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THE APPLICABILITY OF THE INTEROPERABLE MASTER FORMAT (IMF) TO BROADCAST WORKFLOWS

MELANIE MATUSCHAK
EBU, RheinMain University of Applied Sciences

ABSTRACT

The broadcast industry is faced with new challenges related to advanced file-based workflows. The adoption of an increasing number of distribution channels and localized content versions points to several editorial versions and output versions being required. Furthermore, broadcasters are starting to produce UHD content, which raises even more questions in terms of file handling, workflow efficiency and compression technologies.

The Interoperable Master Format (IMF) has capabilities that might make it a suitable candidate to solve many of today's challenges in the broadcasting industry. However, it doesn't yet appear to be sufficient for broadcast applications.

This article suggests a way of adapting IMF to broadcasters' requirements by giving an insight into possible extensions to the IMF structure. It will be of interest to broadcasters, distributers and producers who need an efficient master format capable of accommodating today's workflow challenges.

The achievements, presented in this paper, are part of a collaborative master thesis, realized at the EBU and the RheinMain University of Applied Sciences, Germany.

INTRODUCTION TO IMF

The Interoperable Master Format (IMF) provides a standardized data structure for packing finalized, high quality audio visual content. It includes all relevant components to create various editorial and technical versions for repurposing to different distribution channels, territories and platforms and, at the same time, reduces storage by avoiding redundancy.

IMF is a final master package for Business to Business (B2B) content exchange and it is designed to be a flexible but nonetheless well standardized framework.

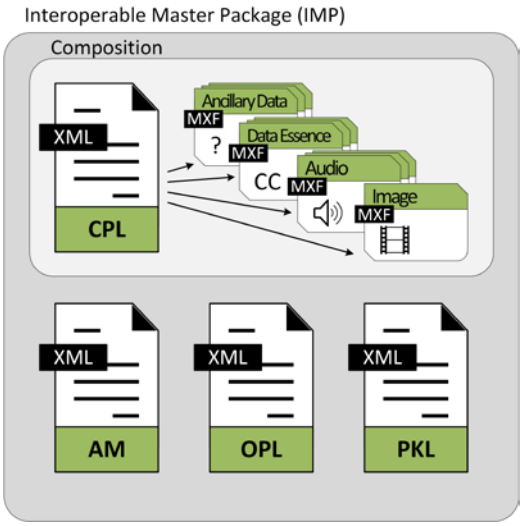

Figure 1: Structure of an Interoperable Master Package (IMP) including Composition Playlist (CPL), track files, Assetmap (AM), Output Profile List (OPL) and Packing List (PKL); as indicated in [1].

Following the example set by the Digital Cinema Package (DCP), the Interoperable Master Package (IMP) has a simple data structure. Referring to Figure 1, a composition consists of a number of essences, which are described by a Composition Playlist (CPL), which can be pictured as a very complex EDL. Essence data, such as video, audio and subtitles, are wrapped into separate MXF files and refer to the CPL. Additional XML files give instructions on the processing and further transcoding requirements. Whereas the CPL is convenient for providing editorial versions such as multi-language versions, the Output Profile List (OPL) contains the technical transcoding instructions for a specific output format. This creates a high level of re-versioning capability and the potential for automation. At the same time, IMF minimizes storage by re-using essence components for different editorial versions. It guarantees optimum quality by maintaining source material at a mezzanine level compression, reducing the number of transcoding processes to a minimum. As a result, IMF is convenient for versioning and repurposing of finalized content.

IMF-related standards are comprised of two types; the core framework, which defines overall constraints and ensures interoperability, and so-called IMF applications that extend the core functionality. Applications provide a detailed description of the supported codecs, including resolutions and frame rates and with the addition of new applications, supporting new codecs, resolutions and other extensions to the IMF core framework. The set of IMF standards may be continuously broadened, as shown in Figure 2.

