Pro-MPEG Forum

Working together with MXF

"We are on the verge of a metadata revolution. Get your data models clean and prepare for an interesting ride"

Tim Berners-Lee, 1999

What is MXF ?

The Material eXchange Format (MXF) is an open file format targeted at the interchange of audio-visual material with associated data and metadata. It has been designed and implemented with the aim of improving file-based interoperability between servers, workstations and other content creation devices. These improvements should result in improved workflows and result in more efficient working than is possible with today's mixed and proprietary file formats.

MXF has been designed by the leading players in the broadcast industry with an enormous amount of input from the user community to ensure that the format really meets their demands. It is being put forward as an Open Standard which means it is a file transfer format openly available to all interested parties. It is not compression-scheme specific and simplifies the integration of systems using MPEG and DV as well as future, as yet unspecified, compression strategies. This means the transportation of these different files will be independent of content, not dictating the use of specific manufacturers' equipment. Any required processing can simply be achieved by automatically invoking the appropriate hardware or software codec. However, MXF is designed for operational use and so all handling processes are seamless to the user. It just works.

Besides offering better interoperability - working with video and audio between different equipment and different applications - the other major contribution is the transport of metadata. By developing MXF from the beginning as a new file format, considerable thought has gone into the implementation and use of metadata. Not only is this important for the proper functioning of MXF files, it will also enable powerful new tools for media management as well as improving content creation workflows by eliminating repetitive metadata re-entry.

The changing technology of television production and digital services to viewers means the ways for moving content – programme video and audio – in studios is changing too. Not only is there far greater use of computers and IT-related products, such as servers, but also reliance on automation and the re-use of material have expanded. Besides the need to carry metadata, file transfers are needed to fit with computer operations and streamed for real-time operations.

The development of the Material eXchange Format (MXF) is a remarkable achievement of collaboration between manufacturers and between major organisations such as Pro-MPEG, the EBU and the AAF Association. It establishes interoperability of content between various applications used in the television production chain. This leads to operational efficiency and creative freedom through a unified networked environment.

How does MXF improve my workflow?

The existence of an open, industry-wide metadata-aware file format will have a big impact on the way in which material is handled. The typical stages in creating a TV program are shown below. At present the hand off between each stage comprises a mix of video tape, proprietary multimedia files, Word documents, Excel spreadsheets, faxes, sticky labels, Post-It™ notes and word of mouth metadata transfer. In fact the only metadata which is handled in a reasonable universal way is Timecode. Experienced professionals will know, however, that even Timecode handling is not "clean" throughout many workflows and often much time is wasted working around Timecode metadata problems rather than reaping the benefits of a clean metadata chain.
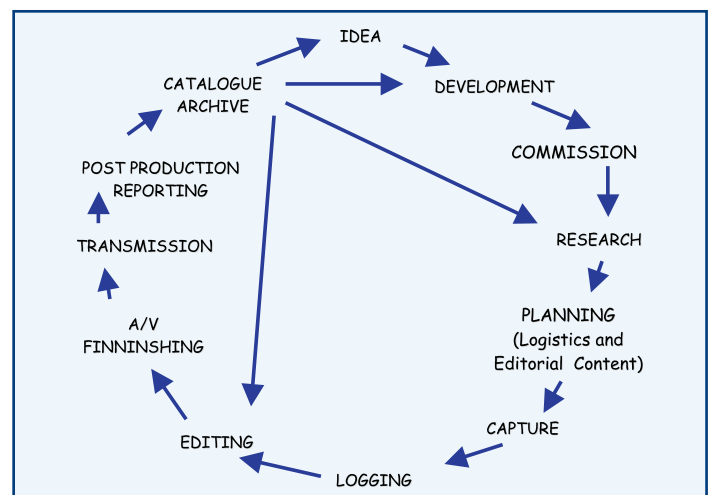
As MXF gets adopted by more manufacturers, more and more of the transfer stages in the figure will allow a rich variety of metadata to be transferred to the next production stage allowing media professionals to concentrate on using the multimedia content and metadata rather than hunting the information they need. This can be demonstrated with a simple example. Imagine that some wildlife footage is shot on location in Africa. GPS metadata (i.e. the geographical coordinates of the camera) is added to each camera shot as an annotation. This metadata will stay with the essence inside the MXF file while the program is being created. An automatic production process could then convert GPS coordinate information into additional human-readable metadata such as "Masai Mara". This workflow automation reduces mundane human chores and improves the accuracy of the stored data.

