



AmberFin White Paper

The New Media Factory:
Linked processes, JPEG2000 and AS02



EXECUTIVE SUMMARY

The New Media Factory approach, which allows creation of high quality masters in a wide range of delivery formats, is a hot topic in our industry right now.

This new approach combines ingest, transcoding, captioning, quality control, audio track management and anti-piracy watermarking as linked processes. Linking these processes, rather than treating them as individual point functions, can save companies thousands of dollars by dramatically cutting costs and time.

Within these processes, one important new technique is the use of optimised JPEG2000 as a high quality intermediate service master format. Using JPEG2000 ensures high quality results can be delivered at cost effective data rates.

Another important technique is the use of MXF AS02 to streamline media movement and eliminate wasteful data handling.

In summary, the New Media Factory approach focuses on operational simplicity, both to minimize manpower overheads and also to ensure correct results are produced on time and on budget.

This white paper outlines how AmberFin has been working with forward looking content service providers to develop this important new business model.



The Media Factory business drivers

Many content companies today are producing large amounts of new content and also re-mastering libraries of other content held on SD or HD digital videotape. Content is then sold on for distribution through terrestrial broadcast, DVD, web, phone and other outlets.

Those outlets need deliverables with specific format, editorial, logo, audio, closed caption, watermarking or language requirements.

Up to now, creating these deliverables has been less than optimal. Extensive use of video tape and use of expensive non linear editors (and skilled creative editing staff on non creative work) has meant large amount of wasteful creation, movement and management of tape content between systems, buildings or even companies. Functions like ingest, QC, Transcoding, captioning, editing and watermarking typically require a number of discrete processes. Because of this, staff costs, equipment costs and tape stock costs have all been significant.

Some companies have introduced a degree of file based workflows as point solutions within these videotape environments. This partial approach has often raised new problems. Files today come in huge number of variants. File standards are often not policed, so compatibility problems arise, when moving content between systems and also when creating many different 'flavours' of final deliverables.

What is needed is a fully thought through new approach, that delivers the right kinds of files with the right contents, to the right customers on time and on budget, without the waste and inefficiencies of tape and without file compatibility issues.

Wasteful processes mean cost. Some useful definitions of wasteful process include:

- Moving media that does not need to be moved
- Keeping media that does not need to be kept
- Copying media that does not need to be copied
- Processing media that does not need to be processed
- Taking too long to process media that could be processed more quickly
- Deleting data or metadata that needs to be recreated in a later process
- Re-keying data or metadata that was previously known
- Making a tape from a file that was previously a tape

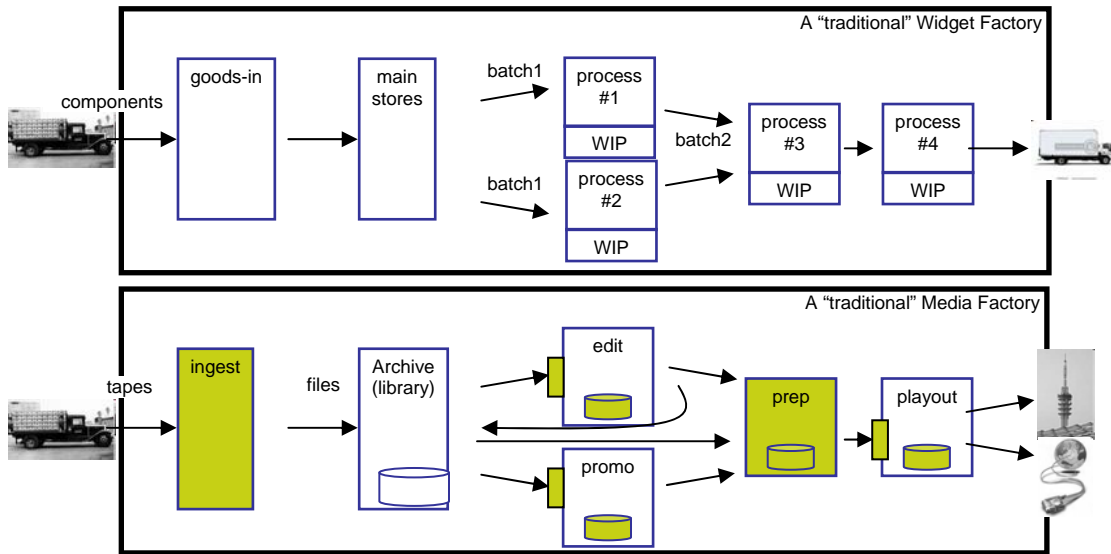
Eliminating wasteful processes is especially critical in HD because of the much higher data rates involved. In a nutshell, there are several key ideas in the New Media Factory:

