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Critical Choices, Critical Decisions: Sound Archiving and Changing Technology.

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In a relatively short period of time sound archivists have had to come to terms with some fundamental paradigm shifts in the way they approach sound archiving. The sound archivist concerned with the preservation of sound recordings and their content was, until recently, camped on the fringes of traditional preservation and conservation of cultural and heritage materials. However, a growing awareness of the need for preservation of digital cultural materials generally in the library and archiving community has seen sound preservation in the forefront of contemporary debate. The sound archivist has, after all, been dealing with electrical materials for over 50 years. The new technologies though, have brought with them an awareness of the limitations of traditional copying programs, and the preservation approach generally described as "the long lived carrier", has been replaced with the notion of "the long lived file".

Collections of unpublished research notes and other heritage objects have generally found their way into cultural collections long after they were created. They were only acquired, or given the curatorial and conservation attention they required, after they were recognised as culturally or academically valuable items. Thus a pre-requisite of most traditional archival materials has been a robust enough nature to survive long enough to be recognised as valuable. The notes and papers of researchers and academics, providing they were stored and ordered in reasonable conditions, survived the decades of benign neglect until their worth was recognised, generally after the retirement of their creators, or perhaps after the creator was prepared to part with them.

After A.C. Haddon's recordings of 1898, and Spencer and Gillen's later recordings in Australia and the Torres Strait Islands, sound recording equipment has become an increasingly more common field tool for linguists and musicologists of all persuasions (Morphy 2001:45). Later cultural criticism notwithstanding, such materials retain an apparent evidentiary nature that seems to transcend that of the paper record, and some farsighted archives began to acquire such materials. Yet within a few decades the curators, if they remembered at all the recorded Edison cylinders hidden in their collection, faced a new problem. In 1929 the Edison Phonograph Company gave up the market battle it had been losing for some time and ceased production of all cylinders and their replay equipment. The cylinder became an early victim of format obsolescence in the audio industry.

Even if they had noticed, it is quite likely the curators failed to recognise the import of the first in a long line of audio format obsolescence, as the equipment to replay the cylinders was more robust than the sound recordings themselves. Even today, some 75 years later, working cylinder machines are not impossible to find. They are fairly rudimentary machines, the technology for inscribing audio in the surface of the cylinder relatively simple, and some modern replay machines have been built in small workshops to aid in the present day replay of the relatively moderate number of cylinders that have been kept. Though the cylinder is susceptible to damage through excessive heat or overly dry or humid environments, or indeed, unduly rough handling, some have survived benign neglect and those that have can be replayed today.

Amongst field workers though, the sound recording remained something of a novelty, and though its value was recognised by discerning researchers, the cumbersome nature of the technology meant that it was still only infrequently used, and then only for material that couldn't be easily written down. The most popular of the new recording technology that followed cylinders was the lacquer or acetate disc. Still large and cumbersome, and requiring portable power to record, it was nonetheless similar to cylinders in that it inscribed an analogue of the audio into the surface of the disc, though it was a sideways, or lateral cut instead of the hill and dale of the cylinder. Acetate discs are most commonly constructed by coating an aluminium disc with a nitro-cellulose/acetate lacquer that was soft enough to allow audio to be cut into its surface, though resilient enough to allow it to be replayed a number of times with only minor damage to the surface. Like the cylinder, the portable disc recording technology was made obsolete, this time by the advent of the magnetic tape recorder. The acetate disc, however, did not survive benign neglect. The volatile compounds that make up its surface lacquer become brittle over time, and the rate of expansion and contraction of the aluminium being quite high, the lacquer would crack and craze, and ultimately fall from the surface of the disc leaving small piles of unplayable debris in the bottom of the storage sleeve.

Thus some curators recognised their first case of carrier decay and began to develop techniques to restore and save the audio for future users. Small groups of experts advised that, in order to preserve the content of the decaying and delaminating acetate discs, their content should be transferred to a new audio carrier, the ¼ inch analogue reel tape that had replaced the acetate disc as a portable recording media.

