HOW THE GERMAN NATIONAL LIBRARY MIGRATED 770,000 COMPACT DISCS AND DIGITIZED 50,000 AUDIOCASSETTES

Ruprecht Langer, Head of German Music Archive, German National Library[1]

DOI: 10.35320/ij.170

Abstract

The German Music Archive of the German National Library collects copies of every sound carrier published in Germany. It began collecting audio CDs in 1982, and growing at a rate of more than 20,000 units per year, the collection contains 770,000 items today. Though the most significant part of the archive's collection of analogue sound carriers consists of vinyl and shellac records, there is also a substantial number of audio cassettes.

Over the last 15 years, the German National Library has put two digitization projects into practice to preserve its library holdings and to make music more easily accessible via the reading rooms' computers at its Leipzig and Frankfurt am Main locations. One project focused on migrating the digital content of all its audio CDs to the digital repository, and another initiative managed the digitization of the archive's 50,000 audiocassettes. The German Music Archive can now provide more than 500,000 hours of digital music to its on-site users.

This article explains the processes and workflows of both projects, challenges encountered, quality control applied, and lessons learned. It describes how the library dealt with hidden tracks, additional materials, non-circular CDs, faulty tapes, audible errors within a CD, and why sound carriers with electronic music seemed particularly complicated.

Keywords: digitization, content migration, compact disc, audiocassette, semi-automated workflow, conservation

Introduction and Background

The German National Library was founded in 1912 in Leipzig as the Deutsche Bücherei. After World War II, Germany was separated into East, the German Democratic Republic (where Leipzig is located), and West, the Federal Republic of Germany. While the Deutsche Bücherei was responsible for collecting all published media in the East, the West lacked its own national library. Therefore, the Deutsche Bibliothek was founded in Frankfurt am Main in 1947 (Rausch, 2023). While Leipzig had already started to collect East Germany's sheet music in the 1940s and vinyl music records in 1970, the Deutsche Bibliothek in Frankfurt founded the German Music Archive (Deutsches Musikarchiv) as one of its departments in West Berlin in 1970. Therefore, beginning in the early 1970s, sound carriers were collected systematically in both East and West Germany. In 1973, the German Music Archive received the legal deposit right.

One of the crucial aspects of the German Music Archive to this day is its agnostic collection policy. The archive does not evaluate whether one kind of music, genre, composer, or artist is worthy of being collected, and is not concerned if an item is economically

1 Ruprecht Langer studied Musicology and Theology in Leipzig, Germany. After working as a researcher at the Johann Sebastian Bach Archive and as a project manager for two independent CD labels, he has held the position of Head of the German Music Archive at the German National Library since 2017. He is currently the chair of the Research Library Section of IAML and the president of IAML Germany.

successful or of particular interest. Mandatory deposits must be made by all companies, institutions or persons who have the right to distribute the media work or to make it available to the public, i.e. publishing companies, originating authorities or self-publishers, and whose headquarters, business premises or primary residence is located in Germany (DNB, n.d.).

Figure 1. CDs inside the stacks of the German National Library in Leipzig. Photo: German National Library.

With the reunification of the two German states, the two national libraries were also united into Die Deutsche Bibliothek (The German Library) and later into Deutsche Nationalbibliothek (German National Library). In 2010, the German Music Archive changed its location from Berlin to part of the building complex of the Leipzig site of the German National Library. The Berlin and Leipzig music collections were merged, and all duplicates were sent to the site in Frankfurt.

According to the library's legal mandate, the German National Library has to collect, safeguard and make available all kinds of media in text, image and sound that have been published in Germany since 1913 (DNBG, 2012). The German Music Archive is responsible for the collection of sheet music, sound carriers published in Germany, as well as digitally published scores and recordings.