- Move to file based operation, thereby reducing all aspects of tape process costs.
- Link processes which reduce unnecessary creation or movement of media
- Use of optimised JPEG2000 for HD work to maximise quality.
- Use of MXF AS02 for efficient data movement.
- Integrated asset management and back office software, to track content from ingest to final delivery and allow automation of processes – reducing the potential for expensive mistakes caused by human error.

All this needs to be done while maintaining quality all the way through to the end user.

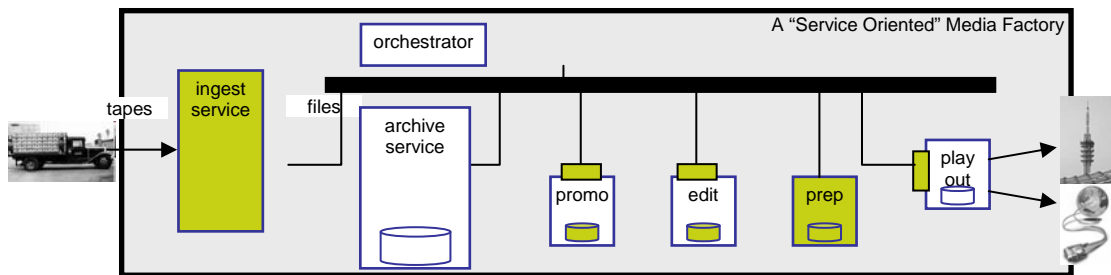


Engineering the New Media Factory



Many media facilities perform a factory function. Their “goods in” receives tapes and files that have cost money to make or purchase. The asset is stored in a central library or archive until needed. Several processes then take place where value is added, until the finished ‘product’ (broadcast programmes, web video etc.) is distributed. The AmberFin iCR ingest, Transcode and Automatic QC system is sometimes used in this traditional approach and tends to be oriented around the engineering of moving and converting formats between the processing islands.¹

However, modern manufacturing is no longer built in this simple fashion. Lean manufacturing and strictly measured business processes change the way factories operate. The same changes have yet to take place in many media operations.



Rearranging the picture shows a similar view of the processes arranged by the service they provide to the business. This “Service Oriented Architecture” has been widely discussed in the industry and is, only now, becoming a reality. The goal is to arrange the services around business processes that add value, and then to measure that value. If value can’t be measured, then either the process shouldn’t be performed, or the “value” being added has not been well defined.