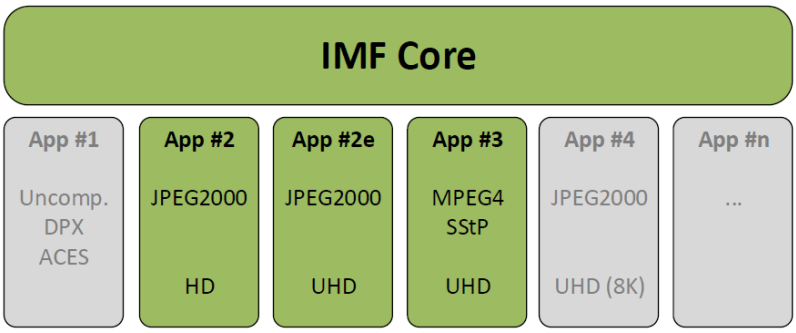

Figure 2: Overview of the IMF general standards structure; basic constraints are defined in the IMF core framework, which is extended by applications, providing a specific description of codecs and resolutions; as indicated in [1].

REQUIREMENTS ANALYSIS

To investigate the applicability of IMF to broadcast workflows, a number of questions had to be analysed. First, it was essential to find out about current problems within broadcast and distribution workflows. Therefore, an international survey among broadcasters, distributers and producers was conducted into their awareness of IMF and their workflow and master format issues. The participation of experts among European broadcasters, distributers and producers was essential for gathering reliable information. After identifying the major issues, the question was raised as to whether IMF is able to solve current broadcast challenges. Taking the current state of IMF development into account, a list of requirements was created to show how a broadcast-adapted IMP could be structured.

The following list shows the elements that a broadcast-adapted IMP may contain:

- *Video essence* — using the AVC Class 100 specification in High 4:2:2 Intra Profile (AVC-I 100), wrapped into MXF OP1a container
- *Audio essence* — using PCM, wrapped into MXF OP1a container
- *Subtitles* — using the TTML IMSC 1.0 Standard, wrapped into MXF OP1a container
- *Descriptive metadata* — as a separate, EBUCore conformed XML scheme

Furthermore, all elements, defined in the IMF core framework shall be included.

The requirements analysis showed that the JPEG2000 codec currently integrated in IMF may not be suitable for broadcast workflows. It has a higher bitrate, compared to video codecs commonly used in the broadcasting industry, and its unfamiliarity concerned a notable number of the broadcasters that were surveyed. The AVC-I 100 broadcast codec was therefore favoured due to its known quality performance, its licensing terms and future prospects for development.

The second major issue to surface amongst broadcasters was the difficulty they experience regarding the exchange of descriptive metadata in terms of format, compatibility, mode of transmission and completeness. There is no obvious, global metadata scheme for the exchange of descriptive metadata built into IMF so far. For that purpose a highly flexible and adaptable but nevertheless standardized metadata scheme was needed. EBUCore is an ideally suitable framework for descriptive and technical metadata that has been developed by the EBU for integration into broadcast workflows [2]. By using the EBUCore metadata scheme, broadcasters have the flexibility of adapting the XML scheme to their specific workflow and production needs whilst maintaining a standardized and reliable exchange of descriptive metadata. Furthermore, EBUCore can integrate references to other metadata bases such as EIDR or to internal (proprietary) systems which enhances its flexibility and reliability as well. The proposal is to integrate a dedicated XML metadata structure into IMF to accommodate EBUCore and hence to better adapt it to broadcast requirements.

Regarding audio and subtitle essence, broadcasters are keen to integrate multiple language versions as well as multiple audio mixes to their master formats in a standardized way to increase workflow efficiency and possible automation. The IMF standard is planned to include the TTML IMSC subtitle profile when it is published by W3C. This is good news for users of the EBU-TT-D format as it effectively is a subset of IMSC, thus providing good interoperability.

FEASIBILITY ANALYSIS

Based on the requirements analysis, a feasibility study was performed to evaluate the applicability of IMF to broadcast workflows. The goal was to enable a full workflow from the delivery of finalized programme files, through the mastering of a complete broadcast IMP, to the transcoding to a final output version, as shown in Figure 3.

To ensure an accurate interpretation of the findings, SMPTE working group 35PM50, responsible for IMF development and standardization, was consulted several times. The result was presented to the HD Forum in Paris, France, to evaluate the practical relevance of the work.