Over the years, approximately 2.5 million sound carriers have been accumulated in the library's collections, including wax cylinders, shellac and vinyl discs, audiocassettes, and most often compact discs (DNB, Statistik 2023, 2024). Over the last 20 years, an average of 1,100 sound carriers was delivered to the German Music Archive weekly. Since the German National Library collects two copies of each publication, these numbers should be approximately halved to determine how many unique copies of sound carriers the library holds. In total, there are approximately 770,000 titles on CD and 50,000 on audiocassette today. All in all, audio CDs account for approximately three quarters of the German Music Archive's audio collections.

The library stacks both in Leipzig and in Frankfurt (Figure 1) provide ideal storage conditions. The collected media is protected from sunlight, and kept at a temperature of 18 °C and a relative air humidity of 50% for paper-based media and 30% in the CD stacks. However, the German Music Archive's sound carriers are still endangered due to decomposition.

From Bad to Worse: Endangered Audio Cds

Due to the mix of different layers and materials like polycarbonate, metal, glue, ceramic, and paint (Figure 2); and also because these materials behave differently under changing circumstances like temperature and humidity, physical and chemical changes to the makeup of a CD might make it become unplayable (Youket, 2007).

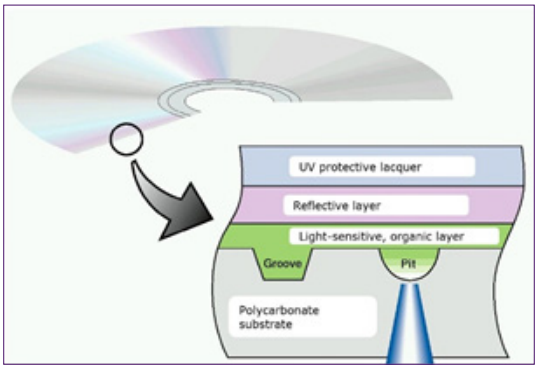


Figure 2. Layers of a standard CD (simplified). Graphic: German National Library.

Even industry-pressed CDs produced by Red Book[2] standards can consist of a wide range of materials. In 1993, the German Music Archive analysed the condition of its CDs. During this process, the archive's staff picked one hundred CDs for a long-term test using a CDQC2, a compact disc test system analyser made by Koch International. Fifteen years later, the same hundred CDs were tested again, using the exact same methods as in 1993. The German Music Archive tested them according to the Red Book specifications, checking for Block Error Rate, E22, and E32 errors (jitter, radial noise, etc.).

As shown in Figure 3, already in 1993/94 only 18 CDs out of 100 could be labelled 'good', 47 were 'OK', 34 'bad', and 1 'defective'. Fifteen years later, the results were much worse: 80 were now 'bad' or 'defective', and only 6 remained 'good'. These analyses were time- and resource-intensive, but the results are not meaningful in the long term, since new damage can occur at any time.

2 The Red Book is the colloquial name for IEC 60908, the International Electrotechnical Commission's standard for the audio CD.

Evaluation of the tested CDs

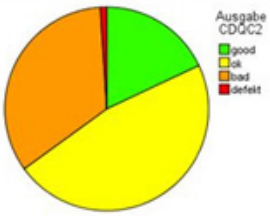
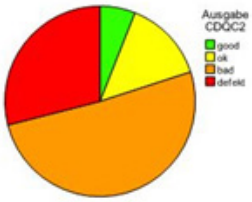
	1993/94		2007/09
			
Category	**Amount = %**		**Amount = %**
good	18		6
ok	47		14
bad	34		51
defective	1		29
Total	100		100

Figure 3. Quality decrease of the CDs in 15 years' time. Graphic: German National Library.

Of particular interest to the German Music Archive was the realization that visible damage only occurs when it is already too late to save a CD. So, it did not seem reasonable to merely check for tarnished or discoloured CDs. But since it was unknown if there was any available procedure to stop the decomposition processes sustainably, the German Music Archive focused on safeguarding the sound itself, rather than the sound carriers.[3]

When digitizing analogue audio content, it is difficult to tell how good the results will be in comparison to the technical knowledge and equipment that might be available in ten or twenty years' time. Luckily, this is not the case with audio CDs. Their audio signal is already digital, consisting of zeros and ones. So, when copying the entirety of zeros and ones from a CD, there will be no loss in quality and no media disruption, so long as the CD can be read without errors.

