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WHITE PAPER

SPECIFICATIONS AND GOOD PRACTICES FOR THE DIGITIZATION OF AUDIO AND MUSIC

INSTITUTE FOR RESEARCH ON MUSIC AND ACOUSTICS

2005 (revision 2008)

This study was compiled by a research group of the Institute for Research on Music and Acoustics (IEMA) commissioned by the Institute of Communications and Computer Systems (ICCS) of the National Technical University of Athens within the framework of the Operational Program "Information Society".

The study aims to constitute a guideline on all sound and music digitization performed in the Operational Program "Information Society" as well as elsewhere.

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Part I. Sound Digitization

SECTION 1: INTRODUCTION-GOALS

A significant part of our cultural heritage consists of sound material recorded on analogue recording media. This material is mainly musical (historical and archive recordings) but also includes lectures, speeches, conversations, interviews and sound from motion pictures. Important and fascinating features of our country's cultural history over the last 100 years can be found within this material.

These recordings must be digitized in order to preserve and utilize them. They must be converted into a digital form and stored in digital devices. In this way we will manage to:

a) **restrict damage** (the analogue material sustains damage through the passage of time and continuous use. Its digitization allows the reproduction of multiple copies of the original file and access to its contents without affecting the original).

b) facilitate **easy access and use** of the material (digitized material needs a lot less space for storage and the organization of its content in databases makes the management of this material a lot easier)

c) facilitate **optimization procedures and material management** (digitized material can be optimized more easily and conversion to popular formats can allow for easier public access).

Through the digitization process cultural heritage is salvaged and passed on to the next generation, thus constituting a point of reference for researchers, students, artists and anyone who seeks to explore the roots of human expression and creativity.

However, in order to be functional, the digitization process should follow the proper specifications and commonly accepted standards. This practice ensures:

- **Protection**. High quality digitization of materials reduces the need to access the originals, which can therefore be stored safely. Furthermore, the conversion and storage within common formats ensures the long-term historical protection of the files.
- **Interoperability**. Converting the material to widely acceptable formats, as well as its organization and documentation under commonly accepted specifications, facilitates easy correlation and comparison of records.
- **Security**. The sound material, through digitization and documentation, is connected to its creators and beneficiaries.
- **Accessibility**. Maximum access to the material and its content by researchers and the public is of great importance (especially if it is part of their national heritage). Clearly this is made possible through the use of common specifications.

GOALS

The present study aims to define the best practices on converting analogue sound material to digital, as well as its storage and management, in order to constitute a "**guideline**" for all possible digitization scenarios.

The basic axis in the compilation of this "guideline" is the definition of *minimum* requirements that ensure high quality conversion of analogue sound to digital, in relation to the *available technology* and *realistic* cost.

More specifically, the goals are:

- to give proper **guidance** to anyone who is interested in digitizing sound archives
- to make the **process** quicker and more systemized
- to **prevent mistakes** that can cause damage to the archive material or produce inefficient digital copies
- to keep digitization **costs** within logical budget limits
- to facilitate the **utilization** of archive sound material through published editions, educational programs, the internet and mass media.
- to establish digitization **models** to be used in all relative cases in the future.

The contents

The "guideline" covers all possible types of sound archives and, in general, all possible phases of the digitization process, such as:

- **preparation** of the material to be digitized
- specifications of reproduction and digital conversion **devices**
- specifications of **storage mediums**
- preferable **procedures** for reproduction, digitization and storage
- typical **formats** and suggested conversions
- **storage** specifications for the original archives and their digital copies
- appendixes with **useful information** on the material and quality of storage mediums
- **glossary** of terms
- references to relative **bibliography** as well as similar projects in the same field.

Interested parties

The specifications set out in this study are addressed to anyone interested in salvaging and utilizing archive sound material recorded in any analogue form. Having said this, the principal concern is with collections and archives containing large volumes of such materials, such as musical, literary and political archives, as well as television, record labels, folklore collections, etc.

In general the guideline is addressed to readers who are familiar with sound digitization procedures and the related technology and therefore some of the terminology used is considered as standard and well-known to such readers.

Validity of specifications

The specifications set out within this study aim to retain their validity over the longest possible duration of time. There are no important changes expected with regard to the preparation and reading of analogue material.

Having said this, the progress of research and development within digital media technology, as well as the continuous reduction of equipment and storage costs, will certainly demand the adjustment of these specifications at some point in the future.

When writing this paper we aimed for specifications that would retain their validity for a duration of at least five-years.

What happens to the originals?

The digitization process ensures that there is no further need to access the original medium. However, it does not negate the importance of this material, since:

a) theoretically, no transcription can be 100% identical to the original

b) technology is constantly evolving

c) further information taken from the original material could possibly be utilized in the future (notes, material analysis, etc)

For these reasons the originals should be stored in appropriate conditions that ensure the least possible damage due to external factors (see relevant section) in order to ensure future access to their content.

TERMINOLOGY

In the specifications' chapter certain expression are used in a specific context. The terms

- "**must**" or "**is necessary**" or "**it is imperative**" refer to an obligatory factor in order to achieve the best processing
- "**can**" or "**is recommended**" or "**should**" refer to suggestions left to the reader's discretion.

The term "**best processing**" refers to the best possible procedure in relation to logical cost and time required.

Abbreviations in square brackets **[ ]** (e.g. [AES]) refer to information sources listed at the end of this paper.

BASIC TERMS – METHODS – REQUIREMENTS – RISKS

The term "sound digitization" refers to the conversion of recorded analogue sound information to digital information.

The digitization process both enables easier management of the material and helps to preserve it. Firstly then, we should ensure that the reading made of an analogue medium is the best possible reading, and secondly the conversion to digital form must be as close to the original as possible **without external interference or improvements being applied** to the sound signal during its digitization. In this way we acquire the best possible copy of the original, even if the latter is in very bad condition. The first generation digital copy, which will be the digital archive file, **must not differ in any way from the original**. Sound improvements can be applied on subsequent generations of digital copies. This process ensures that as technological improvements advance there will be no need to return to the analogue prototype, since such new technological improvements can be applied to first generation digital copies.

Best quality digitization requires the following:

a) **best possible reproduction of the existing information**

Insufficient preparation of the sound recording and sub-optimal or incorrect settings on the reproduction device can limit sound information retrieval to 50-60% of what could be read under the appropriate conditions. Furthermore, such playback risks damaging the analogue storage medium irreparably.

b) **best possible analogue to digital signal conversion**

Improper amplification of the sound signal, the use of a medium quality A/D converter and incorrect resolution settings may also lead to signal loss of up to 30%, along with the infiltration of distortion to the digital version of the original signal.

CONDITIONS COMPELLING THE IMMEDIATE DIGITIZATION OF SOUND MATERIAL

Although the technique of analog to digital conversion has been known to us for quite a while, the conditions facilitating the implementation of this process on a wider scale have only recently been developed. These conditions are a) the availability of **high-resolution converters** (24/96), able to capture practically the full span of an acoustic signal with no distortion, within the market at a logical price and b) the recent drop in the costs of **large volume digital storage mediums** that previously used to hinder the process. There are, however, additional issues that compel the immediate digitization of analogue sound archives, which can be summarized thus:

- **Demagnetization** of materials. Various radiations, magnetic fields and the magnetic interaction of surfaces cause distortions and loss of the sound information.
- **Corruption** due to **usage**. All analogue mediums gradually wear with each use.
- Material **impracticality** due to the large volume of analogue mediums and their variable forms that require specific reading devices.
- **Lack of analogue equipment**. Most analogue reading devices are now out of production, with spare parts for tape recorders, gramophones and reading heads are becoming scarce.
- **Experienced technicians**. Technicians with the experience necessary to use and calibrate analogue devices are also hard to find.

We are heading towards an information society where the use of the internet, new prospects emerging in education and the utilization of archive material are all becoming a worldwide reality. A properly digitized archive can serve these new prospects.

Categories of analogue sound material

All forms of recorded sound on analogue materials and corresponding processes are studied in this section. Analogue recordings can come in a variety of forms according to the period in which they were recorded and the system used, as can been seen in the following table:

Format	Description	Usage period
Phonograph cylinders *	2 or 4 minutes long, wax or other similar materials	1888 – 1929
Gramophone records	(Shellac, other materials) 5.5" to 16" diameter (transcription records). 78.26rpm speed (72-82). From 60 to 130rpm before 1930.	1890 - 1960
Microgroove records	Vinyl, 7" diameter for 45rpm, 10 or 12" for 33 1/3rpm.	1949 - today
Wire recorders*	Magnetized wire, usually 15-30 minutes duration, single direction	1945 - 1955
Reel-to-reel recordings	1/4"-2” wide, 3-10 ½” reel and speed between 1 7/8, 3 ¾ 7 ½ 15 and 30 IPS (inches per second) (or 4.75, 9.5, 19 and 38 cm/sec)	1945 - today
Stereo 4-track cartridge	1.4" wide, 3.75 IPS	1962 - 1970
Compact cassette	1 7/8 IPS, hard case	1965 - today
Microcassette/ MiniCassette	2-4 cm cassettes, 1 7/8-3.75	1977 – today
Stereo 8-track cartridge*	1.4" wide, 3.75 IPS,	1965 - 1975
Optical sound recording to motion picture film		1918 - 1950
Digital recording analogue magnetic mediums	PCM-F1,DAT, VIDEO PCM, ADAT…	1985 – today

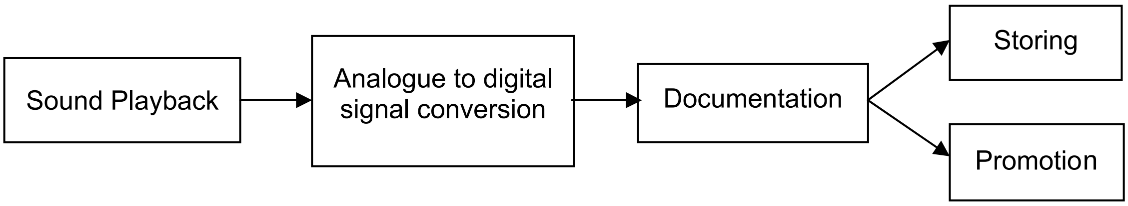
* There are no Greek sound archives recorded on such mediums and therefore they will not be analyzed in this paper.

The last two formats differ from the others mentioned above and will be analyzed separately.

SECTION 2: DIGITIZATION PROCEDURES

SCHEMATIC PRESENTATION OF THE DIGITIZATION PROCEDURE

The digitization procedure can be briefly described as follows



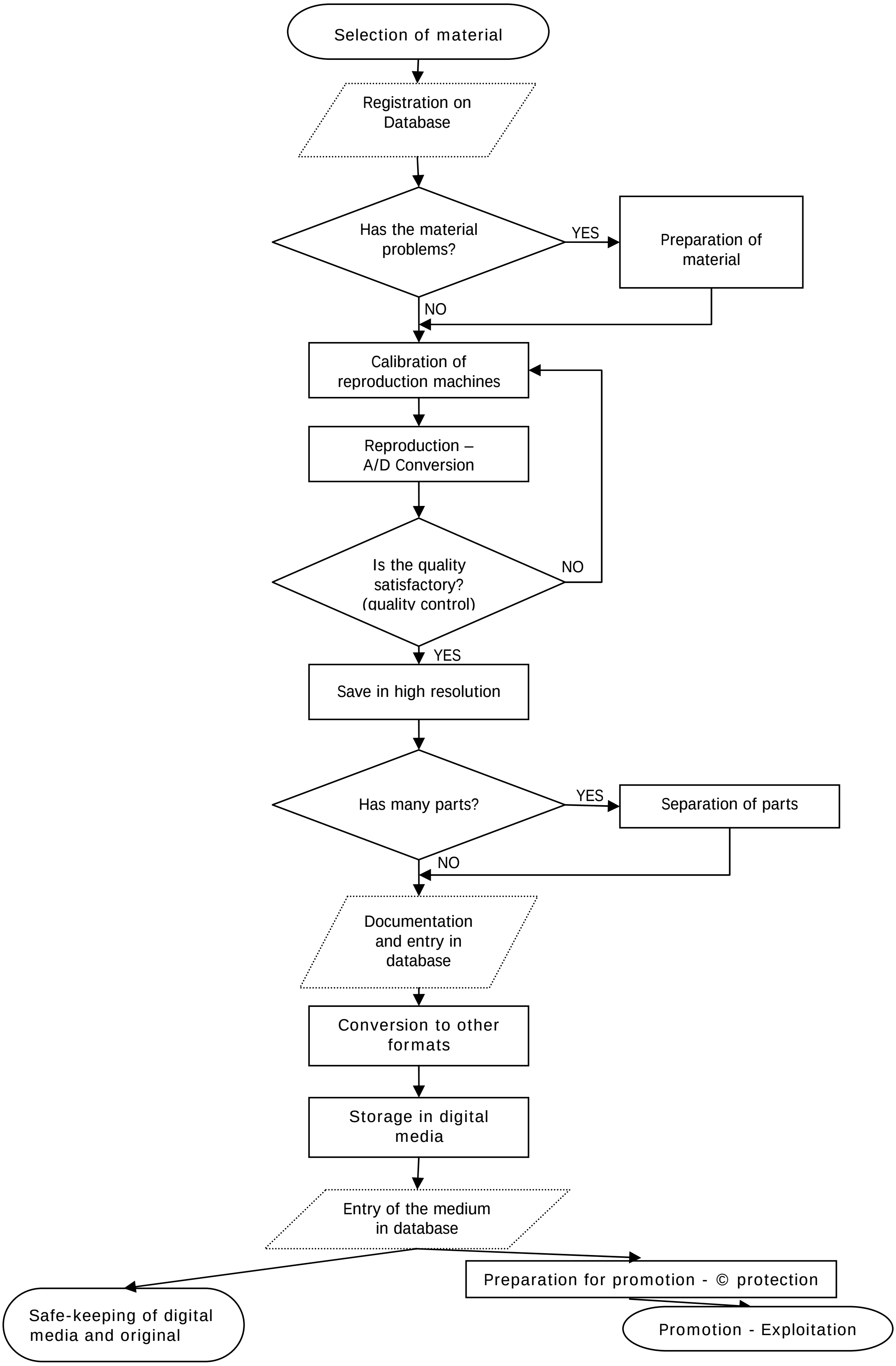
Basic digitization stages

Suggested digitization steps that will be analyzed in the following discussion include:

1. Selection of material
2. Importation of material's properties into a database and creation of Unique Identifier (UI)
3. Examination of the status of the analogue sound material
4. Preparation and resolution of possible problems
5. Adjustment of settings on playback device
6. Analogue sound material playback and A/D conversion
7. Storage of digitized sound material in high resolution
8. Separation of possible parts
9. Material classification by use of metadata (Dublin Core, MPEG-7, other) – Importation to a database – Exportation – Database entries of contents and UI creation
10. Conversion of digitized material to various lower resolution formats according to the use intended
11. Storage and organization of digitized material on digital storage mediums
12. Create database entries of the digital mediums used
13. Copyright protection of sound material
14. Storage of analogue and digital storage mediums and access organization.

