MP3 Format Preservation Assessment

Document History

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1. Introduction

This document provides a high level, non-collection specific assessment of the MP3 file format with regard to preservation risks and the practicalities of preserving data in this format.

This format assessment is one of a series of assessments carried out by the British Library's Digital Preservation Team. An explanation of criteria used in this assessment is provided by the italics below each heading.

1.1 Scope

This document will focus on the MP3 format (also known as MPEG Audio Layer III).

Note that this assessment considers format issues only, and does not explore other factors essential to a preservation planning exercise, such as collection specific characteristics, that should always be considered before implementing preservation actions.

1.2 MP3 Summary

MP3 is a lossy data compression format for digital audio [1]. It is a commonly used as an audio format for storage and streaming, as well as "a de facto standard of digital audio compression for the transfer and playback of music on most digital audio players" [1]. As the compression is lossy, the amount of data which embodies the audio recording is greatly reduced but has been designed to sound like it accurately replicates the original uncompressed audio (for most listeners) [1]. "MP3 compression employs perceptual coding, an approach based on psychoacoustic models that permit the codec to discard or reduce the precision of audio components that are less audible to human hearing" [2].

MP3 files can be encoded at higher or lower bit rates, with corresponding increases or decreases in audio quality and file size. For example, audio data encoded as MP3 with a constant bit rate of 128 kilobits per second would result in a file approximately 9% the size of the equivalent data in uncompressed CDDA-quality audio [1].

The three classes of audio compression associated with the MPEG-1 and -2 specifications are known as Layers I, II, and III (MP3 being shorthand for "MPEG Audio Layer III") [2]. The difference between the two MPEG specifications, with regard to MP3, was support for an additional range of bit and sample rates.

There is no "official" file format container associated with the MPEG-1 and -2 audio compression schemes. As such, many MP3 files simply consist of a raw audio bitstream, optionally appended or prepended with metadata [3]. The bitstream itself is made up of frames, each of which consists of a header and a data block, within which segments of the audio data are encoded [1].

2. Assessment

2.1 Development Status

A summary of the development history of the format and an indication of its current status.

The history of MP3 dates back to 1987 when the German Fraunhofer Institute began its research on digital audio broadcasting. In 1988 the Moving Picture Experts Group (MPEG) was established as a working group of the International Standardisation Organisation (ISO). Its remit was the development of compressed digital audio and video standards. MP3 was patented in Germany in 1989 (though not in the U.S. until 1996) with the MPEG-1 standard being published in 1993, and the backwards compatible MPEG-2 in 1995 [2]. On 12 July 1995, the Fraunhofer researchers decided to adopt *.mp3* as the file format extension, which then became the acknowledged acronym for ISO standard IS 11172-3, or "MPEG Layer Audio 3" [4].

The first time music was distributed in the MP3 format was in 1999 [5]. In 2004, the Fraunhofer Institute for Integrated Circuits (IIS) and Thomson introduced MP3 Surround, an MP3 upgrade for “high-quality” 5.1 surround sound [6]. In 2009, following collaboration between Fraunhofer and Technicolor (formerly Thomson) the mp3HD format was also produced for lossless audio coding [6]. As of 2013 though, this format appears to have been abandoned [7] and the official website no longer exists.

In April 2017, Fraunhofer announced that they were terminating the MP3 patent-licensing program [8] which led to many articles announcing the death of the MP3 [9; 10] but this announcement simply confirmed that the patents had expired, with a suggestion that users could move to their other patented formats [11].

Potential alternatives to MP3 include audio codecs like AAC [12], Ogg Vorbis [13], or Opus [14].

- The AAC (Advanced Audio Coding) format, which Apple has popularised via its iTunes store [15], is able to produce better quality audio than MP3 at lower bitrates, but it is not as widely supported by players and devices [11]. The format is still covered by patents.

- Vorbis is an open-source codec for the lossy compression of audio [16], offering similar quality advantages over MP3 as AAC [11]. It is most frequently used with the Ogg container format and thus is more generally known as Ogg Vorbis.

- Opus is a more recently developed lossy open-source audio format designed for real-time audio transmission over the Internet, though also applicable to storage, and optimised for efficiently encoding both music and speech [17]. Opus has been standardised by the Internet Engineering Task Force (IETF) as RFC 6716 [18], and like Vorbis, can be encapsulated in an Ogg container [19]. While having much to recommend it over other lossy audio codecs, including those previously mentioned [17], it currently suffers from relatively poor ecosystem support when compared to older formats.