During the project preparation which started in the early 2000s, the German National Library stated that during the entire process of mass digitization and long-term archiving, it only needed to be informed if a CD was *not* able to be read faultlessly. Therefore, a key element of this project was to establish a robust quality management with a particular focus on precise detection and documentation of any reading errors.

3 The physical audio CDs (as well as the digitized audiocassettes) are still kept under ideal storage conditions. Covers, booklets, and other accompanying material were only digitized in a test phase. It was considered too expensive and not urgent since paper-based media is more stable in the long term.

Reading Errors

CDs and their players are error-prone (IASA Technical Committee, 2009, pp. 132–134). Dust, scratches, or fingerprints can cause data segments to become unreadable. Furthermore, there are technical issues that make it harder to transfer disc data to mass memory: the compact disc is not a storage medium for IT systems and it does not have its own file system. There are some error correction systems, but these are designed to hide errors from the listener so that they can enjoy the music. Those reading errors were never intended to be reported or presented.

Following IASA's guidelines (IASA Technical Committee, 2009, pp. 132–134), the German National Library was looking for C1 and C2 reading errors (small and larger singular errors caused, for instance, by scratches), sub-channel errors (additional information to the music data), bad blocks (duplicate frames or faulty sectors), frame loss, sample holds (where the laser is not able to measure a single sample correctly), and clicks.

In-House Processing

Once the scope and goals of the project had been established, the library decided not to outsource but to run it with the library's own resources. The members of the project team had to develop their own know-how by consulting digitization experts within the German National Library, colleagues from other libraries and sound archives as well as its own external IT partner. Once a certain degree of expertise had been achieved, library staff was able to supervise the whole process, including quality management, and quality control could be far stricter than with a vendor. In-house projects also provide an institution with greater control to alter or expand the project as needed, or to continue digitizing newly-received discs after an official project has concluded.

Since the greatest part of the project funds had to be invested during the project's initial phase, the cost of digitization per CD decreased considerably over the years. According to internal calculations, the cost per item started at 1.67€ for the first year and dropped to 0.72€ for the following years. According to contractors' offers, the outsourced cost per CD would have been a constant 2.70€. Over a period of five years and for 500,000 CDs, outsourcing would have cost almost three times as much in comparison to doing this project in-house.

CD Inspector, Cube Workflow and Dobbin

The German National Library chose Cube-Tec as its external IT partner. Located in Bremen, Germany, Cube-Tec specializes in audiovisual quality management (Cube-Tec, n.d.). They created software specifically geared to the needs of the German National Library. This so-called ingest system consists of three scalable system units that are able to exchange information with each other:

- CD Inspector: an ingest software to migrate information from CD to the library's storage system, and to control the hardware
- Cube Workflow: controls the workflow of the entire migration process
- Dobbin: an audio processing and analysis engine for audio files.

For hardware, the library purchased an NSM 7000, a so-called 'optical jukebox' or robotic data storage device (Cube-Tec, n.d.-b), as well as a computer with matching specs. This jukebox is fitted with five internal and three separate drives and can be filled with up to 500 CDs at once. The library trained staff to operate the entire process. These colleagues had to be able to detect audible errors both by listening and by analysing visualisations of the CDs' content.

Three Steps to Migrate 770,000 CDs

In 2008, the CD migration project started. The transferring process can be divided into three steps. First, the shelf numbers of the CD batch are scanned, and the jukebox is loaded with up to 500 CDs. Loading and unloading takes approximately 27 seconds per CD. Once this is done, the CDs are read and the CD Inspector starts ingesting the lossless files. This process only begins when a CD matches with an existing catalogue record.