Should the digitized material need to be published on a CD or other medium, an experienced sound engineer can apply the correct techniques to resolve potential problems.

Note: The creation of entries in standardized databases and unique identifiers are studied in more detail in the relevant sections.


Selection of material
Registration on Database
Has the material problems?
YES
Preparation of material
NO
Calibration of reproduction machines
Reproduction – A/D Conversion
Is the quality satisfactory? (quality control)
NO
YES
Save in high resolution
Has many parts?
YES
Separation of parts
NO
Documentation and entry in database
Conversion to other formats
Storage in digital media
Entry of the medium in database
Preparation for promotion - © protection
Safe-keeping of digital media and original
Promotion - Exploitation

Facilities and archive manipulation

The facilities where digitization procedures are performed should be:

- **free of dust**
- **heat** and **humidity** regulated
- **sufficiently ventilated**

A handheld **electric vacuum cleaner** and a **compressed air** system are necessary for quick dust removal before it settles on the surfaces of the original materials. Special care should also be taken in order to avoid the creation of **magnetic fields** (via transformers and speakers) close to magnetic mediums, as well as the avoidance of devices that produce vibrations (e.g. floor air-conditioners).

People handling the materials must not touch the recorded surfaces and their hands must be washed before handling the materials so as not to stain the surfaces. It would be better to use special **soft cloth gloves** that can be washed when dirty or exchanged for clean gloves.

Operator

The person handling the original materials (especially in the case of reel-to-reel tapes) and undertaking the digitization process must be a **specialized technician** experienced in

- analogue mediums and playback equipment
- digital recording systems and sound processing on computers
- digitizing analogue sound material

If such a technician is not available, then **the operator must attend a special educational seminar**.

Reel-to-reel (tape) recordings

Digitization process for reel-to-reel recordings

Historical facts

The first devices recording on steel wire appeared in Germany in 1925. In 1947, the wire was replaced by a magnetic film made of acetate or polyester overlaid with iron oxide on one side that could thus be magnetized and preserve the magnetic polarization for a long period of time. Reel-to-reel manufacture techniques remain the same up to the present day. In the ‘80s, however, other materials were tested as well as alternative methods explored to hold the overlaid material in place. During the last few decades, reel-to-reel recorders have been gradually set aside and digital recording mediums adopted.

Reel-to-reel manipulation

Reels must only be touched on their outer surface and central axis area. The reel’s wide surfaces must not be pressed together in order to avoid destruction of the tape’s edges. If the tape is not incased in a reel, then it must be tightly held by the ends of the tape and not the central axis and quickly placed on a suitable base because it may unfold.

If it is necessary to unfold the tape it should not be in contact with non-revolving parts of the recorder, and sudden stops should be avoided to prevent the tape from breaking up.

The recorded side of the tape must not be touched with naked hands. If need be, it must be touched gently without pressing onto the surface. If you need to edit splices then you must use a special adhesive tape on the outer surface of the tape.

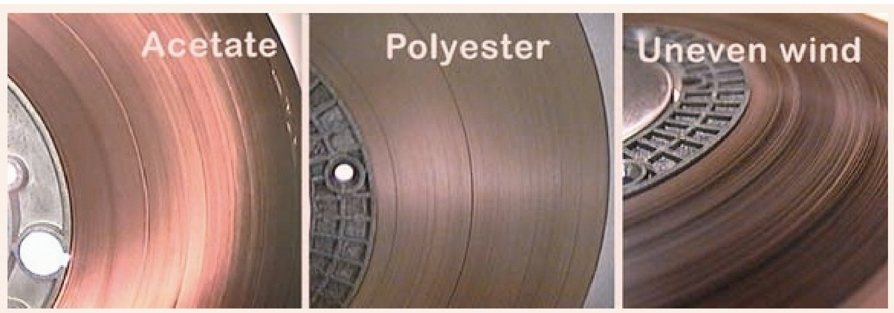
Tape preparation

Equipment

- Special dehydration oven for baking and laboratory thermometer
- Tape-player, reading quality not significant
- Tape and stitching guide and leader strips

Evaluating the tape’s condition, defining type of tape

Tapes are generally distinguished into two main categories; those made in 1948-1970, mainly made of acetate, and those made since 1970 when the magnetic overlay changed, thus improving the noise reduction and frequency response of the tape’s technical characteristics. It was later proven that these latter tapes were much more sensitive to temperature and humidity fluctuations and serious storage problems emerged (these problems were diagnosed in 1984 and partly corrected).



Types of tapes

If the tape is wound on a reel for a long time, and especially if it is unevenly wound, then you must rewind it once (or unwind it if the tape was wound the wrong way around - tail out). However, if you observe that the tape is sticking on the heads and tape motion is not smooth, you must first apply a dehydration technique (see the following) and rewind it once. As far as tape playback is concerned, the quality of the reading device is not important. However, all mechanical parts of the device must be revolving and in a good condition in order to avoid damaging the tape.

[Caution! In some of the early professional devices used in radio stations, the head was located on the outer side and tapes were wound with the overlaid surface facing up. These kinds of tapes must be rewound by half a spin (the magnetic side internally) if they are to be played on a modern device.]

The STUDER, a top quality professional reel-to-reel device.

Playback

Equipment

- High quality reading device
- Test tapes

Preparation and device settings

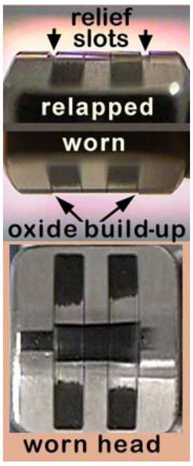
Professional devices must be used that have the following features:

- Good controls with regard to tape movement (slow acceleration, soft brakes, revolving guides)
- Very good quality electronics and amplifiers (see Technical Specifications)
- Memory settings for calibrating each tape separately
- Head azimuth adjustment feature
- Changeable heads (1/4' – monophonic – 4 track) to fit the tape
- Double motors
- Multiple speed playback (1 7/8, 3 ¾, 7.5 and 15 IPS) according to each recording
- Available spare parts and components

A micrometric revolving speed-setting feature is also very useful.

Device preparation

- All parts of the device where the tape will be directed must be cleaned (heads, mechanical parts and pinch roller)
- Check of head condition. You must make sure that the heads are clean and in good condition. Heads are gradually worn by the tape and their characteristics alter, mainly in terms of their frequency response, and a stripe is formed on their surface.
- You must carefully and with the proper movements demagnetize all metallic components (heads – guides)
- You must turn on all devices at least 20-30 minutes prior to use. All analogue electronics need a certain amount of time to reach maximum performance.
- Set spinning speed to match that of the tape you want to digitize (7 1/2ips – 15ips, etc.)
- Set the EQ to match that of the tape to be digitized (CCIR – NAB – AES, etc.)
- Set the level of frequency response on the device:
    - If the tape has a level, set the device to match it.
    - If the tape doesn't have a level, set the device according to a test tape, preferably one from the same time period as the one you want to digitize.



Using a test tape enables us to apply settings with regard to

- Playback level 1kHz
- High frequencies (10kHz – 12kHz – 16 kHz)
- Low frequencies (40 Hz – 60 Hz – 100 Hz)
- Azimuth (based on high frequencies 12,5 – 16 kHz)

In the case of tapes recorded in stereo use the "MONO AND POLE" method to achieve ideal azimuth settings and consequently high frequency settings. (see RESTORATION PROCESS OF ANALOGUE TAPE PROBLEMS)

Check if the tape is recorded in Dolby (A, SR) and apply the corresponding settings if the specific tones are written on the tape.

If the tape does not specify the Dolby tones, set the Dolby device to the typical settings and check the playback output to make sure that it is normal and without compression.

Table 1 MRL Multifrequency Calibration Tapes for Open-Reel Applications

Tape Width *Playing Time*	Tape Speed	Equalization Standard	Fringing Compen-sated?	Level of Frequency Response Section	Catalog Number for Reference Fluxivity:			
					200 nWb/m	250 nWb/m	G320 nWb/m	355 nWb/m
6.3 mm **¼ inch** *6 minutes*	95 mm/s **3.75 in/s**	IEC & **NAB**	No	-10 dB	**21F101-A**	**21F201-A**	—	—
	190 mm/s **7.5 in/s**	IEC (IEC1)		-10 dB	21T102	21T202	21T302	—
		NAB (IEC2)		-10 dB	**21T104**	**21T204**	—	**21T404**
	380 mm/s **15 in/s**	IEC (IEC1)		0 dB	21J103	21J203	21J303[a]	21J403
		NAB (IEC2)		0 dB	**21J105**	**21J205**	—	**21J405**
	760 mm/s **30 in/s**	**AES** (IEC2)		0 dB	**21L121**	**21L221**	—	**21L421**
12.5 mm **½ inch** *8 minutes*	95 mm/s **3.75 in/s**	IEC & **NAB**	Yes[b]	-10 dB	**31F156-A**	**31F256-A**	—	—
	190 mm/s **7.5 in/s**	IEC (IEC1)		-10 dB	31T128	31T228	31T328	—
		NAB (IEC2)		-10 dB	**31T118**	**31T218**	—	**31T418**
	380 mm/s **15 in/s**	IEC (IEC1)		0 dB	31J129	31J229	31J329[a]	31J429
		NAB (IEC2)		0 dB	**31J119**	**31J219**	—	**31J419**
	760 mm/s **30 in/s**	**AES** (IEC2)		0 dB	**31L120**	**31L220**	—	**31L420**
25 mm **1 inch** *10 minutes*	95 mm/s **3.75 in/s**	IEC & **NAB**	Yes[b]	-10 dB	**41F157-A**	**41F257-A**	—	—
	190 mm/s **7.5 in/s**	IEC (IEC1)		-10 dB	41T125	41T225	41T325	—
		NAB (IEC2)		-10 dB	**41T115**	**41T215**	—	**41T415**
	380 mm/s **15 in/s**	IEC (IEC1)		0 dB	41J126	41J226	41J326[a]	41J426
		NAB (IEC2)		0 dB	**41J116**	**41J216**	—	**41J416**
	760 mm/s **30 in/s**	**AES** (IEC2)		0 dB	**41L117**	**41L217**	—	**41L417**
50 mm **2 inch** *16 minutes*	190 mm/s **7.5 in/s**	IEC (IEC1)	Yes[b]	-10 dB	51T122	51T222	51T322	—
		NAB (IEC2)		-10 dB	**51T112**	**51T212**	—	**51T412**
	380 mm/s **15 in/s**	IEC (IEC1)		0 dB	51J123	51J223	51J323[a]	51J423
		NAB (IEC2)		0 dB	**51J113**	**51J213**	—	**51J413**
	760 mm/s **30 in/s**	**AES** (IEC2)		0 dB	**51L114**	**51L214**	—	**51L414**

Converting analogue signal to digital

If all steps have been completed and everything is ready, and there is no need to apply restoration processes for problems such as those analyzed below, you can proceed with the digitization using a top quality A/D converter. The recording level must be set so that 0 Vu, that is +4dB, on the analogue playback device corresponds to -14 dbfs on a digital meter (peak meter/ DAW meter).

Quality control

The digitized material must be checked for possible distortion, drop out and should it be stored on a server or DVD-R, it must be checked that the copy is exact (bit identical).

RESTORATION PROCESS OF ANALOGUE TAPE PROBLEMS

Carefully examine the condition, type and manufacture date of each tape before placing it on the reading device. Attention must also be paid to how it behaves during reading. Some of the problems you may encounter include the tape sticking on the heads, tape wearing off, leading strips getting out of place, waving of the tape during movement, "weeping" sound, crooked reels, non-calibrated Dolby system, unset azimuth, etc.

These problems can be resolved to a large extend by use of several techniques.

Baking

Baking successfully solves the most important problem that occurs mainly in tapes manufactured in 1970-1984 - the existence of humidity that causes the tape to stick on the reel or the device's guides.

As mentioned earlier, you must check if the tape's surface is sticky. This is caused by the "fixation agent", the chemical that retains the oxide particles and places them on the tape. Polyurethane, a compound of the "fixation agent", tends to absorb water particles in high humidity conditions. The water particles react with those of polyurethane and displace the latter to the tape's surface from where they are spread during playback. The "sticky surface" phenomena is most common in tapes manufactured from 1970 to 1984, when the molecular structure of the "fixation agent" was not controlled. Therefore, if the tape has a sticky surface, it must be "dried out".

For this procedure a dehydration oven, able to maintain temperature to 55^{o} C, is necessary. The oven must be equipped with a precision thermometer to control temperature.

Tapes are heated according to width from four (¼") to eight hours (2") or more depending on their condition. The tapes must be allowed to return to normal temperature prior to use. Furthermore, tapes must be properly wound before entering the oven. If that is not the case, they must be rewound slowly and without coming into contact with non-revolving parts of the playback device.

Baking temporarily removes moisture to enable the digitization process. Manufacturers (for example AMPEX) state that the digitization process can be performed many times without damaging the tape, but we recommend that it should be performed only once, 48 hours after baking.

Setting azimuth (MONO AND POLE method)

To set azimuth for stereo tapes that don't specify their recording tones, pass the signal to a console and reverse the phase of one of the two channels. Combine the output of both channels to a monophonic signal and set the head's azimuth. Setting must be made very gently with small movements. An external oscilloscope or software equivalent could improve precision.

Set the azimuth to achieve cancellation of high frequencies. This means that when both channels are restored to phase you will achieve maximum yield of high frequencies, which is what we are aiming for, since the angle of the head reading the tape will be the same as the one used in the original recording.

EDITING SPLICES

If the tape is split you can fix it using a special adhesive tape (2-3cm) on a guide (rail), making sure that the two ends are properly connecting with each other. If this is not the case, cut both ends on a 45^{o} angle removing as little tape as possible. If a significantly large piece of tape is missing, add a white leading strip. If there are noticeable scratches on the tape, it can be reinforced by placing adhesive tape on the outer surface. If the tape doesn't have leading strips at the beginning and ending of the reel, they must be added (at least 75cm long) using adhesive tape on the outer surface.

CONVEYANCE TO METALLIC REELS

Tapes are sometimes wound on damaged reels that reduce playback quality. Although good playback devices have guides and very good tension control, it is advised to use large metallic reels which exhibit exceptional inertia and homogeneity during movement.

DOLBY SETTING

Dolby playback tones <u>must</u> be identical to the ones used in the recording of the tape to be digitized. The techniques used for Dolby A and Dolby SR on stereo or multi-channel devices are beyond the scope of this guide and must be performed by a qualified technician.