MXF has the added benefit that it shares a common object model with the Advanced Authoring Format AAF. The Advanced Authoring Format is a sophisticated data model and software toolset which allows complex post production devices to share essence data and metadata. This means that taking material into the Post Production environment and extracting finished content from that environment is done in a seamless fashion.

What can MXF do ?

MXF is a versatile file format which can perform a number of tasks. It can:

- Store simple completed works with metadata (tape replacement)
- Store files in a streamable format which allows viewing while transferring
- Wrap up a playlist of files and store the synchronisation information
- Wrap any compression format
- Store cuts-only EDLs and the material they act on

To understand more, it is important to understand the difference between streaming and file transfers. Traditionally broadcast television has been built around streaming video and audio. This is logical as the original scene action and the viewer expectation is of continuous real-time video and audio – supported by continuous streaming. PAL and NTSC analogue composite video, and digital SDI (serial digital interface) and SDTI (serial digital transport (data) interface) all stream. But computer systems exchange data by file transfers.

Streaming media:

- Is viewable during transfer – before all the data is delivered
- Offers minimum delay for live action
- Is point-to-point with no bottlenecks: offers reliable, continuous operation

Networked media:

- Uses low-priced, standard IT components
- May be stored on a wide variety of devices including disks and tape
- Offers flexible data exchange, sharing and distribution

Both real-time streaming and file transfer have their advantages and both will continue in use. Therefore, it is essential that both have some degree of compatibility so they can co-exist and allow material exchange between them. With this in mind, the design of MXF makes it a file format that can stream – creating a seamless bridge between the two transfer types. Operationally, there is no effort involved beyond requesting the transfer. So, for example, advantage can be taken of the flexibility of AAF in post production and, via 'invisible', simple file conversion, MXF for the finished playout to tape streamer or server storage. Note that the file conversion is loss-less for video and audio, if the compression scheme is not changed.

In a similar way, operational and creative staff want to concentrate on their tasks and not bother with compression issues. But is it also true that no single compression format will suit all applications and various schemes will continue to be used. Therefore MXF is compression-independent, offering the same service regardless of the compression in use. This allows manufacturers to provide equipment with multiple compression codecs, which could lead to seamless working between, for example, MPEG and DV-based systems.

Open formats and standardisation
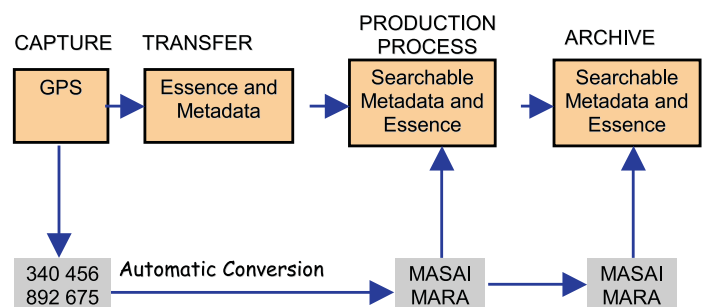
MXF is an open solution and so has been submitted to SMPTE for standardisation. Together, the Pro- MPEG Forum and AAF Association have support from a substantial cross-section of the industry. In addition, close collaboration with user groups, such as the EBU, ensure that users' needs are incorporated. At the same time, many manufacturers and suppliers of software and hardware are keen to implement MXF as soon as possible

As mentioned, in a move towards early standardisation, MXF already adheres to SMPTE KLV guidelines (Key, Length, Value - a method for wrapping data for transport over networks) and has extensively used and tested the SMPTE dictionary and other registries.

Achieving interoperability is the prime objective of Pro-MPEG and MXF. This has been implemented in three areas!

Cross-platform. It will work across different network protocols and across operating systems including Windows, Mac, OS, Unix and Linux.

Compression-independent. It does not convert between compression formats; it does make managing more than one in a single environment easier. It can handle uncompressed video.

