FILTER          filter by name
  --fuzzy                  Fuzzy mode only (very slow)
  --limit LIMIT            stop after x klv parsed
  --slow                   Slowdown parse to avoid flood loadavg
```

```
# mxf_analyzer.py -f 2D.mxf
offset | uuid                              | ber      : data-size |                                        data | name
     0 | 060e2b34.02050101.0d010201.01020400 | 83.000078:      120 | 000100020000000100000000000000000 | Partition
   140 | 060e2b34.02050101.0d010201.01050100 | 83.000596:     1430 | 0000004f000000120201060e2b340101 | Primer Pac
  1590 | 060e2b34.02530101.0d010101.01012f00 | 83.0000be:      190 | 3c0a0010aaffbd07420e44a2b3f87d3c | Preface
  1800 | 060e2b34.02530101.0d010101.01013000 | 83.0000d8:      216 | 3c0a0010c00c5d91bc1b4e58aefabf33 | Identifica
  2036 | 060e2b34.02530101.0d010101.01011800 | 83.00005c:       92 | 3c0a0010acc6d12cda0c465b861a1c33 | Content St
  2148 | 060e2b34.02530101.0d010101.01012300 | 83.000048:       72 | 3c0a0010bf8a6ebc3aca4164a47e45e0 | Essence Co
  2240 | 060e2b34.02530101.0d010101.01013600 | 83.0000a0:      160 | 3c0a001096b13153bd5d4cd29abcd608 | Material P
  2420 | 060e2b34.02530101.0d010101.01013b00 | 83.000070:      112 | 3c0a0010005ea82d6afb4a37aae4d74b | Timeline T
  2552 | 060e2b34.02530101.0d010101.01010f00 | 83.000050:       80 | 3c0a0108afb9187a608464f85713462 | Sequence
  2652 | 060e2b34.02530101.0d010101.01011400 | 83.00004b:       75 | 3c0a0108fe911af95d4464e9e794651 | Timecode C
  2747 | 060e2b34.02530101.0d010101.01013b00 | 83.00006e:      110 | 3c0a0010f8427198af884d4f8c9855f3 | Timeline T
  2877 | 060e2b34.02530101.0d010101.01010f00 | 83.000050:       80 | 3c0a0010e2bfd055e5d249a0bfcb4da8 | Sequence
  2977 | 060e2b34.02530101.0d010101.01011100 | 83.00006c:      108 | 3c0a00106daf21bab69a41c99ec54f4f | Source Cli
  3105 | 060e2b34.02530101.0d010101.01013700 | 83.000116:      278 | 3c0a0010b87f0871f98446d39a842893 | Source Pac
  3403 | 060e2b34.02530101.0d010101.01013b00 | 83.000070:      112 | 3c0a00106378d2218be746d28508fedf | Timeline T
  3535 | 060e2b34.02530101.0d010101.01010f00 | 83.000050:       80 | 3c0a001075ef53606937484a9ee14472 | Sequence
  3635 | 060e2b34.02530101.0d010101.01011400 | 83.00004b:       75 | 3c0a001059cf1ad86f314b5db0164871 | Timecode C
  3730 | 060e2b34.02530101.0d010101.01013b00 | 83.00006e:      110 | 3c0a0010d4e733700afb45329cc796c6 | Timeline T
  3860 | 060e2b34.02530101.0d010101.01010f00 | 83.000050:       80 | 3c0a0010e2f035aa64684a7f98eddfa7 | Sequence
  3960 | 060e2b34.02530101.0d010101.01011100 | 83.00006c:      108 | 3c0a0010c93d2257b09a4dbea24c782e | Source Cli
  4088 | 060e2b34.02530101.0d010101.01012900 | 83.0000bd:      189 | 3c0a00102cb46505be6b41c3abbe8848 | RGBA Essen
  4297 | 060e2b34.02530101.0d010101.01015a00 | 83.0000b5:      181 | 3c0a00106054268f8fdf47ba98db7167 | JPEG2000 P
  4498 | 060e2b34.01010102.03010210.01000000 | 83.002e5a:    11866 | 000000000000000000000000000000000 | KLV Fill i
 16384 | 060e2b34.02050101.0d010201.01030400 | 83.000078:      120 | 000100020000000100000000000004000 | Partition
 16524 | 060e2b34.01020101.0d010301.15010801 | 83.009cc8:    40136 | ff4fff51002f00040000100000000870 | Picture Es
 56680 | 060e2b34.02050101.0d010201.01040400 | 83.000078:      120 | 000100020000000100000000000dd68 | Partition
 56820 | 060e2b34.02530101.0d010201.01100100 | 83.000083:      131 | 3c0a00101c86aa0136fb414ebcd47120 | Index Tabl
```

With more verbosity :