SPECTRUM ANALYZER

The use of a spectrum analyzer is necessary because it provides information about the audio signal and enables the detection of problems, during setting and playback, which are related to level, frequencies, azimuth, stereo image, etc.

Digitization process for cassette recordings

Since Phillips introduced the cassette in the ‘60s, it became extremely popular and dominated home sound systems, replacing reel-to-reel systems.

Cassettes use a 1/8’’ wide tape and a spin speed of 1.875 inches/sec.

Preparation

Evaluate tape condition and flow.

In rare occasions, when tape is jammed or cut, you will need to open the casing and edit the tape or even replace the case. Break the special tab on the case that protects the tape in order to avoid accidental deletion.

Playback

Carefully clean and demagnetize the heads on the playback device.

Check spin speed and tone level of the recording.

Many earlier recordings were made on tape recorders running on batteries and thus a common problem is an incorrect speed due to battery depletion. In many occasions, spin speed fluctuates during the recording and tone levels must be corrected in several sections during digitization.

The main problem with cassettes is incorrect azimuth settings created during the recording. As a result, playback is correct when performed on the tape recorder that made the original recording but problematic on other tape recorders. This problem becomes evident as high frequencies fluctuate and, in the case of recorded speech, the “k”, “f”, and “s” consonants diminish and become hardly audible. In the case of music recordings, playback is “dull”, lacking clarity in high frequencies.

To solve this problem, a tape recorder is required that, aside from containing good electronic components, also has setting features for head azimuth during playback. Combine both channels’ output to a monophonic signal and set head azimuth to achieve maximum response on high frequencies. These manipulations must be made with extreme caution.

It would be very helpful to employ an external oscilloscope or software equivalent to enhance precision.

Play the tape and digitize the material using a using a top quality A/D converter..

Gramophone - vinyl records

Digitization process for 33 1/3 rpm/ 45rpm vinyl records

Vinyl records appeared in 1948 and gradually replaced 78rpm records.

Vinyl records can be divided into two categories: 12" diameter records that have a 33 rotating speed with 1/3rpm rotation and 30 minutes duration (long playing) and 7" diameter records that have a 45rpm rotation speed.

Sound quality reduces in recordings over 20-22 minutes duration due to the fact that the grooves become smaller. However, vinyl is a medium able to reproduce the full frequency spectrum of a recording on contemporary gramophones that have better arms and heads.

Vinyl records were produced in almost the same way as 78rpm records, but the recording was first made onto a magnetic tape from which the matrix was created and then the mass production of vinyl records began.

In earlier years, recordings - and therefore the vinyl records themselves - were monophonic. Stereo recordings and vinyl records began in the late '50s.

The development of analogue recordings, vinyl records and playback systems have developed considerably and today, 20 years after the development of digital technology and CDs, they can still produce high sound quality.

The main problem associated with vinyl records is that of noise (clicks) during playback, a phenomenon greatly dependent on the cutting quality of the records achieved during manufacture and the settings on the playback device (gramophone-arm-head).

Records created from good quality vinyl that are played on well-adjusted systems can be preserved in perfect condition for many years.

Handling

All records must be handled by their edges and the central area where the label is.

Preparation

- Carefully examine the type and material of the record to be digitized (laminated, shellac, soft lacquer, etc.)
- Choose the correct chemical method to clean the record's surface and grooves from dust and other material. [see complimentary section on record washers]
- Carefully clean the surface, preferably using a record washer similar to those for vinyl records, making sure that the proper chemical solution and equipment for 78rpm records is employed.
- Never use the same equipment twice because iron filings that may remain from cleaning other records will damage the surface of vinyl records.
- Check record eccentricity and symmetrical spinning on the platform. If there are problems you must carefully centre the record. This way you avoid the "wow" phenomenon during material transfer and the arm and head can read the recorded information more easily.
- If you have more than one sample from different record cuts, choose the specimen that seems to be in the best condition and sounds better. Check if the spinning speed is correct, although you will rarely encounter speed mistakes on 33rpm and 45rpm records.
- If you have more than one sample from different record cuts, check if they share the same tone height.

- Choose a proper head according to date, label and condition of the record. [see complementary section on heads]
- Use a good quality pre-amplifier to enhance the head signal.
- Use a pre-amplifier with a RIAA curve
- Choose the correct head reading weight on the assumption that geometry and antiscating are properly regulated. [see complementary section on heads]
- Play the record and digitize the content using a high resolution and tonally precise A/D converter.

Equipment

- precision gramophone with wow-flutter and micrometric speed adjustment features
- magnifying glass to evaluate the condition of record and needle
- record washer for cleaning
- suitable chemical solution to remove dust, particles and microorganisms and to protect against reappearance and deposition on the record's grooves

Digitization process for 78rpm records

78rpm records were the first mass distribution recording and playback mediums from 1890 to 1960. They are also referred to as "short playing" records in contrast to the long-playing 33½ vinyl records.

Although they were called 78rpm records, their speed was not set with precision and varied from 60 to 130 rpm until 1930-1932!

Prior to 1925, most records were played at 72-82rpm speeds. Edison Diamond Discs, however, were all played at 80rpm speed.

Occasionally, we find discs from radio cuts of 78 or 33 rpm with 16" diameters, and music for films on 33rpm 16" discs, etc.

Most of these records are manufactured from materials based on shellac.

Handling

All records should be handled by their edges and the central disc area where the label is located.

Carefully examine the type of 78rpm record you are about to digitize (laminated, shellac, soft lacquer, etc.).

Select the proper chemical method to clean the disc's surface and grooves from dust or other particles. Carefully clean the surface, preferably by the use of a record washer similar to those used for vinyl records. Make sure you use a chemical solution and equipment designed specifically for 78rpm records. Never use the same equipment twice because iron filings that may remain from cleaning 78rpm records will damage the surface of vinyl records.

Check record eccentricity and symmetrical spinning on the platform. If there are problems you must carefully centre the record. This way you avoid the "wow" phenomenon during material transfer and the arm and head can read the recorded information more easily.

Check if the spinning speed is correct. Many 78rpm records vary in playback speed between 76-80 rpm. Some rare old discs may also be played at 76-80 rpm.

If you know the tone height of a recording then you can regulate the gramophone's pitch to the correct rpm.

If you don't know the tone height of a recording, but you can hear a guitar in it, for example, that plays MI flat lower than it would normally do, then you can conclude that the recording is a lower tone than what it should be.

In some recordings, however, this is not possible - traditional music recordings would be one example.

Choose the correct head according to date, label and condition of a record. [see complementary section on heads]

Use a good quality pre-amplifier to enhance head signal.

CAUTION!! Never use a RIAA pre-amplifier for 78 rpm records.

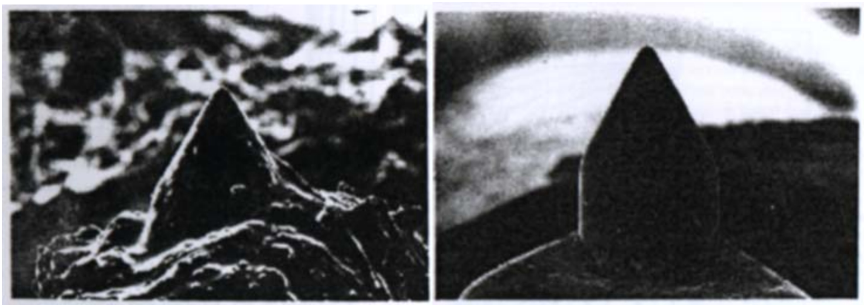
Determine if the cut is vertical or lateral and choose the correct decoding on the pre-amplifier. [see complementary section on heads]

Choose the correct reading weight for the head given that geometry and antiscating are properly adjusted. [see complementary section on heads]

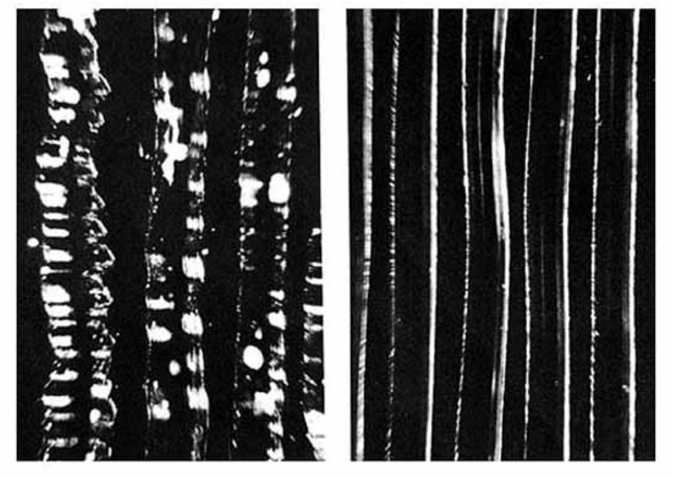
- Play the record and digitize the content using a high resolution and tonally precise A/D converter.

Equipment

- Precision gramophone with "wow-flutter" and micrometric speed regulation features, capable of 78rpm playback
- Magnifying glass for closer analysis of the record and needle condition
- Record washer for cleaning
- Proper chemical solution for the removal of dust, particles and microorganisms, as well as protection from particle deposition on the record's grooves.



A gramophone needle before and after cleaning



Vinyl record grooves before and after washing.

Record washers (cleaners)

The basic preliminary procedure for record playback is to clean the record's surface. Over time, dust and other particles settle on the record's grooves, especially when storage conditions are not suitable. Microorganisms and funguses can also develop on the grooves. All these deposits can affect playback and sound output.

To avoid these problems, records must be carefully and thoroughly washed. Washing can be done manually, although it is not recommended. The ideal solution is to acquire a record washer that ensures proper washing, eliminates the risk of record disfiguration and removes all residues of the chemical solution used as well as salts from the water.

Several types of washers can be found in the market:

Product	Webpage	Manufacturer	Price
The Archivist Record cleaning machine	http://audio-restoration.com/monks5.php	Keith Monk	4.950$
Loricraft PRC2/3	http://www.smartdev.com/loricraft.html	Smart Devices	1.795$
MKII Moth Record cleaning machine	http://www.britishaudio.co.uk/rcm.htm	Moth	821€
HW-16.5/17	http://www.vpiindustries.com/hw17.htm	VPI	399.95$
2.5Fi Mk II Record cleaning machine	http://www.nittygrittyinc.com/	Nitty Gritty Record Care Products	579$

You can also construct your own washer.

http://www.teresaudio.com/haven/cleaner/cleaner.html

It is very important that the washer has a vacuum extractor fan to remove dust and dirt.

Records must not remain in the chemical solution for a long time. Certain records (like early Columbia records and Edison Diamond Disks) are layered and they will swell if moisture seeps in between the layers, causing them to peel and deform around the edges. Furthermore, certain labels are more porous and therefore extremely sensitive to humidity.

1.2.5 Cleaning solutions

You can find many chemical solutions in the market especially made for record cleaning.

Product	Webpage	Capacity	Price
L'art du son	http://www.positive-feedback.com/Issue12/LArtduSon.htm	5lt	46€
Smart mild		8oz	9.95$
Nitty Gritty Purifier 2	www.garage-a-records.com/nitty.html	2 lt	34.95$
Phoenix II record cleaning fluid	www.sleevetown.com/vinyl-cleaning.shtml	4 lt	25.95$
Phoenix record cleaning spray	www.sleevetown.com/vinyl-cleaning.shtml	8oz	15.95$
Groovy cleaner	www.vinylconnect.com/ catalog/product_info.php?products_id=693	4oz	10.00$
RRL Super Record Wash	www.amusicdirect.com/products/search.asp?mfr=REC	32oz	29.95$

You can also make your own solution. Some of the most common solutions suggested are mentioned in the following table:

Suggested by	Purified water	Alcohol *	Other compounds
Steven Rochlin	1 part	1 part isopropyl	-
Steven Rochlin	1 part	1 part isopropyl	1 drop Triton X-100
Steven Rochlin	1 litre	½ litre denatured alcohol	10 drops Photoflo
Laura Dearborn	3 parts	1 part isopropyl	1 drop Triton X-114 or Monolan 2000

Don Roderick	4 parts	1 μέρος isopropyl (91%)	7-8 drops no-additives detergent
Jonathan Scull	3 parts	1 part NON-lanolin isopropyl	10 drops Photo-Flo + 10 drops "Direct" tile cleaner
Library of Congress	4 litre	-	Triton™ XL-80N 20 ml, Ammonia liquor (analytical reagent grade), 20 ml, Alkyl dimethyl benzyl ammonium chloride, 0.5 ml

*CAUTION! Solutions that contain alcohol compounds are not suitable for older (78rpm) records because they alter organic materials (shellac).

The **solution suggested by the Library of Congress** is a simple solution, friendly to the environment, for records as well as CD and DVD cleaning:

Cleaning solution preparation

In 4 litres of purified water add:

- *1.20 ml (0.5%) TritonTM detergent*

This compound is the solution's main detergent. It is marketed by Union Carbide Corporation, a member of Dow Chemicals. Its main advantage is that it is designed to be washed off more easily than most detergents.

- *2.20ml (0.5%) liquid ammonia (analytical reagent grade)*

This compound is included only for cleaning acetate records. The analysis of white residues found on acetate records determined that they consist of fatty acids from deteriorating lamination compounds used in manufacture. The liquid ammonia will not damage other records. However, it will not assist in cleaning them better.

- *3.0.5ml (0,13%) Alkyl dimethyl benzyl ammonium chloride*

This compound is added to prevent the development of microorganisms during storage. It is also useful for mould removal, but it does not influence the cleaning procedure.

The bottle must then be properly capped and turned upside-down a few times for all ingredients to dissolve.

Instructions of use

This solution can be used to clean records with or without the use of a washer. In any case, residues from the cleaning process must be rinsed off. The record must then be dried, using a non-flocculent soft cloth. This might not be necessary if you use a washer that has an extractor fan.

The solution consists of relatively harmless compounds and is thin enough to allow disposal through the drainage system.

The necessary precautions during manufacture are presented on the Library of Congress' webpage. These precautions concern both the facility and equipment necessary to manufacture the solution safely.

SPECIFICATIONS

Pick-ups

The proper playback of records is a complex issue.

First of all, records have been produced according to various different methods and therefore require different types of pre-amplifiers for their correct playback.

In addition, different rpm records require different platform rotation speeds.

Finally, different recording speeds, the method by which the grooves on a record were made and the record's condition due to time and use all necessitate different playback settings.

Therefore, in order to achieve correct playback of records on a record player you must:

- Use pre-amplifiers that have the correct equalization according to the manufacture methods of 78rpm and 45rpm records, as the following tables demonstrate.