Streaming / transfer bridging. MXF interoperates seamlessly with streaming media – especially SDTI where fully transparent interchange is achieved. This performance is bi-directional: achieved going from MXF to streaming and vice versa., and means SDTI fits easily into a file-based environment. This is true convergence.

How does MXF work ?

A simple MXF file looks quite unexciting on first inspection:
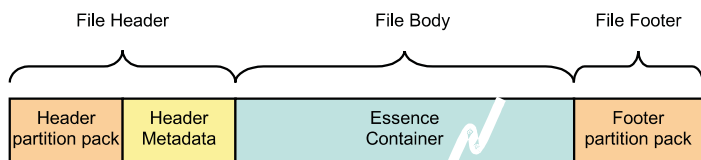
It has a header at the head of the file, a footer at the foot of the file and some Essence in the body of the file. Every item in an MXF file is KLV (Key Length Value) coded. This means that every item with in the file is identified by an unique 16 byte key and by its length. Defining the length of every field in the file (including the essence) allows simple MXF decoders and processing engines to ignore bits of the file they don't understand i.e. Keys they don't recognise. This in turn allows the file format to grow and for extra features to be added as new compression techniques and metadata schemes are defined.

The header metadata area of the MXF file is where much of the benefit of MXF comes. It is the area where metadata is added and the timing and synchronization parameters of the file are defined. The synchronization and description of the essence is controlled by 3 packages:

● Material Package

● File Package

● Source Package
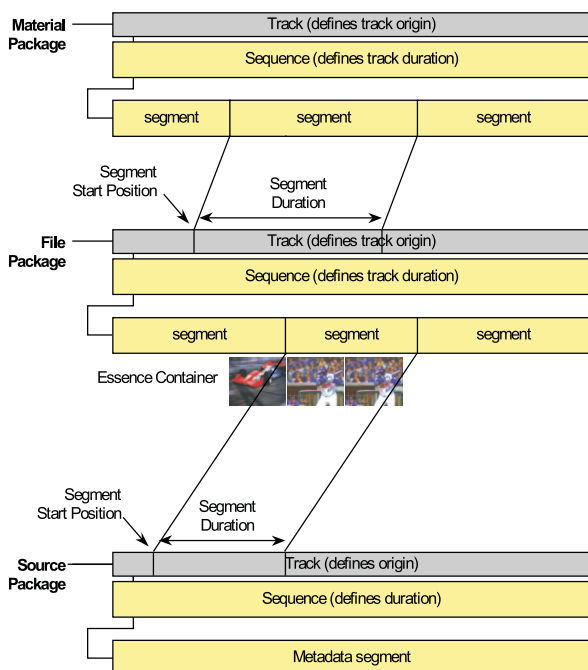
The Material Package represents the output timeline of the file. The actual essence is described by the File Package. The derivation of that essence (previous EDLs, descriptions of original film stock etc.) are contained within the Source Package. It can be seen in the diagram that each of the file packages can have a number of tracks. The tracks represent each of the different elements of the essence (e.g. a Picture track for the video, a Sound track for each of the audio channels, a Metadata track for the metadata). These tracks in turn hold a sequence of segments which define how to create the desired output of the file.

If there is a single segment in the Material package which corresponds to an entire File Package, then we have an MXF file which represents a simple tape. If the Material package has many segments coming from many file packages (which are wrapped up within the MXF file) then we have an MXF file which represents an EDL. To manage the complexity of MXF, Operational Patterns have been defined which limit the features which can be used in different applications. These form a grid which is divided vertically depending on the timeline complexity within the file and horizontally depending on the number of different packages within the file.