Second, parallel to the ingest process, the Cube Workflow software picks up the finished folders and enhances each item's metadata, adding the German National Library identifier code, the German Music Archive shelf number, and technical metadata including an MD5 checksum.

The Dobbin software analyses the created audio and metadata files and categorises the results. It checks the audio file for digital signal errors (clicks, digital zero or block repeating), generates markers (beginning and ending of tracks), generates MD5 checksums and merges all this information into one XML file. According to the analysis' results, the files will then be categorised and moved into one of the following folders:

- OK
- Probably not OK
- Audition temp
- Audible OK
- Audible not OK
- Missing metadata

Over the course of the project, 98% of the CDs have ended up in the 'OK' folder. Of the remaining 2%, most items can be migrated using the manual single drives.

CDs in the 'OK' folder can be processed into the library's long-term storage[4] without being checked manually. If the system detects a media read error, it sends the file into the 'Probably not OK' folder. Media read errors can include duplicate frames or faulty sectors. The system checks for calculated audible defects and audible verified defects. Not every one of the mentioned errors results in audible errors. If there is evidence that errors might be audible, the files are sent to the 'Audition temp' folder, where sections of the files with potential audible errors are manually auditioned. The selection and analysis of these segments in question take an average of five to six minutes per CD.

Over time, the staff and the IT contractor fine-tuned the software to be more and more reliable in the distinction of audible and non-audible errors. CDs that only contain non-audible errors can be archived without manual post-processing.

4 The audio files, XML files including cue sheets and all data from the migration process (reading errors, events, some bibliographic metadata) are currently stored in a file system on a mass storage system (ESS from IBM) at the Frankfurt site of the German National Library. The system is mirrored at the Leipzig site. Additionally, the data is stored in a tape library (TSM).

To process one batch of up to 500 CDs takes approximately six to eight hours and usually happens during the night. The next morning, machine-readable protocols (log files) are available for each processing stage of each CD, and an audio file in a lossless format (wave format)[5], accompanied by a set of metadata in an XML file, that provides information about track data, track positions, CD-Text and technical metadata.[6]

The third and final step is manual quality control. CDs categorized as 'Audible not OK' need to be manually post-processed. For this, the German National Library uses the Dobbin ResultViewer interface (Figure 4), which shows what errors have occurred. This is then linked to the Dobbin EventPlayer (Figure 5), which provides a visualisation of the audio as a wave form. By carefully inspecting this visualisation and listening to the audio, the quality manager decides whether an error is audible.

Figure 4. Dobbin ResultViewer (Cube-Tec). Screenshot: German National Library.

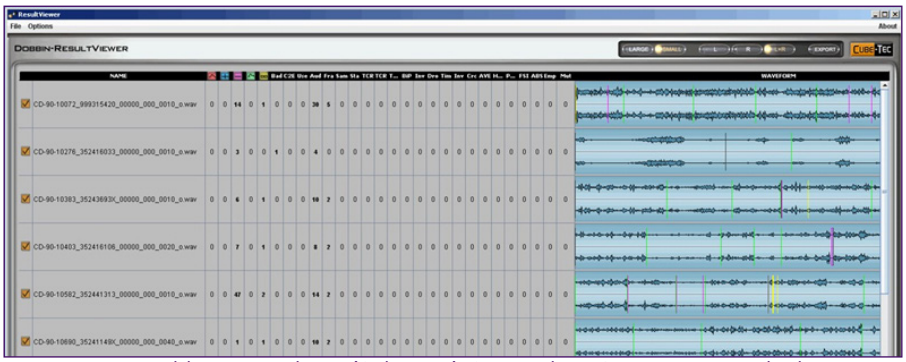


Figure 5. Dobbin EventPlayer (Cube-Tec). Screenshot: German National Library.