COARSE GROOVE ('78 rpm')					
SYSTEM	Treble turnover	Bass turnover	Lower bass t/o	Cut at 10 kHz	Boost at 50 hz
DECCA 78	3.4 kHz	150 Hz	-	9 dB	11 dB
ffrr 78	6.36 kHz	250 Hz	40 Hz	5 dB	12 dB
WESTREX	Flat	200 Hz	-	-	15 db
BLUMLEIN	Flat	250 Hz	50 Hz	-	12 dB
BSI 78	3.18 kHz	353 Hz	50 hz	10.5 dB	14 dB

- The pick-up must have a variable speed feature of at least 65 to 85 rpm (like Rek-O Kut Rondine, Murray/Ramses-II) with optical or digital rotation control.
- If there is no variable speed feature, there should be at least option for 71.26, 76.59, 78.26 & 80 rpm speeds in order to cover most record speeds.
- Pick-ups must have conical elliptic needles from 2.5 inch mm to 3 inch mm.

Record players should provide the ability to alter needle type and weight for 78rpm records, as well as the ability to alter platform speed to allow playback for records recorded at 60 or even 90rpm. It would be very helpful to have access to a microscope by which to observe the grooves and general condition of the record, in order to select the appropriate type of needle. Special attention should also be paid to the selection of the pre-amplifier (RIAA or other according to the recording) as this will determine the final output of the record player, noise levels and frequency response. (These pre-amplifiers intentionally enhance high frequencies and generally produce a non-linear frequency response, as is shown in the table above).

Heads – Needles

Early 78rpm records were recorded using two different methods. The first demanded the sound signal information to be located at the side of the groove. This method is called “horizontal relocation technique”. In this way, the needle touches the walls and not the bottom of the groove, vibrates according to the engravings and reproduces the sound recording. Ninety percent of all 78rpm records have been manufactured according to this technique.

However, the first record companies, such as Edison, Operaphone, Par-O-Ket, Pathe, etc, used a different technique. The information is located on the bottom of the groove instead of the side. The needle moves in the vertical axis instead of the horizontal axis to provide the electrical fluctuations that will compose the sound signal. This is known as the "vertical relocation technique".

In both cases, using the wrong type of needle causes a large increase of noise and other "distortions" that significantly reduce sound reproduction quality. Note that while most 78rpm records are considered to be coarse groove records, there are many cases where they have 45 and 33rpm grooves (microgroove) and therefore require the corresponding pre-amplification.

For these reasons you should use a microscope to determine the type and size of needle to use, making comparisons, if necessary, with record types of known manufacture.

A/D conversion

A/D conversion is the second most important step (after playback) of the digitization process, because the quality and frequency precision of the conversion determines the amount of information captured and digitized.

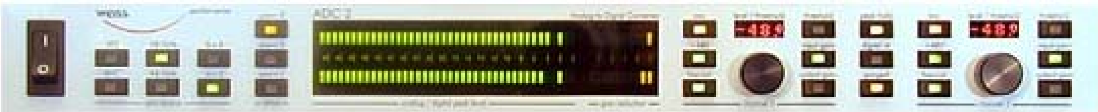
- The A/D converter must have the least possible errors during conversion.
- The converter can be located on a sound card installed in a PC or Mac workstation as long as it meets the required specifications. However, it is preferable for the converter to be located on a separate device because the computer environment is susceptible to various interferences.

3.1 Conversion process

The first thing to tend to during digitization is the input and output level of the various devices. The proper regulation of levels, besides avoiding distortion (digital distortion is extremely unpleasant), can ensure a good quality digitization with the least possible errors.

The output level of the analogue playback device must be **the highest possible**, but always within a safe margin to avoid distortion. Of course, if you have test tones on reel-to-reel recordings, you should follow the procedure mentioned earlier. In general, try to establish the best possible signal to noise ratio.

As far as the converter is concerned, the input level must correspond to the output level of the analogue playback device. For example, if a cassette player can reproduce a +12dB



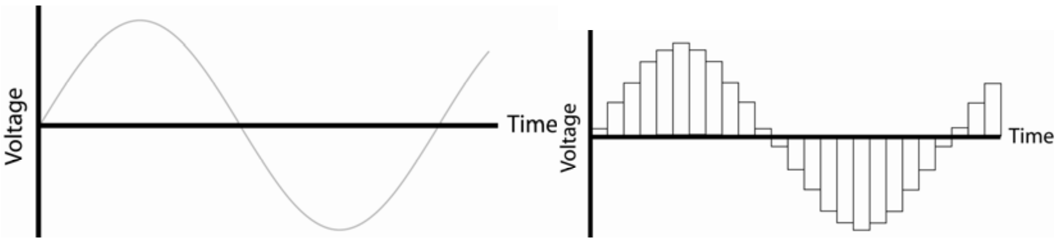
signal (without distortion), then the converter should also be set to the highest possible level without distortion. A common practice is to set maximum levels just below that point (analogue +9, +10dB, digital -2, -1dB).

The second thing to tend to during digitization concerns the software settings by which the digitization will be performed, assuming of course that a computer is used in the digitization process. The settings of the specific software as regards to sampling frequency and bit depth must be identical to the corresponding settings on the converter.

Digitization analysis

Sampling analysis affects the digital copy's closeness to the original and is determined by two variables: sampling frequency and bit depth.

- **Sampling frequency** is the frequency by which samples from the sound signal are received and converted to digits. It is measured in kHz. Given that a full oscillation of the signal needs two digits for its conversion, the sampling frequency should be at least twice as much as the highest frequency of the signal (Nyquist theorem). Under this concept, CD quality was established at 44.1 KHz sampling frequency, which is somewhat higher than double the frequency limit of human hearing capacity (22 kHz).



This minimum convention of the Nyquist theorem does not adequately describe high frequencies and therefore, if the signal has high frequencies, there is loss in signal information; high frequencies become harder in their digital version and the aliasing phenomenon that converters try to filter is also created. For this reason, when aiming to create a correct digitization of a sound signal, you should rely on higher sampling frequencies (96 or 192 KHz). Given that sampling frequency increases parallel to data volume increase, a sampling frequency of 96 kHz is considered to be well balanced between quality and practicality. On special occasions where the sound signal doesn't have high frequencies (e.g. speech), you can also use a 44.1 or 48 kHz sample frequency (the 44.1 kHz sampling frequency is preferred due to Audio CD compatibility).

- The second variable, **bit analysis**, concerns the analysis of each digit as measured in bits. In accoustics terms it is translated as the depth of the dynamic field (in dB). Therefore, the standardized values in CD quality digital recordings gives a 16bit analysis corresponding to a 96bB dynamic field. This analysis is lower than the dynamic field of human hearing (120 dB) and imposes certain "adjustments" on the sound signal against digitization fidelity. For these reasons, the minimum bit analysis proposed during digitization is 25 bit corresponding to a 144dB dynamic field depth. In cases of simpler sound signals (e.g. speech) a 16 bit analysis could surfice.

As already mentioned, analysis influences the amount of digitized data. The following table presents a correlation (in Megabytes) between one hour of stereo sound against different values of analysis.

	Sample frequencies in Hz				
Bits	32	44,1	48	88,4	96
16	460,8	635,04	691,2	1272,96	1382,4
24	691,2	952,56	1036,8	1909,44	2073,6

SECTION 3: Digital Storage

Storing digitized sound material during conversion

During conversion, the digitized material can be stored on a computer's hard drive or directly on a portable digital medium.

- Recording on a computer hard drive

  This option is the more flexible of the two because it allows further processing. For example, editing of the beginning and ending as well as cutting can be performed, before the material is finally stored.

- Direct recording to CD-R or DVD-R.

  This option is the fastest, especially when there is no need for further processing, but it is not recommended because the material usually needs to be separated into tracks.

Separating in parts

A tape reel or a record can include more than one independent part (e.g. songs or separate pieces). For practical reasons, you can digitize the whole reel or side of the disc and then separate the digital file into its separate parts. Alternatively, you can keep the digital file as is but you will have to define its independent parts in its metadata (e.g. in MPEG-7 form).

If you choose to separate the different parts you must avoid fade-in and fade-out occurring at the points of separation, but if you intend to remove the existent noise you must definitely include sections (2-3 seconds long) with typical recording noise and no music beforehand in order to be able to analyze it. The separated parts can be the master files so long as no other alteration was made to them, with the uncut file then discarded.

Format according to use

The digitized material can be held in various formats according to the use intended. Therefore, we can separate digitized sound material into two main categories:

<u>Digital Master</u>

The first category of files are the digital masters or high fidelity main copies, which have high sampling frequencies, high bit depths and no signal compression, thus securing maximum quality of digitized sound material. The sampling frequency and bit depth of the digital master is set during sound conversion from analogue to digital. In cases where the sound material is already in a digital form (e.g. DAT), then the best strategy is to maintain the sampling rate of the original digital form. That is, if the DAT file is written at 44.1 kHz and 16 bit then the corresponding digital master must also be 44.1 kHz and 16 bit in order to avoid losing information during D/D conversion.

<u>Service Files</u>

The second category of files are the service files or usage copies. These files are the ones made available to various users. They usually have lower sampling frequencies and bit depths to enable smaller file sizes and faster access. For even smaller file sizes, you can compress these files. Therefore, according to whether these service files are compressed or not, they can be separated into lower fidelity and higher fidelity respectively. The service files will be created from the digital master and not the original analogue recording.

Digitized sound material formats

In the following list, we detail the different formats used for digitized sound material with specific further information in each case:

- Digital master: 96 kHz and 24 bit wav or aiff uncompressed, stereo or mono depending on the characteristics of the original material. Storing one hour of two channel stereo sound material with a 96 kHz sampling frequency and 24 bit analysis requires 2.025 GB.
- Service files (higher fidelity): 44.1 kHz and 16 bit wav or aiff uncompressed, stereo or mono depending on the characteristics of the original material. Storing one hour of stereo sound material with this format requires 620.156 MB.
- Service files (lower fidelity compressed): 128 or 256 kbps MP3, Quicktime, Windows Media Audio (WMA) or Realmedia. Storing one hour of stereo sound material with 128kbps MP3 compression requires 56.25 MB and 112.5 MB with 256 kbps MP3 compression, double the size of the first.

Compressed files can constitute the whole or smaller parts of the original material, and they aim to serve as reference files for database and internet use.

The master copies exist in at least **two identical versions** (back-ups) and each of these is stored in a different location for safety reasons.

For each file format and analysis setting, the following table specifies the data volume required for sound recordings of one hour duration, together with compression ratios and volume (in hours) that can be stored on a DVD in each case.

Format	Analysis	1 Hour volume	Compression ratio	Hours on one DVD
WAV, AIFF	24bit 96kHz	2 025 GB	1	2,2
WAV, AIFF	16bit, 44.1kHz	620 MB	1	7
MP3	256 kbps	112 MB	5,5	37,5
WMA	128 kbps	62 MB	10	75
AC3	128 kbps	56 MB	11	78,5
MP3	128 kbps	56 MB	11	78,5
MP3	64 kbps	28 MB	22	157
OGG	48 kbps	20 MB	31	220
RM	56 kbps	16,3 MB	38	270
MP3	28 kbps	10,6 MB	58	415
RM	28 kbps	9,6 MB	64	460

Digital storage mediums: hard drives, CD-R, DVD-R, Digital Audio Tape (DAT), Hexabyte, etc.

- Hard drive sets: IDE, SCSI, SATA, etc. These constitute a good solution if you can guarantee their safety inside a network or even a system. Speed and large capacity are their advantages, while security and malfunction risks, as well as high cost, are their disadvantages.

- CD-R: These may seem like a good solution at first, but in case of large files they become hard to manage. Furthermore, it is not certain that they will last through time.
- DVD-R: Similar yet somewhat better than the CD-R. They can offer a solution for large file storage as well.
- DAT: We will not include DAT as a storage solution because it is better to have the file in a data form rather than in an audio form.

The following table presents the indicative cost in Euros for each hour of digitized material in 96/24 format.

There is no perfect solution for storage. The appropriate storing medium must be selected according to the demand, based on speed, security, cost and compatibility criteria.

Storing medium	Cost* per hour (96/24)
SCSI	**2 €**
Hard Disk IDE/SATA int/ext	**0.2 €**
CD-R	**0.60 €**
DVD-R	**0.10 €**
Blue-Ray	**2 €**

(**2008*)

Documentation by use of metadata

In order to have quick and easy access to the material in a file, its digitized content must be accompanied by further information. This information may include technical details concerning the recording process through to information about copyright holders. This complementary information is called metadata, and is considered to be part of the file and necessary for any documentation process. The programs used to create such data are:

- MPEG-7
- Dublin Core

The proper creation of metadata is essential for the creation of a reliable and long-term functional archive. The most common practice is to create metadata from the existing information that accompany the analogue recording, but you may also need to create metadata from scratch. There is no specific strategy for its creation, but most metadata patterns are as follow:

Descriptive metadata	Describes the content of sound material
Management metadata	Contains information on property and management of intellectual rights

Structural metadata	Contains information on the connection of a specific digital material with others within the file
Technical metadata	Contains information on the sampling, digitization, applied enhancements, devices/plug-ins used, etc.

(*More information on metadata is presented in Part II of this study)*

Digital copyright protection of sound material

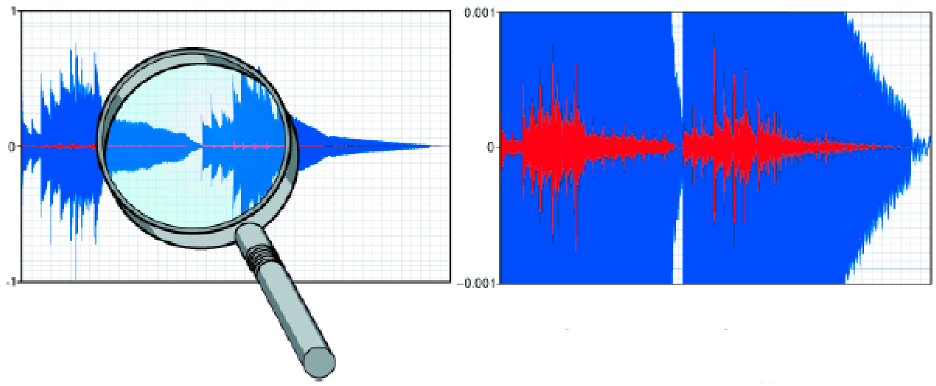
Digital sound material can be protected by various watermarking methods, so long as they ensure the good quality of the resulting sound.

We can define audio watermarking as the non-audible entry of information into digital sound data. A properly designed watermarking system has certain attributes necessary for the security and management of the system. Therefore, watermarks should be:

- non-audible
- undetectable by statistical methods
- powerful against signal processing functions
- fixed
- directly connected to the music and not just some kind of header
- dependent on a keyword/password

The attributes mentioned above are accomplished by the combination of psychoacoustic techniques and spread spectrum modulation techniques. Psychoacoustic techniques ensure that the data added is not audible, while the spread spectrum modulation makes the information able to withstand various signal processing techniques by dispersing the information on all time-frequency levels. We can separate watermarking techniques into two main groups:

- Bitstream watermarking, where the watermark is applied to a compressed audio signal
- PCM watermarking, where the watermark is applied on a linear audio signal



Graphical representation of watermarking. Watermark information (red) is applied on the audio signal (blue) in a way that doesn't affect the resulting audio.