At each technological paradigm shift, such as when mechanical recording technology gave way to magnetic, it is very common to see a range of competing technologies developed. Most of these technologies soon fall from favour and the surviving technology remains dominant until another shift alters the market again. Wire recorders are an example of this. The wire recorder was largely developed at the same time as the magnetic tape recorder and along the same principles. When the technology was marketed to the public after the Second World War, the tape recorder was its competition and its success soon drove the wire recorder from the market. Most wire recordings still carry the magnetic signal with which they were recorded, but the scarcity of replay equipment means that this obsolete technology cannot easily be replayed. Unlike magnetic tape recorders, wire recording technology was never developed further and so modern equipment is unavailable.

Analogue magnetic tape recording technology has permeated every area of the recording industry since its mass distribution and popularisation in the post WWII era. Magnetic tape was first made commercially available in Germany in 1935, but it was the commercialisation of the American market after 1947 that drove its popularity and eventual standardisation. Technological advancements made tape the primary recording format for professional recording studios, and manufacturing developments made the reel recorder affordable for the domestic market. The introduction of the Philips Compact Cassette in 1963 put a recording device within the grasp of many people and it became possible and practical for people to record whatever seemed important to them. In its professional reel form, a well aligned modern tape recorder with suitable tape and noise reduction systems can produce a recording with a dynamic range and frequency response that rivals that produced by digital equipment.

One of analogue recording's primary failing is that the inherent noise that is present in all recording systems becomes, on recording, an integral part of the signal itself. Every subsequent generation duplicate retains the noise of the previous generation and adds that of its own. A long term preservation strategy that depends on such systems is clearly untenable unless the carrier remains permanently playable and the systems to replay that carrier remain viable indefinitely. Even pioneer sound archivists recognised the flaw in their thinking, yet there was no alternative to that of analogue recording. Instead, recommendations were made to the archiving community to preserve the content by maintaining the recordings in such a way that the life of the carrier was extended for as long as possible.

Meanwhile, analogue recording technology became the indispensable tool of researchers and fieldworkers throughout academia, the social sciences particularly and linguistics and musicology especially. Virtually every sound archive and library holds analogue magnetic tape recordings, and the PRESTO Project (Preservation Technologies for European Broadcast Archives) estimates there are over 20 million hours in European Broadcast archives alone (Wright 2001) and 100 million hours of analogue tape recordings in broadcast collections throughout the world (Wright personal communication) a figure in no way contradicted by the IASA survey of endangered carriers (Boston 2003). Recent discussion however, has estimated that there is as much undocumented analogue audio material again in universities and research institutions, much of it critically important as evidence and as a research resource for future scholars to understand a particular period that has passed (Schuller 2003).

The analogue tape recording industry is now a cottage industry compared to its heyday, very few tape machines are produced, and blank tape is an expensive item increasingly hard to procure. Just over 50 years after its introduction, analogue reel has fallen victim to format obsolescence.

Yet not only format obsolescence, but also carrier decay threatens this medium. The first tapes were manufactured on a cellulose acetate backing and this continued until the introduction of polyester (polyethylene teraphthalate or PET, commercially known as Mylar) tapes in the mid 1960s. BASF manufactured tapes on PVC from the mid 1940s until 1968 when it introduced its own range of polyester tapes. Cassette tapes have always been manufactured on polyester. The binders that bind the magnetic particles to the tape substrate are often identified as that part of the tape most susceptible to chemical breakdown. This is especially so with PET tapes that most commonly use a polyester urethane binder, though AGFA and its subsequent owners, BASF and Emtec, used a PVC based binder on particular types of tape, notably 468.

The polyester urethane binders have in many cases been prone to decay by a process sometimes described as sticky shed syndrome; the main component of the reaction is hydrolysis[1], by which term it is often described. It is typified by a sticky brown or milky deposit on tape heads and fixed guides, often accompanied by an audible squeal and reduction in audio quality. Acetate tapes are suffering the same failure as their image cousins, films and negatives. The tape is subject to shrinkage, the oxide layer to delamination, some tapes are now so brittle that they will not traverse the tape path of a replay machine without breaking (ANICA 2002). This is by no means as critical in audio as in image yet, nonetheless it signals the failure of the carrier.