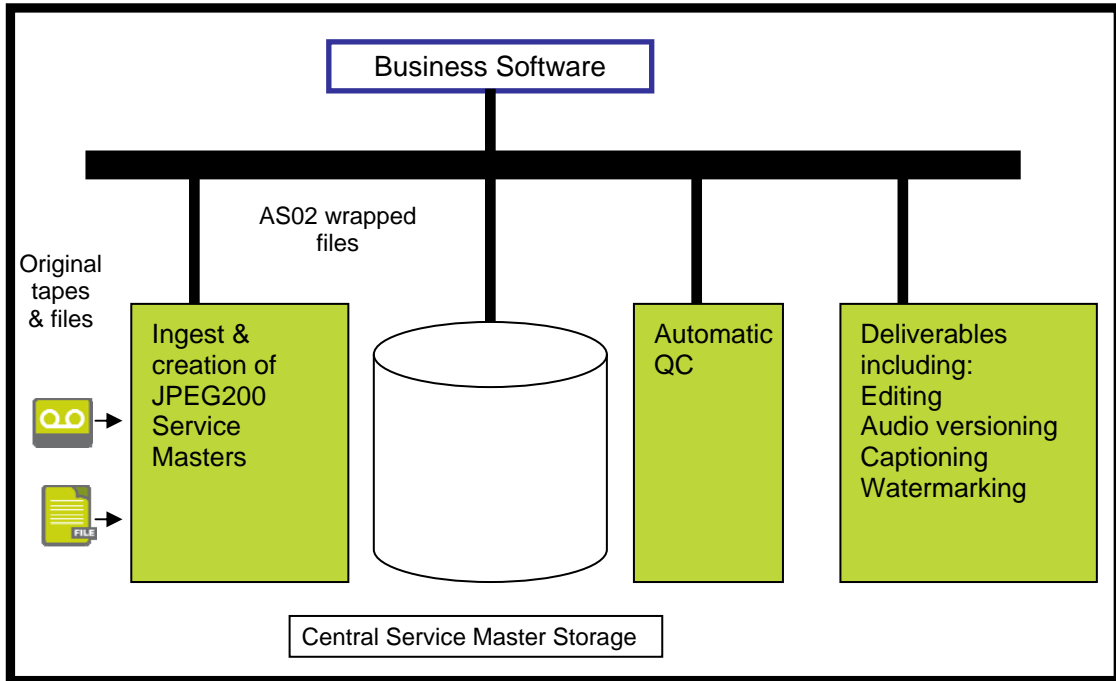
Measures of value are often called Key Performance Indicators. For example, a KPI of ingest is the number of operator-hours required to ingest, QC, annotate and make ready one hour of content. It is an important number and can vary widely between, for example, a sports broadcaster and a film channel.

¹ Highlighted in green.



For an individual business, it is a key metric and one that needs to be considered in conjunction with “reject rate” and “rework rate” of the ingests performed.

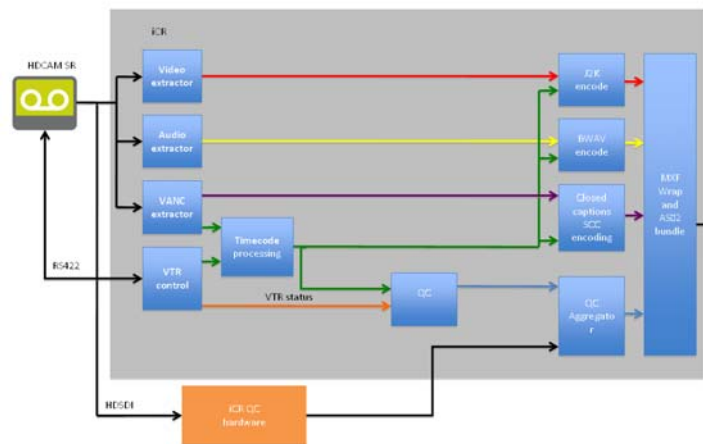
Automated tools for QC-assist and annotation can push these ingest KPIs in a direction that makes the business more profitable and at the same time improve the overall quality of the assets within the facility. An idealised New Media Factory resembles the diagram below – maximum integration of processes with minimum copying and movement of media²:



JPEG2000 Service Masters

When everything has to happen on an industrial scale, it makes sense to ingest original SD or HD tape, (or in some cases data content) and create a generic intermediate file based ‘Service Master’. Original content is thus used only once and can be returned to safe storage.

HD tape ingest



² iCR is used on the areas marked in green.



Digital in theory offers perfect quality copies every time. Unfortunately, as many papers presented at NAB and IBC have shown, there are real problems of concatenating between image compression techniques. Quality will tend to reduce with every generation of transcode. For this reason, the Service Master needs to be of high quality in order to allow the business to take advantage of the limitations of editing, promotional and distribution tools that need to be applied to the asset throughout its lifecycle.

The Service Master also need to be arranged in a way that allows Lean principles to be applied. This means reducing waste wherever possible. The compression method increasingly being chosen for the New Media Factory is an optimised version of JPEG2000 which is proving to produce excellent Service Masters.

Why JPEG2000?

JPEG 2000 is a 10 bit³ or higher format and is Wavelet based. Wavelet progressively softens as compression levels rise. Unlike DCT based compression, there are no blocking artefacts. The viewer simply sees what subjectively appears to be a lower resolution image. Correctly transcoded 1920x1080 JPEG 2000 files @ 100Mbit/sec have been found to be subjectively indistinguishable by most viewers from their 2048x1556 2K originals.