The various watermarking techniques allow us to have proof of rights ownership, to have control over access to digital data, to be able to trace illegal copies and to transfer metadata, such as information on the composer, genre, etc, along with the music.

In spite of all the advantages watermarking provides, it is easy to understand that any change in the signal can possibly become audible.

Other protection methods are:

- Audio "watermarks": Specific sound signals are added in fixed intervals.
- High compression that reduces quality without damaging recognizability.
- Making parts of the file available (samples). This is a common practice, exercised according to the following table.

Total duration	Sample
0-5 min	30 sec
5-10 min	45 sec
10min <	60 sec

Samples could be larger, of course, if the copyright holder agrees.

STORING THE PHYSICAL SOUND DOCUMENTS

Storing magnetic tapes

Medium-term storage

The mean value of relative humidity in a medium-term storage environment must be above 20% but must not exceed 50%. In ideal conditions, the maximum temperature for large time periods must remain below 25^{o}C. The temperature is allowed to reach 32^{o}C for a small period of time, but must not exceed that threshold. Tapes must not be stored in temperatures below 8^{o}C because at that temperature the lubricant may separate from the fixation agent.

Medium-term storage		Long-term storage	
Mean temperature value (^{o}C)	Mean humidity value (%)	Mean temperature value (^{o}C)	Mean humidity value (%)
		20	20 - 30
		15	20 - 40
23	20 - 50	10	20 - 50

Long-term storage

The pace of chemical reactions such as the destabilization of the tape's base and the polymer fixation agent reduces according to temperature and relative humidity. Therefore, the storage medium's lifespan decreases according to temperature and/or humidity decrease in the storage environment. Moreover, low temperatures can compensate for high humidity values and keep the storage medium's life span stable, given that they are within the 8 – 25 ^{o}C margins. If the tape is stored in low temperatures, special caution should be paid during the heating process performed prior to use, to avoid humidity condensation. Changes in relative humidity should not exceed +/- 5% during a 24hour period, while the corresponding changes in temperature should be less than +/- 2^{o}C.

Magnetic fields

The maximum amperage of external DC magnetic fields must not exceed 4kA/m (50 Oe) and the corresponding value for AC magnetic fields must be below 800 A/m (10 Oe). Tapes must be place at a safe distance from magnetism and heat sources, like speakers, screens and mobile phones. You should also be careful of objects with revolving metallic parts (like vacuum cleaners) being in the same area as the tapes, because they can create magnetic fields that affect them.

Materials

Objects used for tape storage - reels, boxes, crates and shelves - must be made from chemically stable materials that don't produce dust or other particles. Any metallic materials used must not be magnetic. Plastics are suitable for storage so long as they are durable and don't deform or break during storage.

Crates

Crates (boxes) must be hardwearing to endure humidity and dust. Paper or carton crates must be avoided because they produce dust and material wears-off over time. Crates must be designed to protect the tapes from pressure by other objects and deformation during storage. They must also close in a way that prevents accidental or incorrect opening.

Preparation

Preparation for storage should be performed in facilities with a 20^{o}C mean temperature and 50+/-10% relative humidity. Reels must be rewound at playback speed. However, if you intend to store tapes in a low temperature environment, you can wind them more loosely. To reduce print-through effects, you should wind tapes according to the tails-out method.

Acclimatization

Tapes should be allowed to acclimate to new temperatures, when removed from a low temperature storage environment, in order to avoid humidity condensation on the tapes. The tapes must remain in a medium-term storage facility, while unwinding and rewinding is prohibited in low temperatures. (The tapes must be allowed to reach normal temperature to regain their original dimensions in order to be safely used)

Inscription

If the original reels are replaced with new ones(an occurrence which is very likely) the new reels must have some inscription system. That system must not produce acids, dust particles or oxidant elements and it must remain in place for as long as possible. The larger part of the information must be placed on the crate in order for the inscriptions on the reels to be small. Manufacture and product information should be written on the tape's superscription and not on the crate/box that contains it.

Record storage

The same facilities used for tape storage can also be used for records, with the main concern here focused on dust, humidity and temperature. Magnetic fields do not present a risk for records. This means that you can store both records and tapes in the same area and with the same specifications. Records must be stored in a vertical position on shelves that can withstand their weight, an installation that can be quite large if you have many records.

More specifically, records must be stored in **dark** rooms with 10-20^{o} C temperature and 40-50% relative humidity. Fluctuations in temperature and humidity values within a 24hour cycle should not exceed 2^{o}C and 5% respectively.

As mentioned above, records should be kept in darkness at all times and when you use a light you should avoid ultraviolet radiation sources (like fluorescent lights).

You can use fireproof cabinets with security locks to store valuable archives.

DIGITAL AUDIO RESTORATION AND ENHANCEMENT

The detailed presentation of digital sound material enhancement is beyond the purposes of this study. In the following passages, we list the main enhancement applications in order to provide basic information to anyone interested in this vast subject.

Denoising

Denoising and cleaning old (as well as new) recordings is undertaken via special software.

The denoising process performs better if you have some part of the recording (1-2 seconds) that consists of noise alone. Therefore, during editing (montage) it's best to keep part of the noise in the recording. The software reads the noise signal and formulates a complex filter that lowers the level with precision at the specific points in the spectrum where the noise is located, while leaving the rest of the signal intact. The operator must then define a number of other parameters like the filter's application amplitude, threshold, application attack and release, as well as add an extra high frequency filter.

The application of digital denoising techniques can create undesirable sound side effects and for that reason it should be done by an experienced sound engineer who will be able to make the correct decisions during the process and use the full capability of denoising devices.

Denoising systems have been in existence since 1985. Contemporary systems can function in real time and their results are very satisfactory.

Of the existing devices the best are considered to be the NoNoise system by Sonic Solutions and the Cedar system. The best new denoising systems that operate exclusively as plug-ins are the Audio Cube, the X-noise by Waves and the DINR by Digidesign.

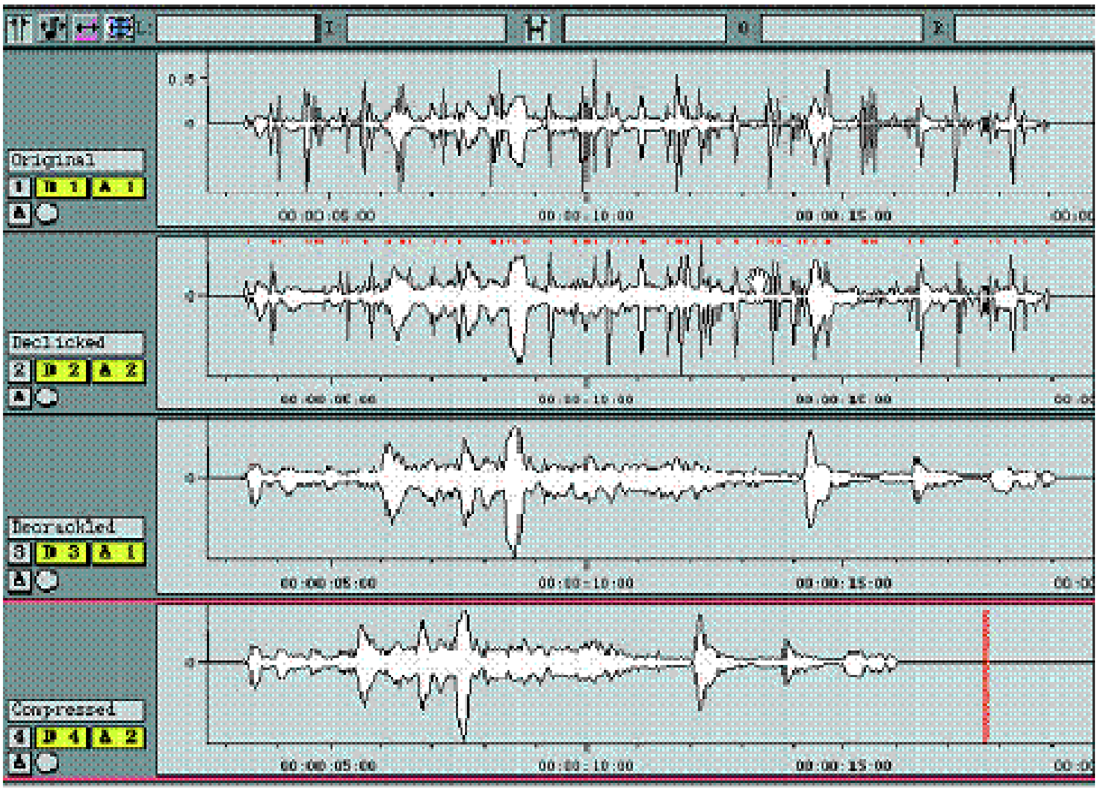
In the last 2-3 years, all denoising systems operate at 96kHz/24bit analysis rates in order to apply processes at high analysis standards.

The basic denoising processes are:

- **De-clicking**: This concerns the removal of "click", "chuck" and "pop" sounds that mainly exist in vinyl and 78rpm records.
- **De-crackling**: This concerns the removal of continuous surface noise, what in English is often called a "frying bacon" sound.
- **De-noiser**: This concerns the removal of "blow" from analogue tapes and other noises that extend over large frequency margins.
- **Filtering**: Filters can be used parallel to other applications to remove buzzing sounds, interferences from the electrical network and general problems in the frequency spectrum where any intervention should be applied with surgical precision.
- **Manual De-clicking**: Manual De-clicking is applied to solve problems that remain after the application of the processes mentioned above, that is by intervening in specific signal locations. This process can restore damaged waveforms with large wavelengths.

After the cleaning process, various digital (as well as some analogue) equipment can be used to enhance the sound material and restore harmonics that were depleted during digitization. This demanding process is called "mastering".

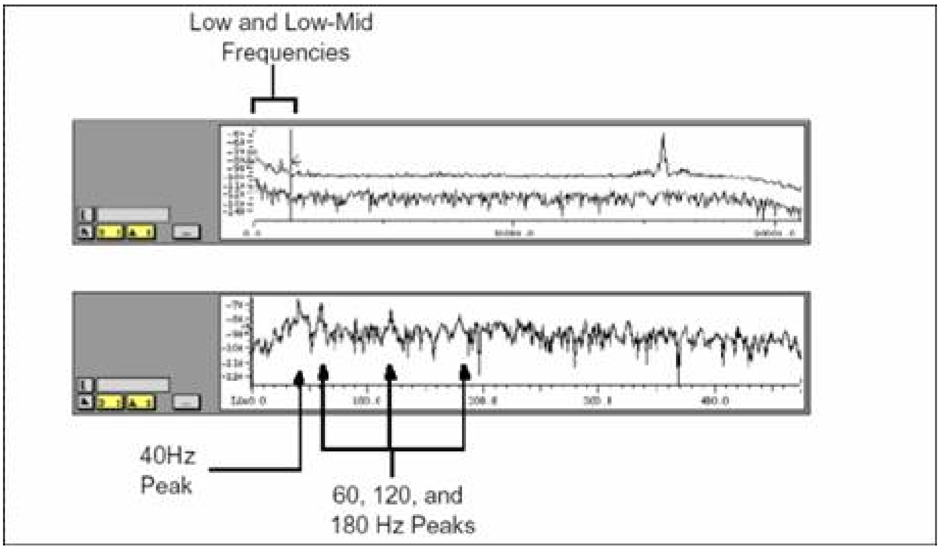
In mastering you can use digital or analogue EQ, multi-band equalization, multi-band compression, phase correction, spatialization, etc.



In the top section of the picture above you can see the original sound file with click and crackle problems. The section below shows the file after the de-clicking process. The next section shows the same file after de-crackle. In the bottom section the file has been cleaned and its length has been altered. This process has been digitally applied (it could be done by the pick-up during recording) to adjust tonality to the correct level (we have already mentioned that many 78rpm records have an incorrect playback speed).

If the process is digital, then special attention should be paid to DSP management to make the process better and faster. Moreover, the internal bit-depth of the devices used should be kept at a high analysis at all times (32 bit float -48 bit fix-40 bit float) to maintain a high analysis and to avoid any narrowing or hardening of the sound.

The most practical solution is to use a workstation on a computer (PC, Mac) and the necessary tools (Sonic Solutions, Cedar audio, Sadie, Audio Cube, etc) that can be in a hardware rack or software plug-in form. The same workstation can also be used during digitization, reducing the cost even further.



An acoustic spectrum analysis that graphically represents an electrical buzzing problem at various frequencies values (multiples of the basic frequency of 60kHz).

SECTION 4: PROJECT REALIZATION – WORKSTATIONS

Sound archives are part of the living heritage of our country. They have been salvaged thanks to the efforts of people dedicated to their preservation through time.

Today, advances in technology have enabled the digitization of such archives with excellent results.

First class technical infrastructure should be used for the digitization of these archives without compromising the quality of the resulting files.

The people in charge of this process must have an intimate knowledge of the subject and provide the best possible directions to the people involved.

In archive digitization, parallel to acquiring the proper equipment, there must be a proper arrangement of the workstation area where the processing and digitization will be performed.

The necessary actions for the digitization of sound archives are:

1. Careful planning of the project itself as well as the workstation, materials and timeline.

2. Acquiring the necessary devices and software to complete the project.

3. Arranging the workstation areas.

4. Applying the necessary repairs and modifications of the workspace to install the proper technical and material infrastructure.

5. Making an acoustics analysis of the workspace would also be beneficial.

NECESSARY EQUIPMENT

The sound digitization workstation must include:

1. Computer
2. Necessary software
3. Sound equipment
4. Archive preparation devices
5. Archive reading devices
6. AD/DA converter
7. Storage mediums

(*Independent digitization systems, like stand-alone CD-Recorders, are not recommended because they don't support high analysis sampling)*

In the following we present the necessary equipment comprising a workstation in more detail, with the exception of reading devices which were analyzed in a former section.

Computer

You must use an advanced level of computer in order to be able to manage large volumes of sound files at large analysis rates (24 bit/96kHz). The computer must also have a large capacity hard drive (>160GB), high access speed (e.g. SATA >=7,200rpm) and a high speed DVD-R/CD-R (>=8x). The computer processor must be fast to complete the various procedures quickly.

Software

The necessary software includes:

a) *An Operating system* that can be a recent edition of any of the available systems (Windows, Linux, Apple OS).

b) *Digitization software* that must be able to support the sampling analysis and file formats mentioned, and be compatible with the AD/DA converter as well as allow basic processing functions.