2.2 Adoption and Usage

An impression of how widely used the file format is, with reference to use in other memory organisations and their practical experiences of working with the format.

MP3 is the most widely supported audio format currently available with everything from mobile phones, car stereos, and Blu-Ray players having the ability to play the format [13]. It is also the format of choice for many digital music service providers (with the exception of Apple): both Amazon’s and Google’s online stores sell their digital music exclusively in the MP3 format [20], while also utilizing it in their music streaming services [21]. MP3 is also a popular and widely accepted access format for memory organisations [22] [23].

Corrado and Moulaison [24] state that whilst ubiquitous, MP3 is often not recommended for digital preservation because it utilises lossy compression that can compromise sound quality for the sake of file size. In the past, where storage space was an issue, this could have been seen as an acceptable concession, but with the improvements to lossless audio compression in formats such as FLAC, MP3 is no longer recommended within the audiovisual archiving community.

The format is normally accepted by custodial organisations, but usually only when no higher quality options are available; some examples include:

- The Library of Congress general preference for preservation-oriented recorded sound is the WAV format, but, for compressed sound, MP3 is considered "acceptable," especially at data rates of 128 kb/s (mono), 256 kb/s (stereo) or higher [2]. It is used extensively as a non-streaming service format for American Memory [25] and is one of the accepted formats for uploading content to the U.S. Copyright Office site as part of their eCO (Electronic Copyright Office) program [2] [26].

- At the British Library, reading rooms provide access copies in MP3 format of archived digital audio. Over 200,000 files are currently available via the Library's SoundServer [27], which provides access in the reading rooms to over 100,000 recordings of music, speech and environments. In the past year, however, the Library has started moving away from MP3 for access in favour of AAC and its improved audio quality.
- Binghamton University Libraries offers full support for MP3,[1] although their general preference for preservation-oriented recorded sound is uncompressed WAV files. They view MP3 as acceptable for compressed sound especially at data rates of 128 kb/s (mono), 256 kb/s (stereo) or higher.
- The National Archives and Records Administration (NARA) does not consider most audio files in the MPEG format, including MP3, to have sufficient quality for archival retention and doesn't recommend MP3 for the reasons already discussed [28].
- The Koninklijke Bibliotheek (KB) have MP3 listed in their 50 most prevalent formats in their e-Depot,[2] narrowly ranking just below WAV in terms of file numbers [29].

2.3 Software Support

2.3.1 Rendering Software Support

An overall impression of software support for rendering the format with reference to: typical desktop software; and current support on British Library reading room PCs.

Almost any digital audio or multimedia playing software is likely to support MP3 [30], with suitable playback software often coming preloaded with operating systems, e.g. Windows Media Player [31] or Apple's iTunes [15]. There is also an abundance of freeware and open-source alternatives, e.g. Winamp [32], Foobar2000 [33], VLC media player [34], Zinf [35], Amarok [36], MPlayer [37], and many others [38].

Issues

Problems with badly formed MP3s can often be traced to problems in frame headers (which may be incomplete), or in parsing ID3 metadata. Some of these issues can be checked with tools such as mp3_check [39], which checks for invalid headers or missing frames.

2.3.2 Preservation Software Support

An impression of the availability and effectiveness of software for managing and preserving instances of the file format.

Format identification

MP3 files can be successfully identified by a range of open-source software: Apache Tika [40], the National Archives' DROID [41], MediaInfo, and the previously mentioned Xena [42], all support MP3 identification, alongside other common audio formats.

Validation, Conformance Checking and Detecting Preservation Risks

MediaInfo provides a display of technical data and information about MP3 files, including format, profile, duration, overall bit rate and any production software information or encoding settings that may be embedded [43]. Along with MediaConch from PREFORMA, it can also be used to extract properties from an MP3 for comparison against a defined profile for compliance checking [44].

MP3 Validator (also known as MP3val) is a tool to validate and fix MP3 audio files [45]. It can be useful for identifying some forms of corruption (e.g. a file which was incompletely

[1] Binghamton University Libraries categorise the level of digital preservation support they can provide. Full support means they will take "all reasonable actions to maintain usability including migration, emulation, or normalization" and "will ensure access and data fixity".

[2] It is not clear from information on their website whether this number includes access copies as well as archival copies.

downloaded). It is, however, only compatible with Windows machines. There is a similar product available for Mac OS called MP3 Scan+Repair which, as above, claims to validate and fix damaged files [46].

A third-party MP3 validation module does exist for JHOVE, but is currently unsupported and requires additional setup [47]. mp3_check should also allow the identification of MP3s which do not correctly follow the format specification, checking for invalid frame headers and missing frames [39].