The replay of the tape based audio collections, their transfer for preservation to a new storage media, and ultimately, continued access to their content is dependent on the availability of tape replay equipment. In short, the highest risk in the standard preservation strategy applied to tape based magnetic collections is the continued availability of replay equipment. The imminent demise of the analogue tape industry and the consequent and almost total cessation of the production of the replay equipment demands that immediate steps be taken to transfer the vast store of recorded cultural history to a more viable system of management. As new replay machines are becoming less available, it will be necessary to maintain current equipment until the transfer is completed. Manufacturers have indicated they will maintain spare parts for up to a decade after the cessation of manufacture. Carrier decay combined with availability of replay equipment and parts makes the window in which this can successfully be carried out very narrow.

The analogue tape machines that are able to extract an adequate signal from a tape are sophisticated, complex machines dependent on proprietary parts and custom integrated circuits. Maintenance will not be an easy task once the existing parts have been exhausted. Nor will it be possible to build satisfactory machines in a workshop, as has been done with cylinder replay equipment. The technology requires industrial support.

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[1] Hydrolysis: chemical decomposition by addition of water, or a chemical reaction in which water reacts with a compound to produce other compounds.

Furthermore, with over a hundred million hours of analogue audio that PRESTO conservatively estimate is held in collections, the archival industry cannot afford a small number of machines limping along and providing access where possible. The time for planning and prioritising has clearly arrived.

Unlike analogue recording, digital audio can be copied and recopied without loss of signal or addition of noise or distortion. The potential offered by the production of digital surrogates for the purpose of preservation seems to provide an answer to linked issues of preservation and access. However, the weakest link in the digital chain is the point of conversion from analogue to digital. The choices made regarding conversion technologies, and the selection of digital formats, resolutions, carriers and technology systems will impose limits on the effectiveness of digital preservation that cannot be reversed, as will the quality of audio being encoded. Optimal signal extraction from original carriers is the indispensable starting point of each digitisation process. As recording media very often requires very specific replay technology, timely organization of copying into the digital domain must take place, before obsolescence of hardware becomes critical.

"The ability to recopy the captured digital copy without further loss or degradation has often led enthusiastic archivists to describe it as "eternal preservation". The easy production of low bit-rate distribution copies broadens the ability of archives to provide access to their collections without endangering the original item. Far from being eternal, poorly managed digital archiving practices may lead to a reduction in the effective lifespan and integrity of audio content, whereas a well managed digital conversion and preservation strategy will facilitate the realisation of the benefits promised by digital technology. Similarly, a poorly planned system requiring manual intervention may present a management task of considerable dimension that could be beyond the capabilities of the collection owners and so endanger the collection. A well-planned system should enable automation of the processes so that preservation can proceed in a timely manner. No system for preserving sound will provide a one-off solution, any preservation solution will require future transfers and migrations that must be planned for when the material is first digitised and stored" (Bradley MIP).

Having faced the need to copy, the selection of storage format becomes the first major issue. The sound archiving community is rallying around the European Broadcast Union's Broadcast Wave Format (BWF). BWF is a format that complies with the specification of the .wav format but has included a number of metadata tags in same manner as TIFF (tagged image file formats) has done for images. The International Association of Sound Archives recommends the use of linear BWF files for archiving. "Because of the simplicity and ubiquity of linear PCM (interleaved for stereo) IASA recommends the use of a .wav or preferably the BWF .wav files [EBU Tech 3285]. The BWF format is widely accepted by the archiving community." (Bradley MIP).

All responsible archiving groups and associations strongly argue against the use of any format that uses lossy data compression or perceptual coding in archival recordings, or in recordings eventually intended for archives. MP3 (MPEG 2 layer 3), minidisk and any form of streamed audio are all formats which employ bit rate reduction or data compression, and should not be used in archival processes, including field recording. It is not possible to "uncompress" recorded audio that uses perceptual coding; instead the part of the audio that is discarded remains forever lost, permanently limiting the quality and use of that audio thereafter.

If the problems facing analogue replay seem almost insurmountable, those which face digital carriers in the same situation are even greater. Digital recording technology is more susceptible to market driven format obsolescence than any audio technology that has preceded it. All recording made in digital form needs to be migrated to a stable storage system and format before the digital recording technology it is made on becomes obsolete. Unless such precautions are taken, much material will be lost. There will not be a workshop-built solution to replaying digital carriers when they are inevitably superseded and replaced. Instead, a planned, organised and standardised transfer to suitable storage will enable the digital file to be successfully and simply migrated when necessary.