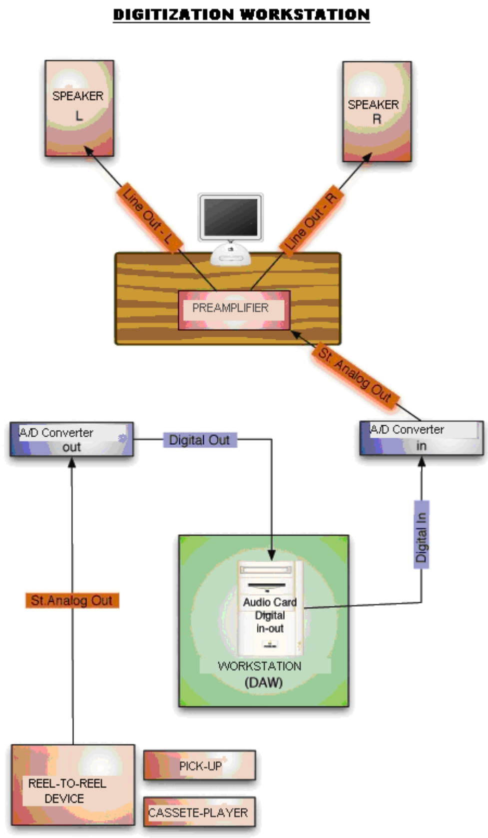
c) *Metadata creation software* (technical, descriptive, structural and management). The software must enable the update of metadata files and the arrangement of information in databases, while also providing the ability to establish links to the sound archive and manage the information.

d) *Storing software* for file transfer to digital storage mediums.

(As an alternative, you can also use integrated sound digitization stations that include both the computer and software systems combined with an automated metadata export capability)

Sound equipment

Sound equipment is used in order to listen to the audio output during digitization. Good quality equipment allows the operator to discover possible problems and make the right decisions to solve them. Special attention should be paid to *monitor speakers* and *headphones* that should exhibit homogeneity and naturalness in the frequency spectrum as well as the ability to reproduce the sound's details.



Graphic representation of a sound digitization workstation

SECTION 5: TECHNICAL SPECIFICATIONS TABLES

In the following section we list the minimum required features of a workstation.

Monitor Speakers

They should exhibit homogeneity and naturalness in the frequency spectrum as well as the ability to reproduce the sound's details in order allow the operator to discover possible problems and make the right decisions to solve them.

Minimum required features:

Capacity :	10-30 ltr
Output :	100-300 W
Max. Continuous SPL (1m)	103 – 108 db minimum
Necessary special features :	Gain reduction and Tweeter protection
Manufacturers :	ATC, Dynaudio, PMC, Genelec

Line Pre-amplifiers

Line In :	5 - 7
Signal to Noise A-weighted :	> 98 db
Frequency Response :	20-20 kHz ± 0.1 db
THD :	< 0.002 %
Maximum Output Level :	> 14V
Useful special features:	Balanced line-in and line-out
Manufacturers :	NAD, ARCAM, ATC

CD Players

Line In:	5 - 7
Signal to Noise A-weighted :	> 98 db
Frequency Response :	20-20 kHz ± 0.1 db
THD :	< 0.002 %
Maximum Output Level :	> 14V
Useful special features :	Balanced line-in and line-out
Manufacturers :	NAD, ARCAM, ATC

Professional sound card PCI/FIREWIRE

PCI card, plug and play with analogue and digital line-in and line-out

Supporting Sample frequencies stereo: 44.1,48,88.2,96,192kHZ kHz input and output.
Real-time settings adjustment
Full Duplex (the ability for different sampling procedures via the line-in and line-out)
Automated monitoring, allowing audible input when in record mode or playback when playing a sound file.
Analogue Input that can be adjusted from +4dBu to -10dBu
Windows or Mac Drivers without problems and bugs.
Dynamic lead-in area >108db and > 112db lead-out (at 24bit/96kHZ)
Fixed clock with low jitter
Manufacturers : SADIE, MERGING, METRIC HALO, RME, LYNX, M-AUDIO

SOFTWARE-WORKSTATION (DAW)

Sampling frequency :	44,1kHz - 192kHz / 16 – 24 bit
Sound files support:	BWF (Broadcast Wave Files), AIFF, Wave, SD2
Digitization software	It must be able to support the sampling frequencies and the file formats mentioned, to be compatible with AD/DA converters employed and allow basic processing functions.
Internal analysis :	32 bit floating point minimum 48 fix - 64 floating recommended
Necessary special features :	Wave, AIFF, SD2 σε BWF Conversion.- Conversion of any file format to AAC, MP3, etc.
Manufacturers :	Sonic Studio, Sadie, Wavelab, Samplitude

A/D CONVERTER (analogue to digital)

A/D conversion is the most important step in digitization and therefore, the A/D converter must have an absolute frequency spectrum balance and be able to capture the original source with absolute precision.

Sampling frequency :	44,1kHz - 192kHz
Analysis :	16 – 24 bit
Line In:	Analogue Balanced and Unbalanced

Frequency Response :	@fs =44.1/48kHz : 20Hz….. 20kHz +-0.3db @fs =88.2/96kHz : 20Hz….. 30kHz +-0.3db @fs =176.4/192kHz : 20Hz…40kHz +-0.3db
THD+N@ 1 kHz	Less than – 103 dBFS @ - 3dBFs output level, unweighted
Crosstalk :	< 120 db, 0…20 kHz
Interchannel phase tracking :	Higher than +- 0.3 degrees from 20Hz – 20 kHz
CMRR:	> 90 db @ 1kHz > 80 db @ 20kHz > 60 db @ 20 Hz
SNR @ - 40 dBFS input :	> 110 db unweighted
Line Out -Digital Out :	Analogue and Digital Balanced and Unbalanced
Necessary special features :	- Noise Shaping at 16bit. - Limitation or removal of Jitter effects - Different adjustment line-in for the left and right channels
A/D examples :	Weiss, Prism, DCS, DAD, Mytek

D/A CONVERTER (digital to analogue)

The output must be characterized by homogeneity and balance of the acoustic spectrum so that the operator can listen with precision to the material being processed.

Sampling :	44,1kHz - 192kHz
Analysis :	16 to 24 bit
Digital In :	2-3 Digital Balanced (AES/EBU), Unbalanced (coaxial) and optional optical
Line Out :	Analogue Balanced and Unbalanced
Necessary special features :	Limitation or removal of Jitter effects
Manufacturers :	Weiss, Benchmark, Mytec, Prism, DCS

REEL-TO-REEL

Tape – head type for the majority of files:	¼ “, 2 track , 2 channel ¼ “ , 4 track , 2 channel
Wow & Flutter :	7-1/2 ips +-0.09 % peak (DIN/IEC/ANSI weighted) 7-1/2 ips +-0.14 % peak (DIN/IEC/ANSI unweighted) 15 ips +- 0.08% peak (DIN/IEC/ANSI weighted) 15 ips +- 0.12 % peak (DIN/IEC/ANSI unweighted)
Reading speed :	3,75ips (9.5cm/sec) - 71/2ips (19cm/sec) – 15ips (38cm/sec) – 30ips (76cm/sec)

Spin speed :	+- 0.3 %
Motor :	- PLL (Phase Lock Loop) for spin precision - Double motors for capstan and reel - Direct drive capstan
Equalization :	NAB and IEC/CCIR
Frequency Response :	7-1/2 ips 30Hz – 22 kHz , +- 2 db at 0VU 30Hz – 24 kHz , +- 2 db at - 10VU 15 ips 30Hz – 16 kHz , +- 2 db at 0VU 30Hz – 20 kHz , +- 2 db at - 10VU
S/N :	Signal to noise ratio at least –55dB at 7.5 IPS with dolby A or -45dB without dolby A.

Cassette Players

Head number - type :	Preferably 3 Hard Metal alloy heads
Tape support :	Normal, CrO2, Metal
Motor type :	DC Servo
Wow and Flutter :	< 0.07%
Frequency Response :	Normal (Type 1) 20-16 kHz +3/-3 db CrO2 (Type 2) 20-17 kHz +3/-3 db
Signal -to-Noise :	No Reduction 56 db Dolby B 66 db Dolby C 72 db
Potentially necessary features :	Double capstan for motion precision, Azimuth adjustment
Manufacturers :	Tascam, Marantz

Test Tapes for Reel-to-reel devices

Test tapes are used for guiding sound engineers in the adjustment of reel-to-reel machines, an absolutely vital process throughout digitization especially when there is no tone specification on the reels. The only company that continues to manufacture test tapes is MRL.

Tapes that cover NAB and IEC/CCIR equalization
Tapes that cover at lest 7- 1/2 ips and 15 ips speed
Manufacturers : MRL

PICK-UPS – HEADS - ARMS

Pick-ups

Vari Speed :	Vari-speed capability mainly for 78 rpm records on a 65 - 85 rpm scale with optical or digital spin control.
Wow and Flutter:	0.025% WRMS (JIS C5521) +/-0.035% Weighted, Zero to Peak (DIN 45507)
Rumble:	-50 dB (DIN 45539A) -70 dB (DIN 45539B)
Desirable features :	Direct Drive pick-ups are preferred to belt pick-ups due to their greater ease of use and higher precision of speed adjustment..
Manufacturers :	Technics, Simon York, Thorens, EMT

Arms

Lateral Bearing friction :	< 20mg
Lateral Bearing friction :	<20 mg
Effective mass :	8 – 12 gr
Cartridge adjustment :	0-3 gr (for 78 rpm records that may weigh as much as 5-6 gr you need an external weight measuring device)
Cartridge range :	3 – 9 gr
Manufacturers :	SME, Rega, Graham, EMT

78 rpm heads (You need separate heads to read 78 rpm records from different time periods.)

78 rpm records from 1910 - 1922	Conical 0.040 “
78 rpm records from 1920 - 1935	Trancated elliptical 0.035 “
78 rpm records from 1930 - 1955	Trancated elliptical 0.028 “
Necessary special features :	Pathe records need special heads that read vertically.
Manufacturers :	Expert Stylus, EMT

33 ½ rpm heads

Channel Balance at 1 kHz : Channel Separation at 1 kHz :	< 1.5 db > 25 db
Tracking Ability at 315 Hz :	> 60 μm
Frequency Response :	20Hz – 20 kHz +- 1.5db
Necessary special features :	MC sliding reel heads are preferred because they have better technical characteristics and sound quality than the MM sliding magnet heads.
Manufacturers :	Ortofon, Lyra, Denon, Grado

Phono pre-amplification for LP and 78rpm records with special EQ curves

EQ Curves	Pre-amplifiers with the proper equalization for each manufacture method for 78, 45 και 33 ½ rpm records according to the following table**
Gain :	Minimum 41db για κεφαλές MM Minimum 65db για κεφαλές MM
Noise :	- 68db CCIR peak 20Hz - 20kHz
RIAA curve precision :	0.5 db
Channel Balance : Channel Seperation :	0.2 db 64 db
Manufacturers :	GSP JAZZ CLUB, ELDBERG MD12 mkII

**

COARSE GROOVE ('78 rpm')					
SYSTEM	Treble turnover	Bass turnover	Lower bass t/o	Cut at 10 kHz	Boost at 50 hz
DECCA 78	3.4 kHz	150 Hz	-	9 dB	11 dB
ffrr 78	6.36 kHz	250 Hz	40 Hz	5 dB	12 dB
WESTREX	Flat	200 Hz	-	-	15 db
BLUMLEIN	Flat	250 Hz	50 Hz	-	12 dB
BSI 78	3.18 kHz	353 Hz	50 hz	10.5 dB	14 dB
MICROGROOVE (lps και 45 rpm)					
SYSTEM	Treble turnover	Bass Turnover	Lower bass t/o	Cut at 10 kHz	Boost at 50 hz
RIAA (CCIR)	2.1215 kHz	500.5 Hz	50.5 Hz	13.6 dB	17 dB
ffrr LP	3 kHz	500 Hz	100 hz	10.5 dB	12.5 dB
EMI LP	2.5 kHz	500 Hz	70 Hz	12 dB	14.5 dB
NARTB	1.6 kHz	500 Hz`	-	16 dB	16 dB
COLUMBIA	1590 Hz	500 Hz	100 Hz	16 dB	12.5 dB

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Part II. Analysis and Organization of Data on Sound and Music Archives

1. Introduction

1.1. The digitization material we refer to in this study comprises of music or audio archives and therefore they are usually in the form of

- recordings (originals or published editions)
- scores (printed or hand-written)
- motion pictures archives (video, DVD, film)
- visual material (pictures, sketches, etc.)
- texts (hand-written, printed, clippings, concert programs, etc.)

  and

- 3D objects (instruments, composers' personal items)

1.2. Of course, to manage and utilize the digitized material, it is necessary to have a data management system.

1.3. There are two kinds of data produced by the digitization process:

A) the digitized material and B) the metadata that accompany the digitized material

3. Digitized material

2.1. There are three basic types of digitized material and for each type there are one or more corresponding file formats. Given that a) the volume of digitized material is very large and probably can't be stored on hard drives b) even if it could be stored on hard drives it would be difficult to manage and c) databases can further be used for internet dissemination, the use of compressed file forms is recommended. The most common compressed file formats according to the type of material they contain are shown in the following table.

Material Type	Uncompressed file format	Compressed file format
Digitized sound	WAV, BWF, AIFF	MP3, WMA, AC3 etc.
Digitized video	AVI, MPG	MPEG-4, WMV etc.
Digitized image	TIFF	JPG, GIF, PNG, PDF etc.

2.2. Furthermore, we consider that in the case of texts and scores the material can be transferred to meta-formats of secondary digitization (through recognition systems, software or manual) and transformed into other file formats, as is shown below:

Archive Type	Secondary Digitization Format
Text	Simple text file (txt) or modulated text (doc, html)
Score	Music notation file (Fnl. Sib, NIFF, MusicXML[1] etc.) or musical coded (MIDI)

2.3. Therefore, a basic characteristic of such a system is for the relational database to be able to support and manage these file formats not only in terms of their organization but also in terms of the possibilities for previewing the material. This means that a visitor should be able to view the digitized images and videos, listen to the sound files, read the texts and preview (read and listen) scores.

3. Metadata

3.1. Digital technology and archive digitization have brought fundamental changes to the way that files are organized. The problems that arose following the creation of this new material were beneficiary to the development of science by constituting a starting point for research into new methods that could cope with these new demands. Information scientists took advantage of the particularities and capabilities of digital material and moved towards the development of new tools that could describe and process it, establishing at the same time a new term called "metadata".

A more general and practical definition[2] of metadata is that it can be considered as *"the final total of the things that one can say for an information object on each level"*. In this case an *"information object"* can include anything that can be used by a system or man as a separate *entity*.