The MP3 standard supports the inclusion of CRC information for frame metadata (such as headers), but does not cover checking the audio data held in frame data blocks [48], making them of limited use in detecting audio corruption.

Metadata Extraction

Metadata such as the title, artist, album, track number or other information about the file's contents appear in a "tag". Standards available for MP3 do not define a format for tags alongside the audio data, and there is also no standard container format which would preclude the need for tags [1]. De facto standards for tag formats for containing metadata do exist, however, with the most widespread being ID3v1 and 2 [49] [50]. Besides ID3, APE metadata tags may also be found [51]. Separate from the audio bitstream, these tags can usually be found attached to the beginning or end of the audio data [1].

There are several tools which allow the addition or modification of metadata tags in MP3s [52] [53], including Mp3tag (which supports multiple tag formats) and ID3 Tag Editor [54].

There are also a number of tools available for the extraction of metadata from MP3, including the NLNZ Metadata Extraction tool [55], ExifTool [56], Apache Tika [40], and MP3::Tag [57]. If present, these tools can extract metadata from title, subject, album, track, year, genre and comment fields, among others.

The previously mentioned MediaInfo can be used to extract additional technical metadata [43], as can FFmpeg's ffprobe utility.

Migration

There are numerous tools and services available, both free and commercial, to convert files to or from MP3 [58]. Some of these include: FFmpeg [59], VLC media player [34], MPEG321 [60], SoX [61], EZ CD Audio Converter [62], AudioFormat.com [63], iTunes, and the aforementioned Xena software [42].

If migrating to MP3 for whatever reason, it should be noted that not all encoders will produce the same quality of sound for a given bitrate, and that the quality can be just as dependent on the encoder itself.

2.4 Documentation and Guidance

An indication of the availability of practical documentation or guidance with specific reference to the facilitation of any recommended actions.

MP3 is an open standard developed by the Moving Picture Experts Group (MPEG) for the coding of audio, picture, multimedia and hypermedia information [2].

ISO specifications exist for all the versions of MPEG, and therefore MP3, which were created during its development. Published in 1993, ISO/IEC 11172-3:1993*, Information technology -- Coding of moving pictures and associated audio for digital storage media at up to about 1, 5 Mbit/s -- Part 3: Audio* [48] specifies the coded representation of audio for storage media and describes syntax and semantics for all the three classes of compression methods known as Layers I, II, and III for MPEG-1 [2]. A technical corrigendum 1 was published in 1996 which simply added a new table to Annex H – the list of patent holders [64]. In 1998, ISO/IEC 13818-3 (Second edition, 1998), *Information technology -- Coding of moving pictures and associated audio information -- Part 3: Audio* [65] was issued covering the MPEG-2 standard.

2.5 Complexity

An impression of the complexity of the format with respect to the impact this is likely to have on the British Library managing or working with content in this format. What level of expertise in the format is required to have confidence in management and preservation?

As with all compressed audio, MP3 is necessarily more complex than uncompressed formats like WAV. However, as noted above, there is substantial information on the structure in the specifications, as well as elsewhere [1] [66], and many tools available which support manipulation of the format.

2.6 Embedded or Attached Content

The potential for embedding or attaching files of similar or different formats, and the likely implications of this.

MP3 files can contain multiple metadata tag formats, such as ID3 and APE, in a single file, any of which may hold duplicate or contradictory information. Besides textual metadata such as album and artist names, these tag formats may also contain embedded image formats, commonly JPEG or PNG, for album art and various other imagery [67].

2.7 External Dependencies

An indication of the possibility of content external to an instance of the file format that is complimentary or even essential to the intellectual content of the instance.

ID3 tags support a number of fields which can link to external entities via URLs, such as cover art imagery or webpages detailing copyright information [67], and like many audio formats, individual MP3 files can be given an order, or structure, through their inclusion in external cue sheets [68], or other playlist formats such as M3U [69] and PLS [70].

2.8 Legal Issues

Legal impediments to the use, management or preservation of instances of the file format.

There are a number of patent claims associated with MP3 though the practical impact of these claims is not clear [2]. “Many organizations have claimed ownership of patents related to MP3 decoding or encoding. These claims have led to a number of legal threats and actions from a variety of sources, resulting in uncertainty about which patents must be licensed in order to create MP3 products without committing patent infringement in countries that allow software patents” [1].

Licences for commercial use are mentioned on a website from Technicolor though this dates back to 2009 [71] and also includes a portfolio of patents from the same period [72]. These parents include P36 21 513 *(Audio signal transmission method using a variable masking threshold),* P4034017 *(Process for the detecting of errors in the transmission of frequency-coded digital signals)* and twenty others.

