KDM : KEY DELIVERY MESSAGE

Short version : A KDM is a « digital key » for encrypted DCPs.

Metaphorical version : A KDM is like a tamper-proof, sealed envelope that contains one or several keys, along with a letter containing details about these keys, what they are used for, etc.

Technical version : A KDM is an XML file containing a multitude of data, such as metadata which links the KDM to a CPL, defines validity dates, and the AES decryption keys which allow the decryption of all the encrypted assets (MXF) defined in the CPLs of a DCP.

A KDM is created by a laboratory for a theater allowing it to read an encrypted digital movie.

In which case is a KDM used ?

A KDM is required **only** in the following cases :

- To decrypt an encrypted DCP (for a theatrical projection, for example)
- To share decryption keys between two post-production entities (such as laboratories)

Thus, a KDM is not required for non-encrypted DCPs

SMPTE STANDARDS

The various standards related to the KDM :

- SMPTE 430-3 (2012) - **Generic Extra-Theatre Message Format** (ETM)
- SMPTE 430-1 (2017) - **Key Delivery Message** (KDM)
- SMPTE 430-2 (2017) - **Digital Certificate**
- SMPTE 429-2 (2020) - **DCP Operational Constraints**

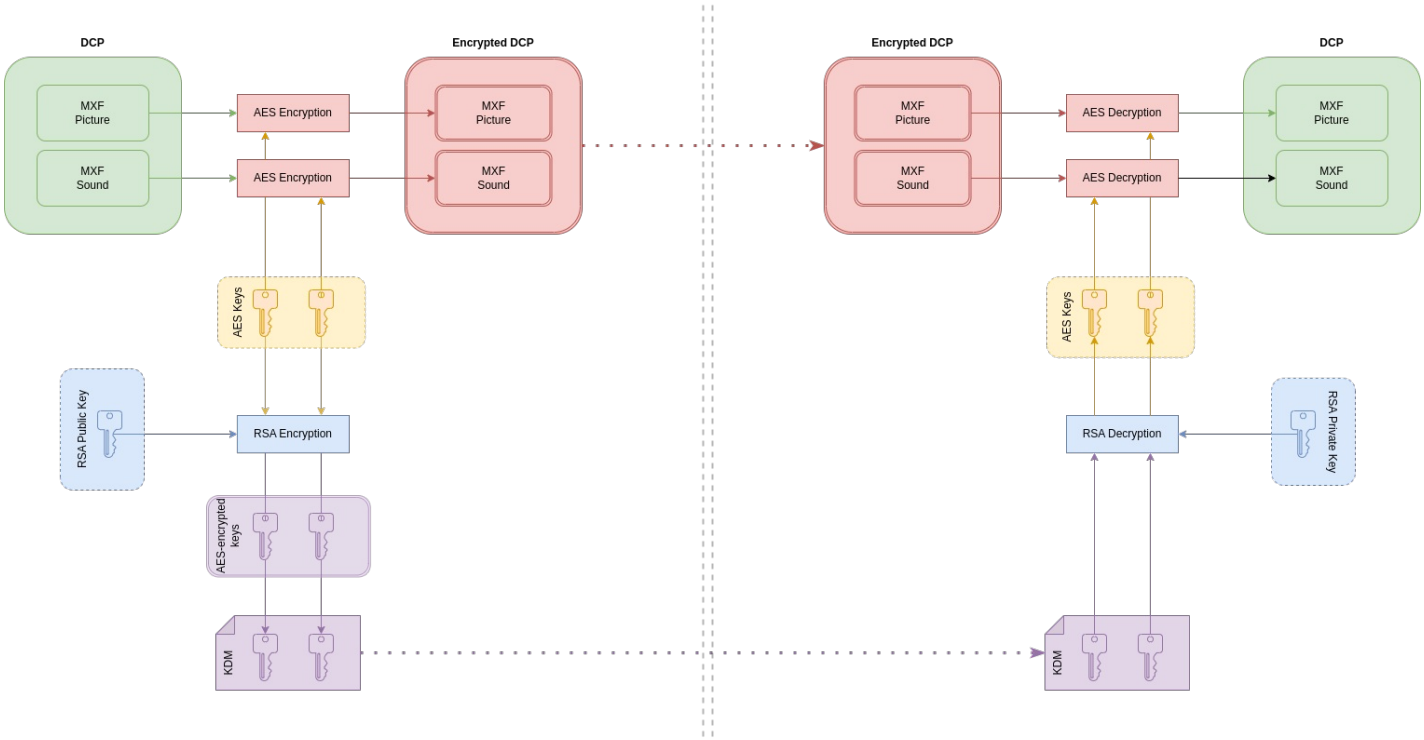
The internal structure of a KDM is based on the following standards :