MXF provides additional tools such as Index Tables, partitioning for streaming, partitioning for file transfer recovery, UMID support and many other features to make it the format of choice for rich-media applications.
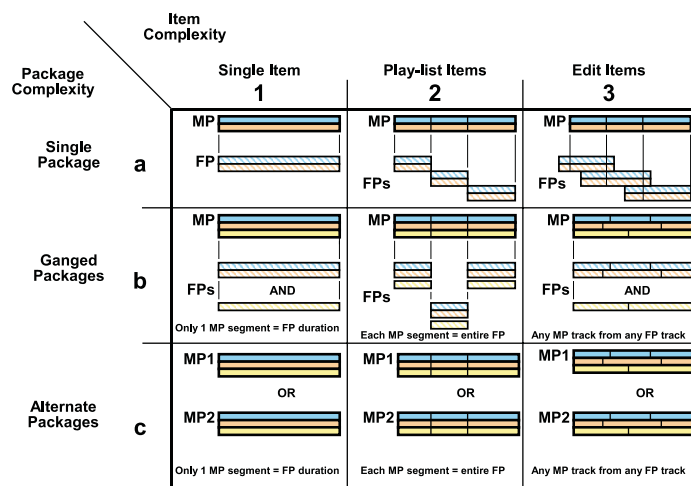
Metadata

A major aim of MXF is the seamless passage of programme content and its associated metadata.

Also referred to as 'data about data' it exists in any system today. For example, timecode is a form of metadata. The problem is that, due to incompatibilities, this information is currently lost as the content moves between systems. MXF-enabled systems will communicate using metadata, video and audio. MXF metadata may carry information about:

● The file structure

● The body contents – e.g. MPEG or DV, 525 or 625, etc

- Key words or titles
- Subtitles
- Reference numbers
- Editing notes
- Location, time, date and version number
- …………

The list may be endless. In extreme cases files may contain more metadata than video or audio content! However, the efficient implementation of metadata is seen as the key to material management. The metadata may be filtered to hold only what is relevant to the particular operational environment, thereby cutting possible meta-mountains.

Industry support

The speed of progress of MXF is a tribute to the many dedicated engineers across the industry working together towards a common objective. Manufacturers and users both recognise that there is a window of opportunity to establish an industry file format standard. The use of video will increase into an expanding array of broadcast and allied applications, as will the use of IT and servers. Any delay in establishing standards will make the task more difficult as proprietary solutions will spread into the format vacuum.

To speed implementations, a number of SDK (software development kit) efforts are underway. The software source code is available for free and using the available tools can give products basic MXF awareness very quickly. Details of the code is available via the Pro-MPEG Forum, the AAF association and the EBU.

MXF and AAF

Advanced Authoring Format (AAF) is an industry driven open standard for multimedia authoring and postproduction. It enables content creators to easily exchange digital media and metadata across platforms and between applications. It simplifies project management, saves time and preserves valuable metadata that was often lost in the past during media transfers.

MXF is derived from the AAF data model and is a simple interchange format, primarily to facilitate the transfer of finished content, whole programmes or completed sections, between servers and to tape streamers. MXF also helps with the migration of playout operations and simpler production systems into standard networked environments.

The two formats are especially complementary.

Whereas AAF integrates closely with, and complements, existing media file formats, MXF offers the same for existing stream formats as well as AAF files. Both formats can stand on their own and each has a functionality and design optimised for their particular spheres of application. At the same time, one does not depend on the other. For example, a whole broadcast system may use only MXF and a postproduction house, just AAF, but a broadcaster with a post facility may well use both.

While the MXF and AAF are complementary, there are many differences. One is that AAF may carry references to outside material held in other places, to be used in an edit whereas MXF is always complete and self-contained: not requiring any access to outside material. In addition AAF includes basic video transition processing whereas MXF, carrying completed programme material, has no need of that.

Conclusions

MXF is driven by user needs and so has a strong commercial base. Even normally competitive manufacturers are working together at high speed to provide an open industry solution to file interchange. Working together, targets have been met; MXF is now submitted to SMPTE and is well on its way to helping media flow in the television/IT convergent world. End users will be able to better manage their media and to concentrate on their prime tasks of productivity and creativity.

References

http://www.aafassociation.org

http://www.ebu.ch

http://www.pro-mpeg.org

http://www.smpte.org

About Pro-MPEG

The Pro-MPEG Forum is an association of broadcasters and programme makers, equipment manufacturers and component suppliers with interests in realising the full potential offered by MPEG-2 as an open, international standard for compressed digital content. The Forum focuses on MPEG-2 equipment interoperability according to the implementation requirements of broadcasters and other end-users. Working together, members of the Pro-MPEG Forum will advance the practical applications of MPEG-2 technology in broadcast systems. The Forum currently has over 130 members throughout the world.