5 The chosen resolution is 44.1 kHz / 16-bit. Currently, the German National Library uses WavPack (a losslessly compressed Broadcast Wave Format with additional sections for metadata), as recommended by IASA. In the near future, the library plans to switch to uncompressed, and more widely used, BWF, as the 30% savings in memory space is now of less consequence with the current infrastructure than it was when the migration project began.

6 Part of the migration was to extract the CD-Text, which often but not always contains track titles. Due to technical reasons, this was not done for the whole project. For every CD the track positions are stored in a cue sheet. As all the audio information is stored in one audio file, these track positions are essential to address different tracks.

The migration process (shifting CDs from the library stacks to the migration system, scanning barcodes, entering CDs into the jukebox, starting and controlling the migration, quality control, removing CDs from the jukebox, putting them back to the CD cases, sending them back to the library stacks) is usually done by two to three library staff members. Throughput increases with the number of staff involved.

If a CD has audible errors, the examiner tries to locate its origin. Discs with dirty reflective layers, often caused by fingerprints, dust or stickers, are cleaned with distilled water and ingested once again. If the reflective layer is scratched, the CD is carefully cleaned and ingested manually. Since the German Music Archive receives two copies of each published sound carrier, the staff can use this second available copy if the cleaning and manual ingestion does not lead to the desired result. Additionally, staff randomly picks CDs from different folders to check if the system worked flawlessly and that the CDs are in their correct folders.

Particular Types and Specific Problems

While this process worked fine for 98% of the CDs, there were, however, non-standard disc types that required special workflows. The robotic parts of the jukebox could only handle standard CDs with a 12 cm diameter, so custom shapes and sizes could not be processed. The same went for CDs with an abnormal reflexion layer (like transparent or coloured CDs), because the robot's optical barrier could not see them. Those CDs had to be ingested manually using the jukebox's single drives.

Also, CDs with electronic music were more challenging to deal with. If such a CD was documented to have audible errors, it could be tricky for quality control to differentiate between technical errors and intentional audio effects. Most CDs with audible errors contained C2 reading errors, which can only be detected by listening when each error lasts more than 30 or 40 milliseconds. If the errors are shorter, they can be interpolated, and the human ear won't be able to detect them, even though they may be visible in the file's waveform. During the migration process, the library staff encountered sections with more than 100 C2 errors per second or errors lasting longer than 100 milliseconds. In such cases, these errors are audible as clicks or small skips. Other errors, like 'digital zero', result in sections with no amplitude in the waveform, while 'frame loss' causes one peak on a sine wave to abruptly change into the following peak. While these errors create unnatural artefacts in traditionally recorded music (e.g., via microphone), they can be purposefully created in computer-generated electronic music. To differentiate an error from a stylistic musical event, the library created an ideal listening environment and combined trained listening skills with the ability to detect errors through audio visualization.

Errors can also occur if a CD's structure differs from a standard CD. For instance, drives cannot recognize non-hybrid Super Audio CDs, video data, or hidden tracks. Everything that is not readable audio is saved as an ISO image and stored in a separate folder connected to the CD's audio folder.

Incidentally, technological protection measures like Digital Rights Management are not an issue for the German Music Archive. Since the German National Library is legally mandated to collect music in digital form, it is entitled to use software that overrides those protective systems. This is integrated into the migration process.

Cost Assessment and Current Workflow

While the above-mentioned cost per CD was 0.72€ for the duration of the five-year project, the price keeps decreasing. By 2024, after having migrated more than 770,000 CDs, the cost per CD is closer to 0.40€. Meanwhile, the German National Library has migrated all audio CDs currently in its collections. This process will be continued and is now a regular feature of the cataloguing and ingesting procedure of the German Music Archive.

Together with other digitized music media, there are more than 500,000 hours of digital music available from the computers in the Germany National Library's reading rooms now. Users search the catalogue for a recording and access its audio files via an HTML5 media player. Using the XML, the audio player shows track positions, track durations and track titles, if available. By default, the user is presented with an ad-hoc transcoded MP3 version of the WAV file, but it is also possible to listen to the uncompressed audio.