AmberFin have selected the Kakadu JPEG2000 encoder (as it is widely regarded as the most developed implementation, used in production and academia around the world) and made extensive field tests to ensure that images are high enough quality to service all the revenue generating deliverables that are likely to be encountered for both HD and SD delivery from an HD tape. AmberFin have also undertaken extensive optimisation of the encode and decode parameters for JPEG2000 to ensure best results.

High Quality 10 Bit data in file based 8 Bit applications

AmberFin have also developed and applied a new very high quality 'dithering' process to avoid truncation errors (visible as banding) when mixing 8 bit and 10 bit sources. The extreme exaggerated example⁴ below (synthesised with open source tools) shows the principle of dithering. The same 8 bit image is shown with and without dithering applied:



³ In an 8 bit system, 256 steps are available to describe luminance. A10 bit system has 1024. Therefore wavelet has the theoretical potential to show more subtlety than, for example, 8 Bit MPEG.

⁴ From <http://en.wikipedia.org/wiki/Dither>. Web image is not representative of the level of quality via AmberFin iCR.

More typically, an image without dithering would show banding problems on soft vignettes, colour ramps, sunsets and skies. By intelligent use of dithering, quality is maximised. Further work has been done to ensure that the resulting noise-like patterning in the picture does not introduce artefacts after downstream compression such as MPEG2 or MPEG4.

In the New Media Factory approach, the choice of optimised JPEG2000, rather than MPEG2 for the service master ensures that the original image quality stands the best possible chance of being preserved further down the delivery chain.

Using MXF AS02

The New Media Factory needs an efficient way to handle data and that way is MXF AS02. Three years of work by AmberFin and a dozen other companies has resulted in an application specification for MXF called AS02 (Application Specification 2) optimized for media processing within a facility, to ensure that the processes acting on it are efficiently and effectively handled. The goal is that web services can implement business processes efficiently at the MXF level whilst remaining agnostic of the compression format.

An example process is the addition of an extra audio channel to an asset. Given that an interleaved HD audio-visual asset may be 100GB in size, the process to add an audio channel needs to read the interleaved file, multiplex in the new audio channel and then re-write the file. 200GB of data needs to be moved through the network and transferred to/from disk in order to add the extra audio that may be only 3-4GB in size. This is wasteful. AS02 is designed to perform the same operation with only 3-4GB of data moves. These savings occur every time the process is performed on every asset requiring it. More details on AS02 can be found in the appendix.

Templating

Templating is key to making the New Media Factory work well. It is well known that configuring encoders is difficult on a single machine. It is also known that configuring the same encoder on machines from 2 or more vendors is incredibly complex. In fact the chances of standardizing a configuration interface are very small due to the rate at which these interfaces are likely to change to incorporate new encoder features.

This is not a problem, in fact it is a benefit. The New Media Factory wraps up business processes and presents them as a service. The interface to this service should expose properties that are likely to change due to demands from the business, rather than demands of the underlying encoder.

As an example, imagine that the iTunes delivery specification changes. The business process does not change – it remains as a request to “Make me asset xyz to an iTunes delivery specification”. The details of the specification change are, nearly always, a matter for the configuration of the encoder or transcoder.

For this reason, the AmberFin iCR ingest, Transcode and Automatic QC system presents its functionality via a web service interface as a templated system with overrides. AmberFin encourages it's customers to communicate to the iCR at the business level, leaving the low level audio-visual manipulation to the highly complex algorithms on the inside. Deliverables are created with the appropriate quality at the appropriate speed.

In addition, when the iCR is operated by a human operator, the use of templates eliminates possible operator errors when initiating ingest or transcode jobs, minimizing the possibility of expensive operator mistakes.