The problem resulting from metadata models is that no model can cover the descriptive needs of all information services. In this particular subject there can't be one solution fit for all institutions because each requires a model based on their particular needs, and these needs vary in complexity and level of use. Under these circumstances, various *metadata schemes* have begun to develop thanks to the initiative of different institutions that required them to meet their specific demands.

The general format of bibliography metadata demonstrated in the following diagram is based on the Dublin Core Metadata Set and is recommended for the description of

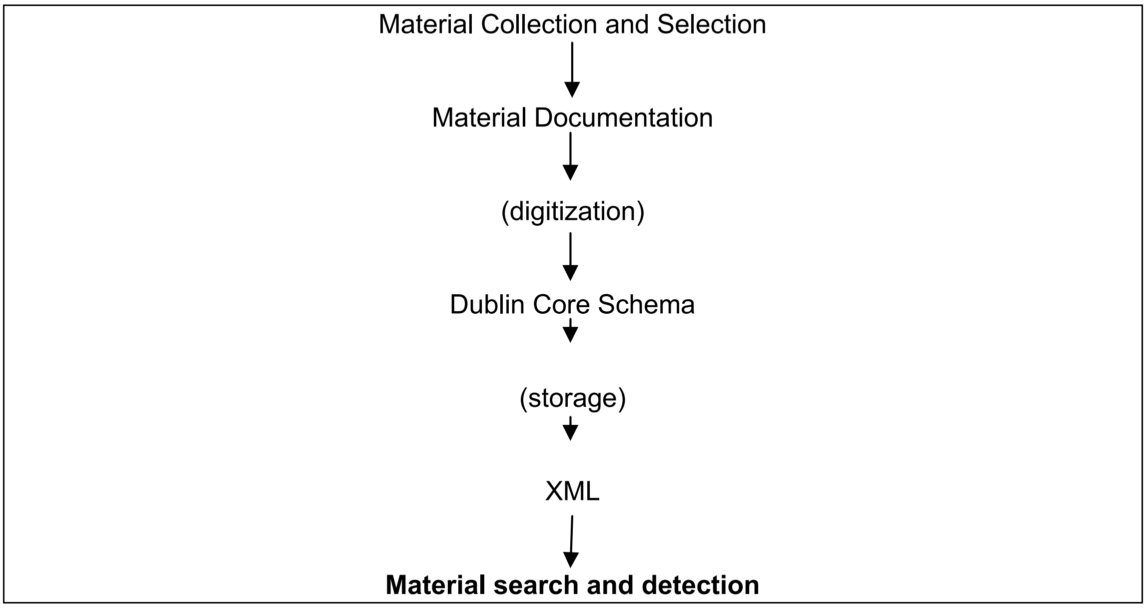
[1] *The MusicXML format is a standardized XML format that supports tree diagrams with configured parameters consisting of the notation characters and symbols (http://www.**music-notation**.info/en/musixml/MusiXML.html)*

[2] *Defining metadata,*
http://www.getty.edu/research/institute/standards/intrometadata/2_articles/swetland/content.html

The American Library Association describes metadata simply as *"data on a digital object that are usually provided by the object's creator or distributor"*. The Association's Committee in documentation issues states that *"metadata are structured and coded data that describe the characteristics of information entities in order to identify, find, specify and manage them".*

The creators of the general metadata standard, Dublin Core, define metadata as *"structured data on the data"* and as *"data that provide information on a source"*. These two very simple and general definitions have almost limitless potential interpretations that can vary from the description of a source produced by a man in the form of a text, as far as the derived mechanical data used in software applications.

music information objects of the Digital Late and Modern Greek Music Archive Program.



4. Metadata standards selection

The subject of metadata is one of the most dynamic and actively studied subjects of larger-scale activities such as the digitization process, information recovery, internet search and data exchange. The term "*metadata*" can be found almost everywhere, accompanied by the simple yet comprehensive definition "*data on the data*". In the beginning, the term was perceived according to the various categories of professionals that designed, created, described, maintained and used the information sources and systems. However, when all those groups of professionals and scientists had to work together in order to establish the information society, the need to "communicate" in a common language became evident. Moreover, there was a need to understand the role of each metadata category in developing effective, interoperable, and credible documentation and preservation systems for cultural and informational heritage.

Until the mid 90s, the term *metadata* was mainly used by people involved in data management and systems design and maintenance. According to them, metadata were used to document, identify, represent, interoperate, and use the data within a system.

However, metadata need to be framed by standards concerning the actual recording of information, and its presentation, recovery and cooperation with other systems. For that reason, we recommend the following models, which support the structure and content of the metadata format presented in the previous section.

Metadata creation	Dublin Core Metadata Set
Information feed in the Metadata format	Anglo-American Cataloguing Rules 2
Metadata coding	XML (eXtensible Markup Language)
Establishing Individuals and Collective Bodies	Greek National Library Library of Congress
Development and propagation of communication protocols for information recovery	ISO 23950 - ANSI Z39.50

4.1. Anglo-American Cataloguing Rules 2 (AACR2)

The use of AACR2 in all Greek libraries has produced a significant degree of uniformity. This uniformity in processing and organizing material makes AACR2 appropriate for cataloguing use in this project.

The cataloguing rules used are the *Anglo-American Cataloguing Rules, 2nd ed., 1988 rev. (AACR2)* and more specifically the Greek edition completed in 1997 (*Anglo-American Cataloguing Rules, 2nd ed., 1988 rev. Greek ed., Translated and edited by Mersini Moreleli-Kakouri. Thessaloniki: Technological Educational Institution of Thessaloniki, 1994-)* (AAKK2) which, as mentioned in the introduction, can "*constitute a starting point for solving specific problems since, through a completed project, it will be possible to suggest solutions on a national level and make basic decisions*". In the Greek edition (AAKK2) an important effort has been made towards the enrichment of the rules via the use of Greek examples, the replacement of English with Greek in rules based on language and more Greek abbreviations in addendum B. This effort should be continued through the cooperation of academic libraries within the framework of the Collective Catalogue, taking into account and incorporating all of ELOT's Greek bibliography models (like ELOT 822-94 on typical abbreviations of Greek words in bibliographic description).

However, as mentioned above, the compilation of a collective catalogue doesn't simply demand the implementation and/or adjustment of certain cataloguing rules but also requires the constant formal implementation of cataloguing practices and policies to be followed by the participating institutions.

4.2. Establishing names

The *Greek National Library Name Authority File* and the *Library of Congress Name Authority File* are recommended for the establishment of the names of Greek and foreign authors, respectively. Appropriate references have been made to allow the names of foreign authors that can also be found written in Greek to be detectable in both languages. The corresponding links have also been made for publishers.

However, the Library of Congress Name Authority File is mainly used for names and subjects in foreign languages. As far as Greek names and subjects are concerned, cataloguing practice varies due to the fact that the Greek National Library Name Authority File is incomplete and cannot be cross-referenced. The lack of standardized name archives constitutes a major weakness of the Greek librarianship community that impedes the user, creates a greater cost in human resources through the overlaps and dilettantisms that are present, and impedes cooperation between libraries. This weakness must be overcome in the near future through the development of the tools required to solve the problem.

The main sources for the creation of a collective name authority file in electronic format must be:

a) The Catalogue of Established Names of Individuals of the Greek National Library.

b) The Library of Congress Name Authority File – LCNAF

The ISO standard 10324 requires the previous implementation of ISO 832:1994 (Information and documentation, Bibliographic description and references, Rules for the abbreviation of bibliographic terms) and ISO 8601:1998 (Data elements and interchange formats, Information interchange, Representation of dates and times). In order to implement ISO 10324 in Greece, the ELOT standard 822-94 must also be taken into account, concerning as it does the abbreviations of Greek words in bibliographic description.

4.3. Development and propagation of the communication protocol for information recovery (ISO 23950 – ANSI Z39.50)

Z39.50 is an international search and recovery protocol (150 23950, 1998) that allows for the searching (usually remotely) of heterogeneous databases and the recovery of data through a remote user connection. Z39.50 defines a standardized way for two computers to communicate and share such information. Designed to support the recovery and searching of information (full text documents, bibliographic data, images and multimedia), it is based on a client-server structure and is fully functional across the internet. It allows users to search various catalogues and other databases with a single search. Note that, until XML request languages are further developed, Z39.50 should still be the preferred protocol for search and recovery in systems that offer multiple searches.

4.4. Definition

Z39.50 is a network protocol that allows the searching of (usually remote) heterogeneous databases and data recovery through an intermediary user interface. It is usually used for the recovery of bibliographic records, although there are also non-bibliographic applications.

4.5. Practical application

Z39.50 is necessary for the connection together of different library systems, regardless of their internal data structure, environment and operational system platforms. The user (or librarian) can communicate through the environment of his or her own system with any other linked library system.

4.6. Dublin Core

Dublin Core (DC) consists of a group of 15 terms that have been selected in order to describe internet sources concerned with cultural information. “These 15 elements have been produced by the cooperation of an international group of libraries, museums, government programs and commercial publishers with the World Wide Web Consortium (W3C). The prospect of the DC is that it will be able to support the detection, recovery and use of digital information sources from a large number of portals in the same way that a library’s electronic catalogue helps us find books and magazines in its collection…”.[3]

A working group consisting of scientists and institutions [4] have undertaken an evaluation of Dublin Core's suitability for this task - they re-checked the 15 elements and related definitions and correlated them to the existing catalogues of each institution that participated. This workgroup also constructed a trial database with DC entries and tested the effectiveness of search capabilities on the gathered Information. Their conclusion was that the terms’ definitions did not fully meet the needs of museums and that a clarification of these terms is necessary from this perspective. A basic objective of the working group’s examination, aside from the suitability and efficiency of the DC model’s terms, was the manner by which these terms could be proven suitable for coding metadata and circulating this data through the internet. They agreed that with regard to future developments, it would be correct to aim for the structuring of metadata through the models seen in the definition languages of electronic documents.

4.7. DATA and METADATA relation

OPAC Catalogue ←——→ Metadata Database

A metadata catalogue organizes and classifies the material in a digital library in the same way that a catalogue organizes and classifies the material in a conventional library. In short, the process is as follows: a user has access to the digital library through an OPAC, the OPAC

[3] Decker S., Harmelen van F., Broekstra J.: The Semantic Web- on the respective Roles of XML and RDF., http://www.ontoknowledge/oil/downl/IEEE00.pdf (1).

[4] Perkins J.,Spinaze A.: Finding Museum Information in the Internet Commons: a Report on the CIMI Dublin Core Metadata Tested Project, Bearman D., Trant J. (eds.): Cultural Heritage Informatics 1999, Archives and Museum Informatics, 1999, (175).

uses the metadata catalogue as a reference point, the metadata catalogue has classification capabilities according to author, title, theme, etc. and therefore, the information will be searched according to this data while at the same time corresponding references in the digital files are integrated into the process, in a similar way as in a topographic catalogue.

4.8. XML language

XML is a group of rules (or a package of guidelines or conventions) that concern the design of text forms , and that facilitate the structuring of data. XML is not a programming language - rather it enables the computer to produce data, to read data and to secure the clarity of data structure. XML is free from the usual problems of language designs: it is expandable, independent from the source material's system and can support both international and local applications. XML is fully compatible with Unicode.

4.9. Model delivery (XML and Dublin Core Set)

The database entries will be coded in XML according to Dublin Core Set and indexed in order to be effectively accessed within the database.

The list of metadata, in short, is configured as follows:

Name
Identifier
Title
Creator
Subject
Description
Contributor
Publisher
Date
Type
Format
Source
Language
Relation
Extent
Rights

(Order is no important)

Therefore, the elements in English will constitute the tag names when the metadata is coded in XML.

In the following example we can see an entry based on Dublin Core Set that is catalogued according to the Anglo-American Cataloguing Rules 2 (AACR2) in XML.

```
<?xml version="1.0" encoding="UTF-8" ?>
<metadata>
<title>
        <mainTitle>Waltzing Matilda</mainTitle>
        <subtitle>song /</subtitle>
        <otherTitle>For voice and piano.</otherTitle>
        <otherTitle>At head of title page: Sung with immense success!!!! The popular
        song.</otherTitle>
```

<otherTitle>Lithography by Turner & Henderson.</otherTitle>

<otherTitle>Believed to have been issued as promotional material for James Inglis & Co. Ltd, Sydney, whose advertisement for Billy tea appears on the back cover.</otherTitle>

</title>

<contributor>

<principalRole>Cowan, Marie.</principalRole>

<composer>Cowan, Marie.</composer>

<unqualifiedContributor>Paterson, A. B.(Andrew Barton),1864-1941.</unqualifiedContributor>

</contributor>

<publisher>

<namePublisher>Printed and published for the proprietors,</namePublisher>

<place>[Sydney?] :</place>

</publisher>

<date>

<published>[1905?]</published>

</date>

<type>

Printed music

</type>

<format>

<extentSource>1 score ([2] p.) ;36 cm.</extentSource>

</format>

<identifier>

<persistentIdentifier>

<PI>nla.mus-an7412026-s1-t</PI>

<objectType>Thumbnail</objectType>

<mimeType>image/jpeg</mimeType>

<URI>http://nla.gov.au/nla.mus-an7412026-s1-t</URI>

</persistentIdentifier>

<persistentIdentifier>

<PI>nla.mus-an7412026</PI>

<objectType>Sheet music/Scores</objectType>

<mimeType>text/html</mimeType>

<URI>http://nla.gov.au/nla.mus-an7412026</URI>

</persistentIdentifier>

<persistentIdentifier>

<PI>nla.mus-an7412026</PI>

<objectType>Multimedia resources</objectType>

<mimeType>application/smil</mimeType>

<URI>/data/smil/nla.mus-an7412026.smil</URI>

</persistentIdentifier>

<systemNo>an7412026</systemNo>

</identifier>

<source>

<institution>National Library of Australia</institution>

</source>

<language>English</language>

<relation>

<isVersionOf>an4784490</isVersionOf>

<isVersionOf>an6012202</isVersionOf>

<isVersionOf>an5749765</isVersionOf>

<hasPerformance>MAVIS: 184122</hasPerformance>

<hasPerformance>MAVIS: 471322</hasPerformance>

<hasPerformance>an8847307</hasPerformance>

<isRelatedTo>an13027891</isRelatedTo>

</relation>

<subject>

<heading>National songs; Australia.</heading>

<classification>783.24215990994; 20</classification>

<name>Paterson, A. B.; (Andrew Barton),; 1864-1941.; Musical settings.</name>

</subject>

<description>

words by A.B. Paterson ; music arranged by Marie Cowan.For voice and piano.At head of title page: Sung with immense success!!!! The popular song.Lithography by Turner & Henderson.Believed to have been issued as promotional material for James Inglis & Co. Ltd, Sydney, whose advertisement for Billy tea appears on the back cover.

‘</description>

</metadata>

Web version of the entry.