Digitization of all CDs in the library's collection has also resulted in less physical wear and tear on the physical carriers, since they are only circulated in justified individual cases. The German Music Archive is confident that its physical sound carriers will be accessible for quite some time into the future.

Digitizing Audio Cassettes

For audio cassettes, the German Music Archive took a different path. With its oldest compact audiocassettes dating back to 1978, they, too, are in great peril of being destroyed over time due to decomposition processes (IASA Technical Committee, 2017 p. 7) For analogue sound carriers, the German Music Archive has established an ad-hoc digitization workflow: When a user needs to listen to a sound carrier (e.g. shellac record, audiocassette) that is in the library's holdings but not yet digitized, the German Music Archive's audio engineer (Figure 6 illustrates an engineer's workspace) has all the necessary tools and knowledge to create an authentic digital reproduction of a sound carrier's signal. This file and its corresponding metadata can then be accessed via the computers in the library's reading rooms. Using this process, approximately 5,000 audio cassettes have been digitized since 2012.

Figure 6. View inside the cassette digitization studio in Leipzig. Photo: German National Library.

But with more than 50,000 cassettes, this ad-hoc process is far too time-consuming and, therefore, too expensive. Like with the music archive's CDs, the German National Library created a workflow that was able to mass-process all of its cassettes. For this,

the library carried out a Europe-wide tender in 2017 to find an external contractor. The Leipzig-based company AVI.DAT (Avi.dat, n.d.) received the acceptance.

Thorough Preparation

Before the actual digitization process could start, numerous preparations had to be made. For example, the German National Library had to evaluate what kind of cassettes were actually in the collections and where they were kept. Being part of different collections, they were stored in different locations, some in Frankfurt, but most of them in Leipzig. The most significant part was commercial cassettes, but there were also some private recordings. Most were still in excellent condition and could be digitized without any pre- or post-treatment. Others had to be cleaned or repaired by the conservation department. And because some of the special collections items did not contain standard metadata, library staff had to correct or complete metadata and shelf numbers.

In order to save on resources, it was crucial to avoid redundancies. For example, cassettes were not digitized when the same audio content had also been released on vinyl record or CD. Also, paper artwork was not digitized because it was not deemed time-critical, unlike the more vulnerable cassettes, and could be addressed in a later project. Overall, the German Music Archive identified more than 50,000 cassettes with an average duration of 27 minutes per side. So in total, approximately 2.7 million minutes of audio content were eligible for digitization.

According to the project documentation, the library aimed for lossless, true to original and quality-assured, 1:1 digital copies of the analogue source material with no qualitative variation (with two exceptions: if necessary, manual azimuth corrections were done in individual cases, as well as a digital level alignment). Following IASA guidelines, the cassettes were digitized in 24 bit, 96 kHz. The audio was saved as lossless Broadcast Wave Format (IASA Technical Committee, 2017 pp. 12–14).

During digitization, tapes were played back at normal speed within the building of the German National Library in Leipzig. For the digitization AVI.DAT used eight Tascam 122 MK III cassette decks and a Cube-Tec Quadriga, including a software called Audiofile Inspector that can detect errors. Before the actual digitization, the tape decks were calibrated and the tape heads cleaned.

Semi-Automatic Quality Control

Once the workflow was well established, an average of 49,000 minutes per month were digitized, or approximately 220 cassettes per week. The project started in January 2018 and finished in June 2022. After that, only newly received cassettes were added to the workflow until the autumn of 2023. After that, the audio cassette digitization project was evaluated, considered a success, and finally terminated.

During this whole process, the library staff oversaw the creation of METS-XML metadata that contained bibliographic information, condition description of the cassette, type of cassette, and results of the automatic quality control (azimuth value, bandwidth, workflow information, the ID of the tape deck, clearance information, etc.). This metadata was generated automatically by the software system that was provided by AVI.DAT.