Some examples of templated tasks include:

- Ingest to my HD JPEG2000 AS02 profile
- Add bars/tone
- Overlay Timecode

Examples of templated tasks with override parameters presented through web services are:

- Add Watermark with payload xyz
- Transcode to iTunes format and place output in folder xxx
- Transcode to flash and splice segments 1, 2, 3 with a logo from files x:/x/x.pn

Integrated QC and Content Verification

Quality control is critical in the service oriented facility. Getting it right first time avoids costly re-works and potential difficulties with customers. One unique function of the AmberFin iCR system is that it can perform automatic QC on ingest. That means potential image, sound or data faults can be identified to the operator at once, before any further work takes place.

iCR Automatic QC also helps quickly identify segment points, as it can be programmed to detect black, silence or freezes. Segment markers can be passed back from iCR to business software such as third party asset management to describe the asset. This information can be used to create the correct sequence of content on the deliverables.

Deliverables

In the New Media Factory approach, when an order comes for a deliverable, the specific end customer requirements can be matched against the content and new instructions sent to iCR by third party software to create the final deliverable output from the intermediate service master, including audio layout, encoding profile, closed captions, watermarking, logos and text. The deliverable is then ready to go to the end customer.

Third party business system software then would be able to track commercial progress e.g. despatch, billing etc.

Integrated Closed Captions

The New Media Factory has an elegant way of handling closed captions. By using a service master format of a .SCC file, it is possible to generate all of the SD and HD captioning formats for deliverables. The .SCC file can be generated at tape ingest from both SD and HD sources if available on the tape.

Caption processing might include replacing of captions and insertion of captions back into VANC / VBI for outputs that support it or insertion of caption / subtitle data into Transport Stream for VoD. Most non broadcast outputs also require captions.⁵

Since original programmes are sometimes divided up into reels, iCR can splice the reels (and if necessary their captions) together. This can happen at ingest. If necessary, new timecode can be applied.

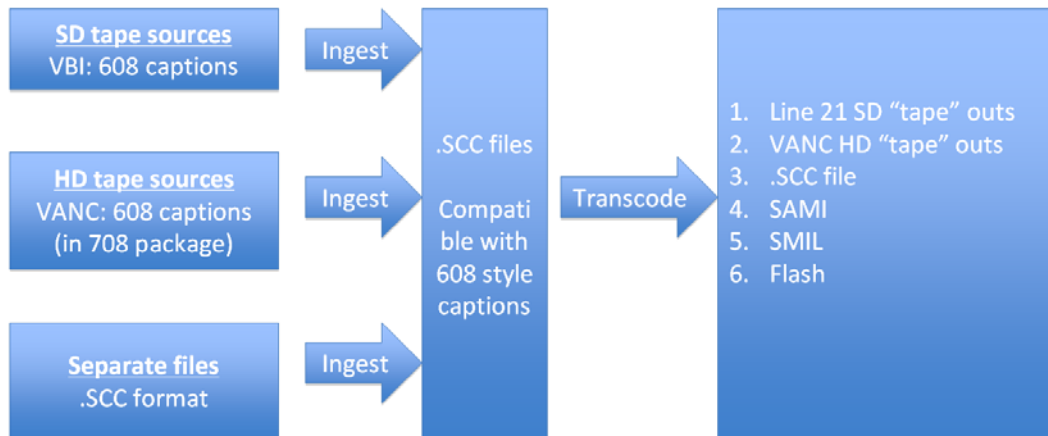
One of the key reasons for storing captions as a file rather than as VANC is deliverables because nearly every deliverable requires manipulation of the caption data when assembling the target output files.

⁵ For example, services such as Hulu and iTunes offer the availability of captions on their players.

Some examples of changes:

- Adjust the time base
- Convert caption file to subtitle file
- Create new caption file based on cutting / splicing operations, timed to the new output video⁶.

With so many potential international versions, audio track insertion and audio track slipping tools are necessary, along with addition of any logos or text.



Audio track management

With so many possible different audio versions, audio track management is important. Since language versions can run to different lengths compared to the original picture, iCR allows trimming, slipping and padding of audio tracks, so that when a deliverable is created, pictures and sound match.

Anti Piracy Integrated Watermarking

In an era when file based content can go anywhere in the world in a matter of minutes, monitoring and protecting content is of vital importance. Watermarking systems such as Civolution can be fully integrated in the New Media Factory process as a plug in within the iCR Transcode engine. Users can watermark content during transcoding, without spending time and money on a separate process and without generation loss.