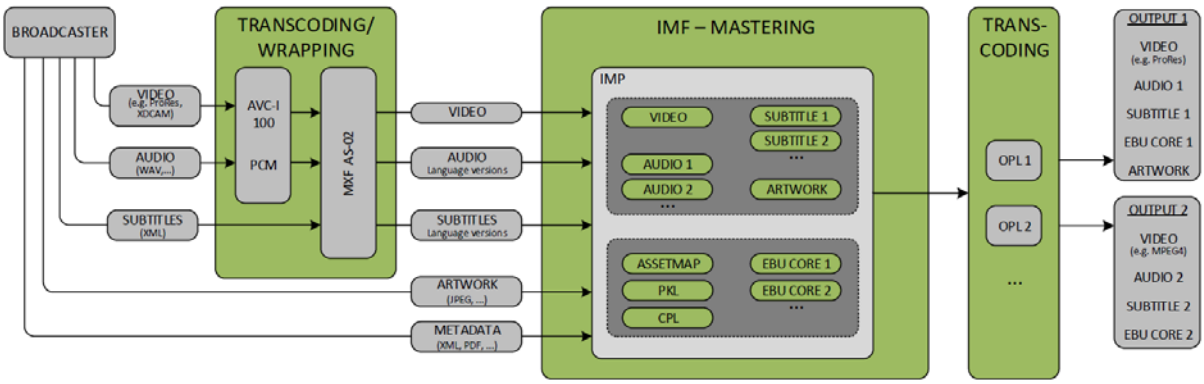

Figure 3: Full working schedule during feasibility analysis, from delivery of final program files to IMF mastering to transcoding of a final output.

To prove a broadcast-adapted IMF workflow, software support for the mastering and transcoding processes was needed. Marquise Technologies kindly provided the full versions of their MIST mastering software, their TORNADO transcoding tool and their ICE Player as a basis for the investigations. Thanks to their excellent implementation support, a full workflow was realized. For this purpose, a potential broadcast application was integrated into the MIST mastering software.

Initially, the AVC-I 100 essence coding requested by broadcasters was put into practice. Though this does not meet current IMF standardization specifications, it nevertheless shows the exemplary extendibility exhibited by IMF to an intra-frame video codec commonly used in the broadcasting industry. After importing any video file to the composition timeline, MIST transcodes essence data to AVC-I class 100 High 4:2:2 Intra Profile, Level 4.1. Finally, the video essence is wrapped into a separate MXF OP1a container during the mastering process. The audio and subtitle essence is handled similarly.

Descriptive metadata support was implemented as an editor for manual data entry. For demonstration purposes, the UK DPP descriptive metadata scheme [3] and a sample scheme from France Télévisions were used. During the mastering process, the metadata entries of each scheme were mapped to their respective EBUCore XML files. In this way, the extendibility of the IMP to any descriptive metadata scheme was demonstrated.

To be recognized by a compatible player or mastering tool, the metadata files must be referenced in the IMP by the Composition Playlist (CPL), Packing List (PKL) and Assetmap (AM). Therefore, all metadata files are related to the composition. Within the XML scheme of a CPL, the ExtensionProperties element can be used to refer to extensions within the IMP [4]. Extensions, such as metadata XML structures, are related to CPL, PKL and AM via unique identifiers (UUID) as shown in Figure 4. Herewith was shown, that multiple files can be integrated into an IMP including standard conform UUID references.