On April 23, 2017, Fraunhofer IIS announced the end of Technicolor's MP3 licensing program, noting that some of the core patents underlying MP3 had expired [73]. In an associated blog, Fraunhofer clarified that this did not necessarily mean that all MP3 technology would be immediately available license-free, adding that "apart from the core mp3 patents included in the licensing program, there might still be some implementation-specific patents (or patents for other functional enhancements) that have not expired." An earlier assessment commented that, although it varies from country to country, the final number of outstanding patents for MP3 appears to expire in December 2017 at least in the United States [74].

Fraunhofer IIS's announcement led some to conclude that the MP3 format was now "officially dead," raising concerns about the format's potential obsolescence [75]. However, the expiry of the core MP3 patents does not mean that the format will disappear overnight. The large-body of content currently in MP3 format will continue to exist and will continue to be useable in the majority of audio playback software. It is possible that the expiration of the core MP3 patents may encourage the longer-term adoption of newer, more capable standards, e.g. AAC or Opus

[76]. The Fraunhofer IIS statement itself mentioned the AAC format, for which it still holds the patents [73]. On the other hand, a MP3 format free of patent restrictions would seem to be a distinct advantage from a digital preservation perspective. Marco Arment has commented that "MP3 is supported by everything, everywhere, and is now patent-free" [11]. He adds that for many of its regular use scenarios, the use of MP3 still makes a lot of sense:

> *AAC and other newer audio codecs can produce better quality than MP3, but the difference is only significant at low bitrates. At about 128 kbps or greater, the differences between MP3 and other codecs are very unlikely to be noticed, so it isn't meaningfully better for personal music collections. For new music, get AAC if you want, but it's not worth spending any time replacing MP3s you already have.*

2.9 Technical Protection Mechanisms

Encryption, Digital Rights Management and any other technical mechanisms that might restrict usage, management or preservation of instances of the file format.

DRM (Digital Rights Management) on digital audio files is less prevalent than it once was but may still be an issue with older supplied items from the early 2000s [77] (iTunes for example used DRM on their files from 2003 to 2009). File properties details will generally indicate the presence of DRM [78] [79].

Software is available to detect DRM in MP3 (normally as a single feature of an overall software package). This includes Danuisoft MP3 WAV Converter [80], MP3 WAV Converter [81] or Aimersoft DRM Media Converter [82].

2.10 Other Preservation Risks

Other evidence based preservation risks, noting that many known preservation risks are format specific and do not easily fit under any of the sustainability factors above.

None known.

2.11 Preservation Risk Summary

A summary of preservation risks and recommended actions (where possible).

- **Lossy compression**
  - Not recommended for digital preservation because it utilises lossy compression, which compromises sound quality for the sake of file size.
  - Where storage space is a concern, losslessly compressed formats such as FLAC should first be considered, followed by more modern lossy formats.
- **Technology patents**
  - While patents covering the core technologies have expired, patents around some of MP3's less common enhancements may still be in effect, hampering their use.
- **Badly formed MP3s**
  - Often a problem in headers (which may be incomplete), or ID3 metadata.
- **DRM**
  - DRM may be present in older files.
- **External references**
  - Metadata images and webpages referenced through URLs may be subject to change or loss.

3. Recommendations for Action

Recommended actions in usage and handling of the format. Recommend actions in the support or development of software applications that provide, or have the potential to provide,

significant risk mitigation for the format. Note that these recommendations do not take into account other requirements such as those driven by specific British Library collections, or non-preservation issues such as resourcing.

MP3 is not recommended for digital preservation or by the audiovisual archival communities as an archival format. Storage space concerns on the level at which MP3 would provide a tangible benefit are now fairly uncommon in modern archival storage systems, and even so, more modern lossy audio formats may provide less of a compromise in sound quality than MP3, and at smaller file sizes. Additionally, while MP3 is still widely available, it is now uncommon for it to be the only procurement option available.

Handling Recommendations

- MP3, as with other lossy audio compression, should only be considered when there are no other options available.
- Where storage space issues do exist, losslessly compressed formats, such as FLAC, should first be considered, followed by more modern lossy formats, such as Opus.

Software Recommendations

There may be value in monitoring validation tools, especially with regard to the use of JHOVE, but taking into account the monitoring recommendations this need not be a priority.

Monitoring Recommendations

The preservation risks faced by MP3 are unlikely to change rapidly; the format is therefore not a high-priority for review.

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