If the inspector software or one of the random listening tests reported a possible error or problem, the cassette was manually inspected once again. If necessary, the library's

staff could clean it and/or calibrate the tape head again, too. The biggest part of the collection could, in this way, be handled semi-automatically. Staff just had to insert the cassettes into the tape decks and remove them afterwards. Manual interference was needed only in special cases (for example, after an error or problem occurred).

Project Completion

After completing the project and with 50,000 audiocassettes digitized, it became clear that less than one percent of these cassettes could not be digitized. For example, failure could be due to broken tape. Approximately two percent were re-digitized with corrected azimuth. Other common issues were crumbled tape or worn-off pressure pads. These cassettes were digitized anyway, but with damage documented so that listeners knew what to expect.

While 90 percent of the 50,000 cassettes were in good or very good condition, the German Music Archive discovered a drop in quality (both manufacturing and audio quality) in cassettes from the early 1980s (Figure 7). This drop could be due to mass production using inferior components (Casey, 2007).[7] [8] The manufacturing quality was determined to be poor when the library's staff discovered worn felt, noise during the process of unwinding the tape, or corrugated/creased tape, even if the cassette's overall condition suggested that it hadn't been played often. Poor audio quality was noted when the cassette's sound was muffled or when there were notable level differences between the stereo channels.

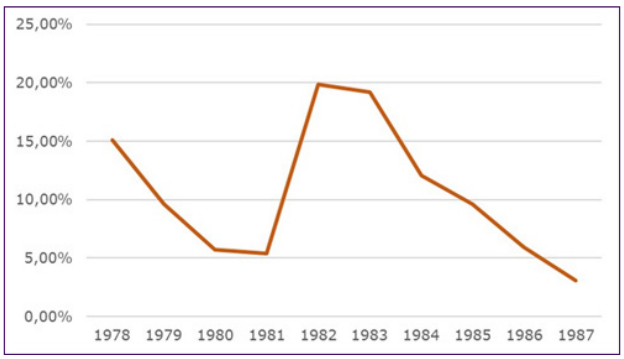


Figure 7. Quality Drop: The y-axis indicates the number of cassettes in bad or mediocre condition. Graphic: German National Library.

Results and Discussion

The two projects described in this paper were both highly ambitious, and the German Music Archive of the German National Library considers that they worked out exactly as intended. By digitizing all its audio CDs and music cassettes, the library can now provide the output of the German music industry in its reading rooms without putting further wear on sound carriers or exposing them to light, touch (fingers, CD trays, cas-

7 For more information about the early history of audiocassettes, problems during the production process and the search for the perfect sound, see interview with Gregg Schnitzer, former Director for Product Development at Mobile Fidelity Sound Lab (Schnitzer, 2004).

8 For further information about long-term stability of music cassettes see Casey, 2007. For a detailed description of the correlation between chemical components, tape thickness and music cassettes' durability, see pages 39–40.

sette players, etc.), or adverse environmental conditions. Furthermore, providing music digitally reduces the waiting time for patrons, who previously had to order media from the library's holdings, from several hours to just seconds. This is especially welcomed by a user community that is used to having immediate access to music provided by streaming platforms.

While planning these projects, the German National Library learned a lot about the condition of its analogue and digital sound carriers. While the outcome of both projects is largely comparable, the processes differed significantly. On one hand, it made financial, technical and organizational sense to train library staff to migrate CDs. Today, employees use skills gained from this training as well as the hardware and software acquired for the project to ingest newly-issued CDs, and acquired institutional knowledge will surely help in future project planning. On the other hand, for the audiocassettes, the library dealt with a more or less bounded collection, since the number of newly released music cassettes in Germany is marginal in comparison with CDs and vinyl records. Therefore, more responsibility was given to the external contractor.