```
# mxf_analyzer.py -f 2D.mxf
offset | uuid                              | ber      : data-size |                                        data | name
     0 | 060e2b34.02050101.0d010201.01020400 | 83.000078 :      120 | 000100020000000100000000000000000 | Par
 ╔═══════════════════════════════════════════════════════════════════════════════════════════════════
 ║   Major Version                              ║ 1
 ║   Minor Version                              ║ 2
 ║   KAGSize                                    ║ 1
 ║   ThisPartition                             ║ 0
 ║   PreviousPartition                         ║ 0
 ║   FooterPartition                           ║ 56680
 ║   HeaderByteCount                           ║ 16244
 ║   IndexByteCount                            ║ 0
 ║   IndexSID                                  ║ 0
 ║   BodyOffset                                ║ 0
 ║   BodySID                                   ║ 0
 ║   Operational Pattern                       ║ 060e2b34.04010102.0d010201.10000000 (Operational Patter
 ║   EssenceContainers                         ║ 2 item(s): 060e2b34.04010103.0d010301.027f0100, 060e2b3
 ║   Resource [1]                              ║ SMPTE.ST.0377-1-2011 - MXF - File Format Specification
 ╚═══════════════════════════════════════════════════════════════════════════════════════════════════
   140 | 060e2b34.02050101.0d010201.01050100 | 83.000596 :     1430 | 0000004f000000120201060e2b340101 | Pri
 ╔═══════════════════════════════════════════════════════════════════════════════════════════════════
 ║   0201                                      ║ 060e2b34.01010102.04070100.00000000 - Statically Local
 ║   0202                                      ║ 060e2b34.01010102.07020201.01030000 - Statically Local
```

```
(...)
```

A (very-very) lighter version of MXF analyzer is available here : https://github.com/sherpadown/js-mxf/ (demo)

UL ANALYZER

A (very) quick & dirty Universal Label parser.

```
$ ul "060e2b34020401010d010301027e0100"
SMPTE UL Format                    060e2b34.02040101.0d010301.027e0100
Hex Format (lower)                 06.0e.2b.34.02.04.01.01.0d.01.03.01.02.7e.01.00
Hex Format (upper)                 06.0E.2B.34.02.04.01.01.0D.01.03.01.02.7E.01.00
Hex Format (small)                 060e2b34020401010d010301027e0100

name                               Encrypted Essence Container (SMPTE)
parser                             essence_encrypted
resource                           SMPTE.ST.0429-6-2006 - DCP - MXF Track File Essence Encryption, Page 10

UL Header (2 bytes)                060e
UL Designator (6 bytes)            2b3402040101
Item Designator (8 bytes)          0d010301027e0100

1 - Object ID                      06
2 - UL Size                        0e (14 bytes)
3 - ISO/ORG Identifier / UL Code   2b
4 - SMPTE Designator               34
5 - Category Designator            02 (Groups - Sets & Packs)
6 - Registry Designator            04 (Variable-Length Pack) - [Length=BER short/long] (All Length)
7 - Structure Designator           01 (Set/Pack Registry)
8 - Version                        01

9 - Item Designator                0d
10 - Item Designator               01
11 - Item Designator               03
12 - Item Designator               01
13 - Item Designator               02
14 - Item Designator               7e
15 - Item Designator               01
16 - Item Designator               00
```

IAB ANALYZER

An Immersive Audio Bitstream analyzer for IAB assets, such as Dolby Atmos, DTS-X, Barco Auro assets.

The project is now available in the github repository: https://github.com/sherpadown/iab-reader/

```
Usage: iab-analyzer.py <IAB data> or <IAB directory>


 |  ┌── IABitstream Frame ──────────────────────────────────────┐  [1]
 |──── Preamble ──────────────────────────────────────────────     [1]
 |      PreambuleTag : 0x01
 |      PreambuleLength : 1603 bytes
 |      PreambuleValue : 11010effffffffffffffffffffffffffff(...1571 bytes...)ffffffffffffffffffffffffffffffff
 |──── IAFrame ───────────────────────────────────────────────     [1]
 |      IAFrameTag : 0x02
 |      IAFrameLength : 44501 bytes
 |      IAFrameValue : 08ffadd10110529bff0200ff020e6402(...44469 bytes...)0173ffc1bfffc0300000200000000500
 |──── IAElement ─────────────────────────────────────────────     [1]
 |      ElementID : 0x08 (IAFrame: Frame Header)
 |      ElementSize : 0xadd1 (44497 bytes)
 |      SubElementValue : 0110529bff0200ff020e64020b12d0202aad16adb68b4ab6daa55b4ab4aa0a2a(..) (44497 bytes)

 |  |  ┌── IAFrame ──────────────────────────────────────────┐  [2]
 |  |      IAVersion : 1
 |  |      SampleRate : 0b00 (48000 Hz)
 |  |      BitDepth : 0b01 (24 bits)
 |  |      FrameRate : 0x0 (24 fps)
```