- Standards **D-Cinema Generic Extra-Theater Message (ETM)**.
- Standards **Key Delivery Message (KDM)**

The first one (ETM) defines a common format (XML) for data and information exchanges between equipment or services in the digital cinema field. The second (KDM) uses the ETM format as a basis and build on it adding or removing elements in order to create a final format : the KDM.

KDM PRINCIPLE

To understand the principle, let's get back to the distribution workflow of a digital film in theater and its constraints :



When a movie is distributed in theaters, all copies of a given version of a movie (such as the French version) sent in theaters are identical. They isn't an individual copy for each theater, they are all identical.

It allows a movie to be easily distributed to several theaters. It prevents a laboratory from making several different copy for each theater that requests it: the laboratory only needs to create a single DCP and send it to all theaters.

Think of it like a DVD or Blu-ray sold in stores: everyone who buys the DVD of a movie gets the same copy. You don't get a custom-made copy just for you and your DVD player.

Why don't we create individual encrypted DCPs for each theater ?

We have to consider the logitics of theatrical delivery: In France, for example, a movie can be distributed to over 400 or even 500 screens. If a laboratory were to encrypt each DCP copy, it should encrypt tera-octets (or even peta-octets) of data to create each copy.

If that were the case, it would require extraordinary computing power — for each copy of a movie, and for every differents versions (original, dubbed, 2D, 3D, Dolby Atmos, ..), and for all movies released in the same week : that's impossible. Even more so in the early 2000s when the DCI specifications were created.

Thus, a single DCP encryption for every theater was adopted.

So, in theater, screen #1 will have the same copy as screen #2.

From this point, to decrypt a DCP, we need to deliver the encryption keys to the theaters.

For security reasons, it is impossible to deliver them to all theaters in plain sight and accessible to anyone : if these keys are leaked, they would allow anyone to decrypt the movie without any problem.

Thus, there is a second mechanism: that of encrypting the encryption keys to create derived keys with the help of another specific cryptographic method which provides a kind of "link" with the equipment in the projection booth (or in a laboratory): Therefore, we can generate a unique key for each screen.

If you haven't read it yet, I recommend reading the following chapter Cryptography that explains all cryptographic concepts involved, with beautiful diagrams.

FIGURATIVE EXPLANATIONS

Use an allegory as example :

Imagine a house (DCP) with several closed rooms (encrypted MXF) that are locked by keys (AES).

These keys (AES) must be transmitted to certain people (eg. theaters, laboratories). To do that, they provide their own mini Safe (RSA public certificate).

As soon as it's closed, these safes can only be opened with a private code (RSA private key) that each of these people has. When the safe is closed, it's impossible to open it, not even by you and someone else. Only the holder of the private code can open their own safe.

Put the key (AES) inside the safe and close it (using the RSA public certificate - which gives an encrypted data for real, but in our example, we just close the safe).

At last, for logistic reason, you put this safe inside a big delivery cardboard box (KDM) accompagnied by a letter containing some useful and public information (KDM Metadata) for those who receive or process the delivery cardboard box (such as the software in booth like TMS).