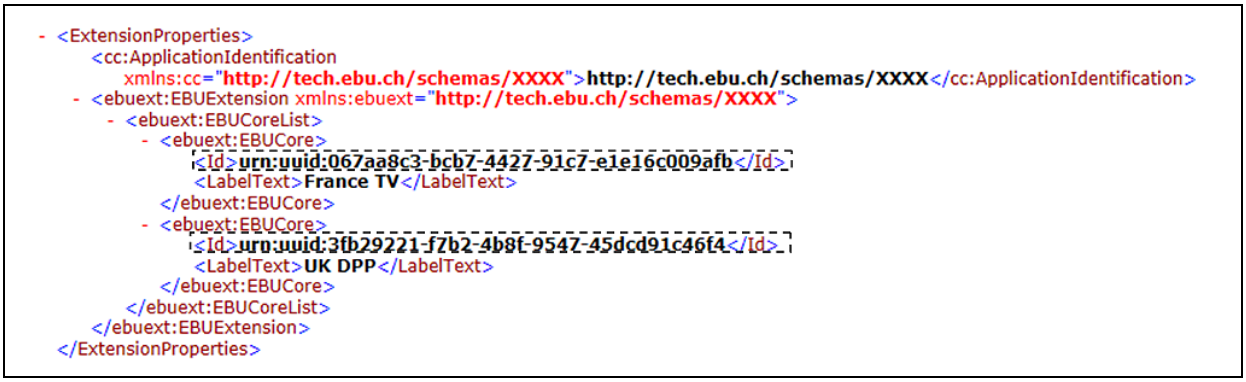

Figure 4: Modified XML structure, showing the CPL ExtensionProperties element. At this point, additional files of the IMP can be referenced via an UUID. The UUIDs of the EBUCore files (UK DPP, France TV) are marked by a black boarder. Furthermore, the used application is named by the ApplicationIdentification element. In this case, a hypothetical, however standard conform, namespace is used.

Within the mastering process, the creation of a full IMP was achieved, an example of which is shown in Figure 5. All the essence data of a composition timeline is wrapped

in separate MXF files. The full IMP contains one video MXF file with the extension "_avci", three separate audio MXF files containing different audio mixes and two more subtitle files in two languages. Furthermore, all describing XML documents are added to the IMP, as there are CPL, PKL, AM and two separate EBUCore metadata extensions.

Figure 5: Content of an example, full broadcast IMP. It contains an Assetmap, CPL and PKL and two EBUCore files as XML documents. Furthermore, there are a number of separate MXF files containing the essence data, such as multiple audio and subtitle versions and a video file.

After mastering, transcoding to a final output was performed. OPLs are meant to contain a sequence of transcoding instructions to generate a final output file. Since, currently, OPL standardization only specifies basic operations such as cropping and scaling, this part of the feasibility analysis was entirely experimental. MIST provides a node-based output tool capable of exporting XML files which define the transcoding steps. By creating a node graph with all desired transcoding instructions, an 'OPL-like' file can be generated. The TORNADO transcoding software was used to execute the 'OPL-like' file to transcode the output of a specific CPL.

In summary, the feasibility study proved that a high level of flexibility regarding IMF adaptation can be achieved. The results are independent of specific software solutions and can be implemented and repeated for any workflow and infrastructure. Nevertheless, open questions were raised that will need further investigation.

CONCLUSION

This article has presented a possible way of adapting the Interoperable Master Format to the requirements of the broadcast industry.

The current IMP file structure was extended by additional, descriptive metadata in an EBUCore XML structure. Using the example metadata sets of UK DPP and France Télévisions, it was shown that various metadata schemes may be integrated into IMF in a standardized way. Extensions made to the CPL allow the integration of multiple files without violating IMF structure in general.

Furthermore, a common intra-frame video broadcasting codec was integrated. In the scope of this paper, the integration of AVC-I 100 was realized but this could just as

well have been an UHD codec. The integration of both metadata and codec has adequately illustrated the ability of IMF to adapt to broadcasters' requirements and makes IMF a likely future proof exchange master format for broadcasters. The investigations have shown that IMF is highly flexible and applicable to broadcast workflows.

FUTURE WORK

The findings of this paper make a contribution to international IMF development by demonstrating the adaptation of IMF to broadcast workflows. Now that this has been proven to be possible, a detailed investigation of the specifications of a potential broadcast application needs to be done in international working groups. This includes the definition of a minimum, mandatory metadata scheme for IMF but also a discussion on the applicable codec, especially to enable UHD support.

In addition, more time must be spent on the specification and implementation of Output Profile Lists (OPL) having the potential to increase efficiency and automation of broadcast workflows and transcoding processes.

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