```
|    |      MaxRendered : 0x52 (82 bytes)
|    |      AlignBits(0)
|    |      SubElementCount : 0x9b (155 elements)
┌    ┌    ┌─────────────────────────────────────────────────────────────
|    |    |───── SubElement 0 ─────────────────────────────────────────           [3]
|    |    |      SubElementID : 0x0200 (Audio Data DLC Encoded)
|    |    |      SubElementSize : 0x020e (526 bytes)
|    |    |      SubElementValue : 64020b12d0202aad16adb68b4ab6daa55b4ab4aa0a2a96d5156d55aab6db6d5b(..) (526 byt
┌    ┌    ┌    ┌─────────────────────────────────────────────────────────
|    |    |    |── Audio Data DLC ───────────────────────────────────────        ▐  [4]
|    |    |    |      AudioDataID : 100
|    |    |    |      DLCSize : 523 bytes
|    |    |    |      DLCSampleRate : 48000 Hz
|    |    |    |      ShiftBits : 9
|    |    |    |      ─────── Predictor Informations ───────
|    |    |    |      NumPredRegions : 0b01 (1 regions)
    ( .. .. .. )
```

JPEG2000 DCI ANALYSER

A JPEG2000 DCI 2K/4K images analyzer.

The project is now available in the github repository: https://github.com/sherpadown/jpeg2000-reader/

```
# jpeg2000-parser.py <file.j2c> <fileN.j2c> ...
read file.j2c
[SOC] Start of codestream                      (FF4F)
[SIZ] Image and tile size                      (FF51)
SIZ - rsiz   : Profile 4
SIZ - Xsiz   : 4096 px
SIZ - Ysiz   : 1716 px
     ( .    .    . )
[COD] Coding style default                     (FF52)
COD - Scod   : 01               Binary Parameters: 00000001
COD - Progression order : 04    Binary Parameters: 00000100
COD - Number of Layers  : 1
COD - Multiple Component Transform : 01 00000001
COD - Decomposition levels : 6
COD - CodeBlockSize : 32 x 32
     ( .    .    . )
[QCD] Quantization default                     (FF5C)
QCD - Sqcd (Scalar coefficient dequantization), Quantization style for all components: 00100010
QCD - Sqcd binary parameters (bit1-3): Number of guard bits 0–7: 0b001 ─► 1 bits
QCD - Sqcd: 0b00010 ─► Scalar explicit
QCD - SPqcd (Exponent+Mantissa), Quantization step size value sub-band  0:
   ─► SPqcd    : 0111111100010110  (0x7f16)
   ─► Mantissa : 01111           : 15
   ─► Exponent :      11100010110 : 1814
     ( .    .    . )
[CME] Comment and extension                    (FF64)
CME - Registration values 1: Text ISO 8859-1
CME - Text: Created with Doremi Labs DMS2000 SN70062 server v1.8.0. Src0.
     ( .    .    . )
[POC] Progression Order Change                 (FF5F)
POC - [2K] RSpoc (Resolution Start) : 0    (0x00)
POC - [2K] CSpoc (Component Start)  : 0    (0x00)
POC - [2K] LYEpoc (Layer)           : 1    (0x0001)
POC - [2K] REpoc (Resolution End)   : 6    (0x06)
POC - [2K] CEpoc (Component End)     : 3    (0x03)
POC - [2K] Ppoc (Progression Order) : 4    (0x04)
POC - [4K] RSpoc (Resolution Start) : 6    (0x06)
     ( .    .    . )
[TLM] Tile-part lengths, main header           (FF55)
TLM - Ztlm: Index of this marker segment: 0
TLM - Stlm: Size of the Ttlm and Ptlm parameters: 01010000
TLM - Stlm Bit-Parameters: SP = 1; Ptlm parameter 32 bits
TLM - Stlm Bit-Parameters: ST = 1; Ttlm parameter 8 bits
TLM - Ttlm -    Tile number of tile-part 1: 0
TLM - Ptlm - Length SOT+SOD of tile-part 1: 190 bytes
     ( .    .    . )
[SOT] Start of tile-part                       (FF90)
```

```
SOT - Isot, Tile number         : 0
SOT - Psot, Length of SOT+SOD   : 190
SOT - TPsot, Tile-part number   : 0
SOT - TNsot, Number of tile-parts : 6
     ( .    .   . )
[SOD] Start of data                             (FF93)
data: 176 bytes : eff07ffe0fc0115054afff5574bcab4000000000000c2425ff69dc40000000000309097fe4a5400000000061212ffc94a
     ( .    .   . )
```

CONCLUSION

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