Still, some of the insights from the CD project could be applied to the cassettes project. This includes the XML schemes that document the migration and digitization processes, and the output data and results. Instead of using the proprietary scheme offered by Cube-Tec for the cassettes digitization project, the German National Library decided to adopt standard schemes such as METS (used as a container for documenting the migration/digitization process, including details of the hardware and software used), MODS (to document both technical and bibliographical metadata, such as information about the musical work), and other metadata standards maintained by the Library of Congress. In general, when documenting metadata and establishing digitization and migration workflows, the German National Library follows the guidelines of IASA as well as the Deutsche Forschungsgemeinschaft (German Research Foundation). Other examples where the cassettes project benefitted from the CD project were basics like dataset naming, the structure of transfer packages and audio data formats, as well as import workflows.

One of the most important differences between both projects might be the quality management workflow. Since the library staff was not fully integrated into Cube-Tec's digitization system for the cassettes, the staff merely received the final results instead of being involved in the monitoring process. While some of the cassette listening tests used similar methods as for the CDs, the overall quality management process differed significantly.

All in all, the two projects were challenging but rewarding and, most importantly, successful. By migrating and digitizing the German Music Archive's 770,000 CDs and 50,000 audiocassettes, the German National Library not only fulfils its legal mandate but also preserves a significant part of Germany's musical heritage.

References

AVI.DAT (n.d.). *Landing page.* Available at: https://avidat.com [Accessed 17 December 2024].

Casey, M. (2007). *Facet: The Field Audio Collection Evaluation Tool: Format Characteristics and Preservation Problems.* Version 1.0. Bloomington: Indiana University.

Cube-Tec (n.d.-a). *CD-inspector features.* Available at: https://www.cube-tec.com/en/solutions/audio/media-inspectors/cd-inspector/features [Accessed 17 December 2024].

Cube-Tec (n.d.-b). *Landing page.* Available at: https://www.cube-tec.com/en [Accessed 17 December 2024].

DNB (n.d.). *Our Collection Mandate.* Available at: https://www.dnb.de/EN/Professionell/Sammeln/sammeln_node.html [Accessed 9 February 2024].

DNB (2023). *Statistik 2023.* Available at: https://jahresbericht.dnb.de/Webs/jahresbericht/SharedDocs/Downloads/DE/2022statistikenGesamt.pdf?__blob=publicationFile&v=2 [Accessed 21 August 2024].

DNBG (2012). *Gesetz über die Deutsche Nationalbibliothek (DNBG).* Available at: https://www.gesetze-im-internet.de/dnbg/BJNR133800006.html [Accessed 9 February 2024].

IASA Technical Committee (2009). *Guidelines on the Production and Preservation of Digital Audio Objects.* Kevin Bradley, ed., Version 2. International Association of Sound and Audiovisual Archives. Available at: https://www.iasa-web.org/audio-preservation-tc04 [Accessed 17 December 2024].

IASA Technical Committee (2017). *The Safeguarding of the Audiovisual Heritage: Ethics, Principles and Preservation Strategy.* Will Prentice and Lars Gaustad, co-eds., Version 4. International Association of Sound and Audiovisual Archives. Available at: https://www.iasa-web.org/tc03/ethics-principles-preservation-strategy [Accessed 17 December 2024].

Rausch, H. (2023). *Wissensspeicher in der Bundesrepublik.* Göttingen: Wallstein.

Schnitzer, G. et.al. (2004). *Mobile Fidelity Sound Lab Interview.* Available at: https://web.archive.org/web/20041016145233/www.aurealm.com/violet.htm [Accessed 9 February 2024].

Youket, M. et al. (2007). *Compact Disc Service Life Studies by the Library of Congress. Proc. IS&T Archiving 2007* pp. 99–104. Available at: https://doi.org/10.2352/issn.2168-3204.2007.4.1.art00024 [Accessed 16 December 2024].