The storage and conversion system consists of three parts, the analogue to digital conversion hardware, the computer system and the storage system.

In converting analogue audio to a digital data stream, the analogue to digital converter should not colour the audio or add any extra noise. It is the most critical component in the digital preservation pathway. In practice, the A/D converter incorporated in a computer's sound card does not, and cannot, meet the specifications required due to low cost circuitry and the inherent electrical noise in a computer. A discrete (stand alone) A/D converter that will convert from analogue to digital in accordance with the professional specifications is always recommended.

The more recent generations of computers have sufficient power to manipulate large audio files. Once in the digital domain, the integrity of the audio files should be maintained. As noted above, the critical point in the preservation process is converting the analogue audio to digital, and this relies on the A/D converter, and entering the data into the system, either through the sound card or other data port. Additionally however, some systems truncate the word length of an item in order to process it, resulting in a lower effective bit rate and others may only process compressed file formats, such as MP3, neither of which is acceptable.

The storage system may be divided into two categories, removable or non removable media. Non-removable media consist primarily of the digital mass storage systems (DMSS), removable CDs and other optical discs. The easy availability and low set up costs of recordable CD (CD-R) has made them attractive to many small, and not so small, collections. However, the successful management of a digital audio archive on CD-R requires significant investment in knowledge and technology, and constant and routine error testing and checking in order to garner reliable service from them. The draft IASA guidelines warn that you should "test your newly recorded disks. If a CD test program is beyond budget, choose a different storage medium." (Gaustad MIP) It is also important to emphasise that recordable optical disk of any sort is not a permanent solution. Carrier decay and format obsolescence will require that the content of the disk be migrated to another format in the medium term. Bearing in mind these constraints, it is possible to use recordable optical disks as reliable carriers for a period of time until the data is transferred to a more permanent solution.

DMSS are the engine rooms of large IT facilities. However, small scale collections are now finding such systems appropriate as technology begins to deliver scaled solutions.

DMSS generally (and generically) consist of hard disc, typically in a RAID array, for online access and data management tasks, a tape copy for back up or near-line access, generally housed in an automated tape library, and a series of servers for catalogue, online access, database and digital management systems. These systems are subject to routine IT based management protocols, which keep the data viable in the medium term. For example, the data on the system will be duplicated a number of times and stored not only within the tape library system, but also nearby to allow rapid recovery, and very often one copy, regularly produced, will be stored offsite. Redundant copies are the basis of data storage.

However, the requirement of keeping data in perpetuity adds extra requirements upon a system, generally in terms of maintaining meaning of the data beyond the life of the systems that store it. Making this a successful approach demands adequate planning, and suitable metadata and access software to ensure that future archivists have the wherewithal to make the necessary decisions and employ whatever preservation strategies are deemed necessary. The principles for digital preservation are laid out in the UNESCO *Guidelines for Digital Preservation.* (Webb 2003).

When, inevitably, circumstances dictate that the stored data must be copied to a new carrier, either through approaching carrier failure or format obsolescence, there are a number of approaches that may be considered. For a CD archive, a CD jukebox will facilitate the process at many times the actual playing time of each file, providing that the disc has been recorded in data format. Better yet, providing the system has been constructed with this in mind, and the formats selected with future open use as a guiding principle, a DMSS will allow a future migration project that does not need to be as labour intensive as the creation of the files in the first place. It will preserve not only the data, but the tools and technologies that will enable future users to gain meaning from the encoded data.

Digital Preservation as a discipline is in its infancy, yet it is here that the potential for audio data to survive past the life of discrete, market driven carriers can be realised. The vast quantity of culturally valuable audio materials being held, the finite resources for undertaking the transfer, and the impact of format obsolescence and carrier decay make it critical that this preservation work is done once and done in such a way that archivists can navigate the inevitable technological changes that will require them to migrate their data from system to system. The long-lived file, migrated from platform to platform, possibly from format to format, will see its invaluable data being used by future researchers in unimaginable ways.

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