The person will receive the delivery cardboad box (KDM), they open it, read the letter (KDM Metadata) to know what the box contains. Then, with their own private code (RSA privave key), they open their own safe (for real, the safe is encrypted data) : at last, they got the key (AES).

Fundamentally and technicaly, after all the processes, the delivery cardboard box (KDM) is useless. In other words, a KDM becomes totally useless once you have access to the AES keys.

However, for several reasons (such as the right management), the DCI players store theses informations (either the entire KDM, or just the metadata) in order to determine whether a theater can or cannot exploit the movie.

To summarize :

- "The house" is our own digital movie (DCP)
- "The closed room" is our encrypted MXF.
- "The key" is our AES key [1]
- "The safe with the private code" are our RSA public certificate (safe) and RSA private certificate (private code)
- "The cardboard box" and "the letter" are own KDM and these metadata.

Thus, our KDM stores :

- Our letter : the public and non-encrypted metadata (in plaintext)
- Our safe : the private and encrypted data (AES keys)

In summary: the main purpose of a KDM is to store AES keys which will be used to decrypt the encrypted MXF and will be identified in the CPLs.

INSIDE A KDM

A KDM is a file in XML format (UTF-8 encoding).

To help with understanding the rest of the document, Get straight to the core with an example of a complete KDM [2], including optional elements, for a CPL generated for this particular case :

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  <AuthenticatedPublic Id="ID_AuthenticatedPublic">
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    <MessageType>http://www.smpte-ra.org/430-1/2006/KDM#kdm-key-type</MessageType>
    <AnnotationText language="en">KDM</AnnotationText>
    <IssueDate>2022-10-02T21:07:09+00:00</IssueDate>
    <Signer xmlns:ds="http://www.w3.org/2000/09/xmldsig#">
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```

```
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    </ds:KeyInfo>
  </ds:Signature>
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```


Don't worry about this content, it may seem complex, but it is actually simpler than it looks.

The ETM standard already defines the basic elements we see above.
The KDM standard adds and removes more.
Thus, a KDM is an extended version of an ETM

If we simplify a KDM for a global overview, we can see this :

```
<DCinemaSecurityMessage>
  <AuthenticatedPublic/>    <!-- (1)st part -->
  <AuthenticatedPrivate/>   <!-- (2)th part -->
  <Signature/>              <!-- (3)st part -->
</DCinemaSecurityMessage>
```

Suddenly, it looks much clearer, isn't it ? :)

We quickly notice that a KDM is divided into three main parts :

	Block name	Description
1	**Authenticated Public**	It's the non-encrypted part (plaintext) Freely accessible, it can be read by anyone without cryptographic constraints **It contains necessary metadata for management**.
2	**Authenticated Private**	It's the encrypted part It can only be read using the private certificate of the receiver (player or encoder). **It contains the encrypted AES keys**.
3	**Signature**	It's the part used to authenticated the message. **It contains several fingerprints, signatures and certificates**.

Each part being quite dense, they are covered in the following chapters :

SUBCHAPTERS

- **KDM - Authenticated Public** : the non-encrypted part and readable by anyone
- **KDM - Authenticated Private** : the encrypted part and readable only by the receiver
- **KDM - Signature** : our part in authenticating and validating the KDM

- **KDM - Codes** : Source code and technical tips on each part of the KDM

RELATED CHAPTERS

- **Cryptography** : To understanding the cryptography used in digital cinema.
- **Certificate** : The certificates used in digital cinema.
- **AES Cryptography** : The symmetric cryptography used to encrypt the MXF.
- **RSA Cryptography** : The asymmetric cryptography used in KDM to encrypt AES keys (among others things).

NOTES

1. To be precise, the AES keys will be used to decrypt the encrypted data in the encrypted layer in MXF. See the cryptograhy inside the MXF chapter for details. ↩
2. For the needs of this document, the KDM elements has been modified. They are syntactically correct but cryptographically wrong. For example, signatures are broken and some UUIDs are modified. Don't use it to validate your tools. ↩