Watermarking is then applied to all Transcode operations that have a watermarking parameter in their conversion profile and can be initiated with the watermark payload in a web services call. All Transcode engines that perform Watermarking can form a watermarking group controlled by a single job controller.

⁶ Cutting might mean extracting just the program content from a complete encode. Splicing might mean inserting 10 second black slugs at chapter points for ad insertion, cutting out existing blacks, merging segments from separately ingested files and so on.

Summary

The New Media Factory model is replicable and scalable so that companies can build and grow their own in-house resources as they need, or use the model in conjunction with external Post houses.

It allows custom workflows to be built from commodity products.

It allows for the interfaces to work at the business level so that improvements to the underlying equipment can be seamlessly integrated.

It creates a framework for a future true 24P process that would allow any HD and SD deliverable to be made from a single source, including audio and captions.

Every opportunity is taken to maximise quality - and by using optimised JPEG2000 for Service Masters, excellent results are easy to achieve.

Every opportunity is taken to minimise waste. Ingest, Transcode, Automatic QC, Captioning, Audio track management and Watermarking are all brought together as linked processes. Wasteful activities are driven out of the system, bringing costs down.

Efficiency is key and use of AS02 streamlines data handling.

The overarching idea is to organise processes by the value they bring to the media business, not simply make a rough fit around existing engineering and operational tools.

The New Media Factory idea is already being invested in by organisations who want to update existing Transcode systems or open new Transcoding operations.

The new media factory is being delivered by AmberFin today.

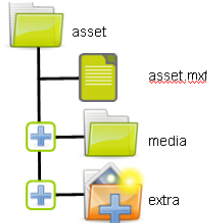
If you want to discuss any of the issues raised in this white paper we'd be happy to do so. Please email

marketing@amberfin.com



Appendix: MXF AS02 – how does it work?

MXF AS02 uses only elements of the 2004 version of the MXF standard, designed for efficiency.

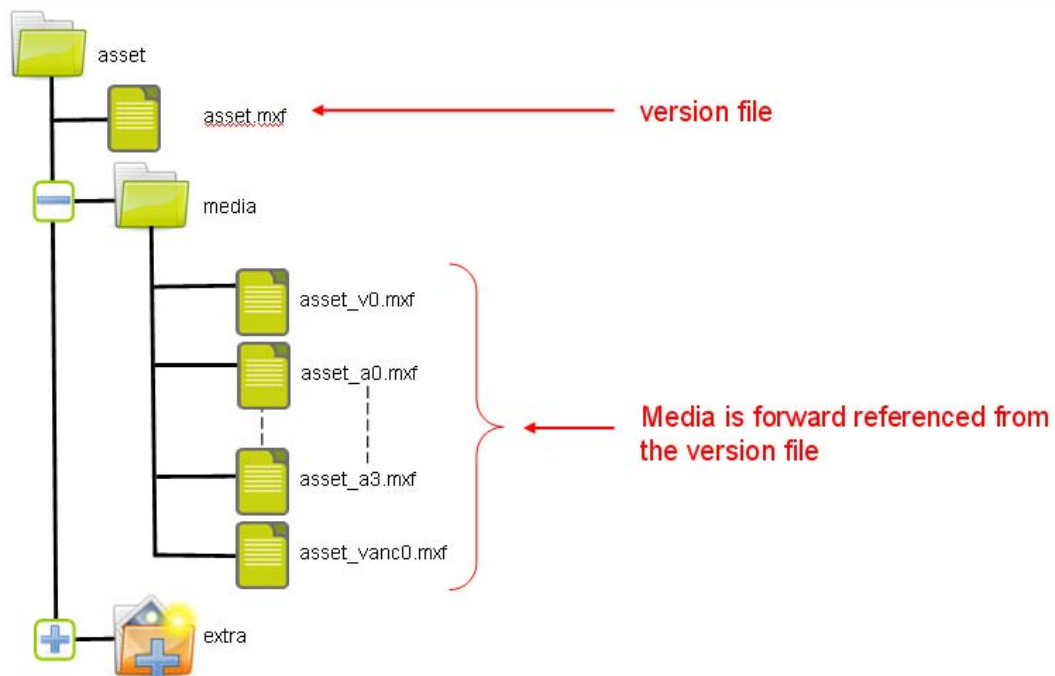


The top level structure of AS02

To enhance interoperability, specific constraints are made on application behavior, file layout and permitted codec range. Whilst most of these constraints are in the controlling document (<http://wiki.amwa.tv>), some of the constraints need to be set at the facility level.

It was realized by the MXF designers that each facility has specific needs, for example DNX in one facility and JPEG200 in another. Full interoperability using vendors standard product requires that these special needs are constrained and documented. These facility specific restrictions are defined by the business and are written into a managed and version controlled document called a shim⁷.

The figure below shows the basic layout of files in an AS02 structure:

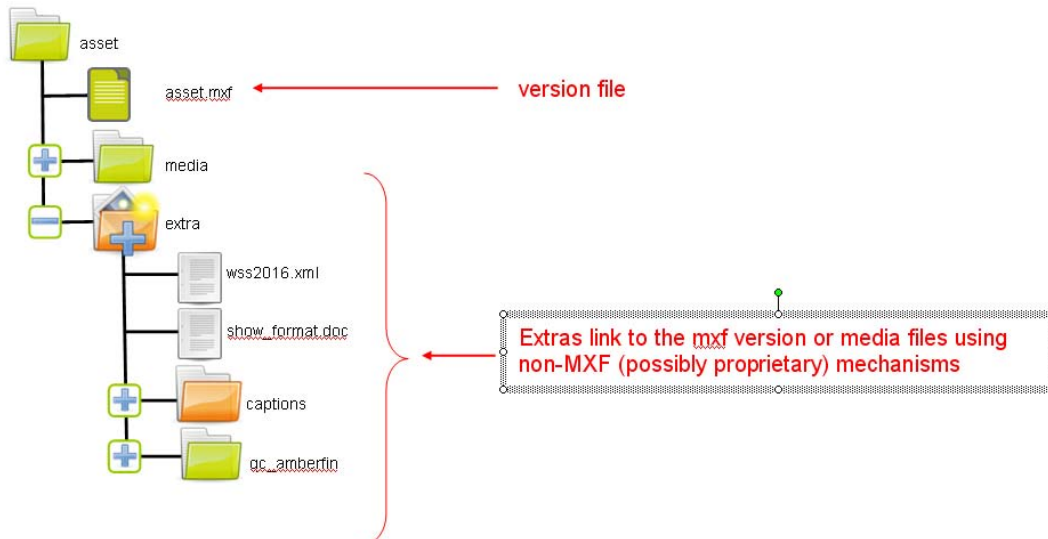


⁷ Chambers dictionary: A shim is a small piece of wood or metal to adjust the gap between machine parts. In this instance, a shim is a small piece of specification designed to fill the gap between the generalised committee specification and the localised use of that specification within a facility.



The operational rules of AS02 are as follows

- All components of the asset lie inside a root folder.
- Multiple versions of the asset may exist.
- The primary version (if it exists) has the name of the root folder.
- Essence components holding video, audio, data and are in a subfolder called **media**.
- Version files are MXF files with no essence and are very small (10kB - 500kB).
- Component files are mono-essence (video in a video file, audio in an audio file).
- Non-essence files are stored in a subfolder called **extra**.



These rules are pragmatic and reflect the fact that the population of MXF software engineers in the world is smaller than the number of software engineers that can move, copy and zip folders of files. The result is that many file based operations can be achieved more simply and without recourse to special MXF tooling. For example:

1. Customized, mission critical metadata can be stored “inside” the asset by putting it in a unique subfolder of. No special MXF code required.
2. The entire asset can be moved with commodity file moving software (move folder, zip folder + move, tar folder + move).
3. Storing a QC report with the asset can be easily performed by putting in a unique subfolder.
4. Multi-lingual audio that is destined for the asset can be stored in the media sub folder until it is required.
5. To check the levels of an audio track, only the audio track needs to be read. The video can be left where it is, saving costly bandwidth (not the case with OP1a).
6. VBI and VANC information can be separated using SMPTE436M so that ancillary data workflows don’t need to read / write / decode video components, therefore saving time and bandwidth.
7. Captioning workflows can be performed with the SMPTE436M component without needing to read / write the video component.