4.10. A Bibliographic and Administrative Metadata form according to Dublin Core Metadata Schema

Field name	1. Identifier		
Definition	An unambiguous reference to the resource within a given context		
Specification	Recommended best practice is to identify the resource by means of a string conforming to a formal identification system.		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	The identification of the document and comprehension of its content through the entry number.		
Example	(see relevant section)		
Repetition	No		
Compulsory	Yes		
Field Type	Not from a list (could be auto-generated)		
Comments	More information in the next chapter		

Field name	2. Title		
Definition	A name given to the resource.		
Specification	Typically, a Title will be a name by which the resource is formally known. [According to AACR2 (Anglo-American Cataloguing Rules)]		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	Identification of the source		
Example	“On the Pulse of Morning”		
Repetition	Yes		
Compulsory	Yes		
Field Type	Not from a list		

Comments	
Recommended fields of identification	Document name Title Other titles Subtitle

Field name	3. Creator		
Definition	An entity primarily responsible for making the resource.		
Specification	This can be a person, a collective organization, a union, etc. Principal Role*, composer*, lyricist*, librettist*, musician*, group*, arranger*, conductor*, singer*		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	Acknowledgement of the content's contributor		
Example	Angelou, Maya		
Repetition	Yes		
Compulsory	No		
Field Type	From a list		
Comments	Name documentation will follow the AACR2 cataloguing rules and name establishment will follow the Greek National Library catalogue.		
Recommended fields of identification	Main producers Artistic contributors Artistic creator Technical contributors Author Translator Entry operator Entry processor		

Field name	4. Subject		
Definition	The subject related to the source's content.		
Specification	Keywords or phrases that describe the source.		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	Assisting the effective search of a source within the database.		
Example	Byzantine Music		
Repetition	Yes		
Compulsory	No		
Field Type	From a list		
Comments	Typically, the subject will be represented using keywords, key phrases, or classification codes. Recommended best practice is to use a controlled vocabulary. To describe the spatial or temporal topic of the resource, use the Coverage element. Keywords can be selected from the Greek Music Thesaurus in their original language.		
Recommended fields of identification	Keywords Subject Label Category		

Field name	5. Description		
Definition	Description of the document and its contents		
Specification	Information on the archive		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	To inform users of the archive's historical value.		
Example	"Wedding song"		
Repetition	Yes		

Compulsory	No	No	No
Field Type			
Comments	Description may include but is not limited to: an abstract, a table of contents, a graphical representation, or a free-text account of the resource.		
Recommended fields of identification	General description of contents Original – copy Document description Number of entities Document condition Document photos Volume of content Structure Text elements		

Field name	6. Source		
Definition	A related resource from which the described resource is derived.		
Specification	Entries here can be a person, a collective organization, a lost archive, etc.		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	To emphasize the source's historical value.		
Example	Alexandrian Archive		
Repetition	No		
Compulsory	No		
Field Type	-		
Comments	The described resource may be derived from the related resource in whole or in part. Recommended best practice is to identify the related resource by means of a string conforming to a formal identification system.		

Field name	7. Publisher		
Definition	An entity responsible for making the resource available		
Specification	Data entered here could be a person, a collective organization, union, etc. The production area will also be documented in this field.		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	Acknowledgement of the publisher.		
Example	University of Virginia Electronic Text Centre		
Repetition	Yes		
Compulsory	No		
Field Type	From a list		
Comments	Name documentation will follow the AACR2 cataloguing rules and name establishment will follow the Greek National Library catalogue		
Recommended fields of identification	Publisher Area of manufacture.		

Field name	8. Date		
Definition	A point or period of time associated with an event in the lifecycle of the resource		
Specification	Date may be used to express temporal information at any level of granularity. Recommended best practice is to use an encoding scheme, such as the W3CDTF profile of ISO 8601 [W3CDTF]		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	More information on the source.		
Example	1993-01-23		

Repetition	Yes
Compulsory	No
Field Type	From a list
Comments	According to ISO 8601 following the format YYYY-MM-DD
Recommended fields of identification	Creation date Entry date Modifications dates Text composition date

Field name	9. Type (of material)		
Definition	The type of original archived material		
Specification	A description can be made) according to what was mentioned in the codification section.		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	To describe the source without opening the file.		
Example	Audio Tape		
Repetition	No		
Compulsory	No		
Field Type	From a list		
Comments	The description of the file will be attributed by its codification.		
Recommended fields of identification	General document type Specific document type		

Field name	10. Language
Definition	The language(s) of the source

Specification	The first two letters of the language's established name.		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	More information on the source		
Example	EN, FR, GR		
Repetition	Yes		
Compulsory	No		
Field Type	From a list		
Comments	RFC 1766 [RFC1766] contains two letters from each country's language codification (according to ISO 639 standard [ISO639]). 'en' English, 'fr' French, 'en-uk' for English - United Kingdom (http://www.loc.gov/standards/iso639-2/englangn.html)		
Recommended fields of identification	Content languages		

Field name	11. Format (if digitized)		
Definition	Description of the source's file format		
Specification	The description could be: Image tif, jpg, gif,… Sound wav, mp3,… Video mpeg1, mpeg2,… Text txt, rtf, xml, sgml… Database fp3 Executable program exe Recommended best practice is to use a controlled vocabulary such as the list of Internet Media Types [MIME]		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	To describe the source without opening the file.		
Example	Jpeg		
Repetition	Yes		

Compulsory	No
Field Type	From a list
Comments	The selection of the proper file format in which to preserve the digital material will result from the digitization standards.

Field name	12. Relations		
Definition	Reference to a related source		
Specification	If the related source exists within the same database, then the reference will be accompanied by its entry number.		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	More complete presentation of the source within the database.		
Example			
Repetition	No		
Compulsory	No		
Comments	A unique number that explicitly identifies the physical manifestation of the file within the general database frame. The recommended solution consists of a string that combines numbers and letters (urn)		
Recommended fields of identification	Relations		

Field name	13. Coverage
Definition	The spatial or temporal topic of the resource, the spatial applicability of the resource, or the jurisdiction under which the resource is relevant.
Specification	Spatial topic and spatial applicability may be a named place or a location specified by its geographic coordinates. Temporal topic may be a named period, date, or date range. A jurisdiction may be a named administrative entity or a geographic place to which the resource applies. Recommended best practice is to use a

	controlled vocabulary such as the Thesaurus of Geographic Names [TGN]. Where appropriate, named places or time periods can be used in preference to numeric identifiers such as sets of coordinates or date ranges.		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	More information on the source		
Example	1946-1952 Crete		
Repetition	yes		
Compulsory	No		
Comments	This entry can also concern individuals and is not strictly chronological nor spatial information		

Field name	14. Intellectual Rights		
Definition	Information on the source's intellectual rights		
Specification	Comment on copyright, IPR and any other limitations on the use of the source		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	The legal use of the source		
Example	The intellectual rights belong to Yiannis Hadjidakis		
Repetition	yes		
Compulsory	No		
Comments	This entry provides information concerning the institution or individual that manages the source's intellectual rights.		
Recommended fields of identification	Rights		

Field name	15. Contributor
Definition	An entity responsible for making contributions to the resource

Specification	Information related to the production or digitization of the document. Examples of a Contributor include a person, an organization, or a service. Typically, the name of a Contributor should be used to indicate the entity		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	Information on source identification		
Repetition	Yes		
Compulsory	No		
Comments			
Recommended fields of identification	Registrant Digitizer Enroller		

Field name	16. Storage		
Definition	Reference to the storage medium or the storage place of the document		
Specification	Specification of the analogue or digital medium on which the analogue or digital data of the archive is stored.		
LEVEL	**COLLECTION / ARCHIVE**	**OBJECT**	**COMMODITY**
Goal	A More complete presentation of the source within the database or storage area.		
Example			
Repetition	Yes		
Compulsory	No		
Recommended fields of identification	Storage location		

(Number 16 is a proposed addition to the set)

4.11. Using MPEG-7 standard on multimedia metadata

In October 1996, the MPEG (Moving Pictures Experts Group) community started a new project under the name “Multimedia Content Description Interface” (MPEG-7 in short). MPEG-7, an ISO/IEC standard facilitates the addition of descriptive information to audiovisual files in a multimedia environment. MPEG-7 exceeds the limited capabilities of previous software solutions concerned with file content recognition, mainly due to its ability to recognize a larger variety of data.

The following text is an introduction to the MPEG-7 standard and aims to explain its philosophy and structure without referring to a great number of technical details. MPEG-7 can have many applications within various types of audiovisual data. In this text we shall focus on applications that are concerned with sound data.

Data types that can be linked to MPEG-7 metadata

The audiovisual data connected to MPEG-7 content descriptions can take the form of images, graphics, 3D models, sound, speeches, videos and composition information on how these elements are connected in a multimedia presentation (scenarios).

MPEG-7 descriptions do not depend on the way that the content is stored or coded. It is therefore possible to create an MPEG-7 description of an analogue tape or a picture printed on paper.

Fundamental features of the MPEG-7 standard

When we refer to the MPEG-7 standard, in essence we refer to its structural features. The main features of the MPEG-7 standard are:

- Descriptive tools: Descriptors (D), defining the syntax and significance of each metadata element and Description Schemes (DS) that define the structure and relations between their components, which can be Descriptors or simpler description schemes.
- A description and definition language (DDL) that defines the syntax of MPEG-7 descriptive tools and allows for the creation of new Description Schemes and possibly new Descriptors.
- System tools that provide a binary coded representation for effective storage and transportation, transport mechanisms, multiplex descriptions, synchronizing descriptions and the content, management and protection of intellectual rights.

Therefore, the MPEG-7 descriptive tools allow for the creation of descriptions, while the use of a DDL language integrates certain applications’ extensions and system tools in order to transmit the descriptions.

Content description with MPEG-7 metadata and description links to the data

MPEG-7 content descriptions can contain:

- Information that describes the content’s creation and production processes.
- Information on content use.
- Information on storage characteristics (format, coding).
- Structural information on spatial and chronological elements of the material.
- Information on characteristics of the audiovisual content like the colors in a picture or the melody in a music work.

- Information leading to the proper use of content (summaries, variations, spatial and frequency subsections, etc.).
- Information on related collections.
- Information on user – content interaction (user preferences, use history).

An MPEG-7 description is related to the content in order to provide easy and fast access to the specific material that interests each user.

MPEG-7 descriptions can be placed in the same location with audiovisual data or within the same storage system, but they can also be located elsewhere. When the content and its descriptions are not placed in the same location, mechanisms are required to link the multimedia material to the MPEG-7 metadata. These links must work in both directions.

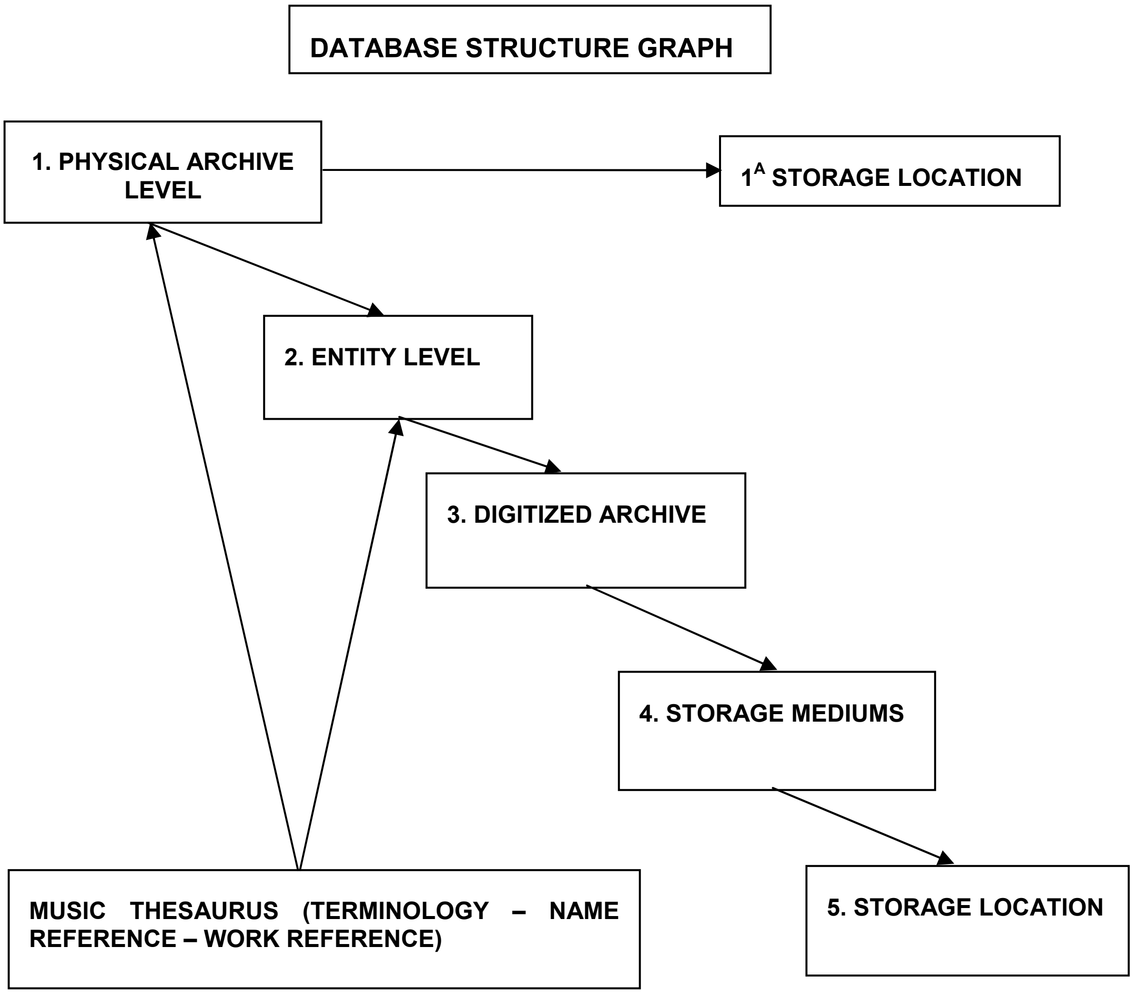
4.12. Dublin Core and MPEG-7 correlation table

DC Element	Definition	MPEG-7 Path
Title	A name given to a resource.	CreationInformation.Creation.Title[@type="main"]
Creator	An entity primarily responsible for making the content of the resource	CreationInformation/Creation/Creator[Role/Name="creator"]/Agent/Name
Subject	The topic of the content of the resource	CreationInformation/Classification/Subject
Description	An account of the content of the resource	CreationInformation/Creation/Abstract
Publisher	An entity responsible for making the resource available	CreationInformation/Creation/Creator[Role/Name="Publisher"]/Agent/Name UsageInformation/Availability/Dissemination/Disseminator[Role="Publisher"]/Agent/Name
Contributor	An entity responsible for making contributions to the content of the resource	CreationInformation/Creation/Creator[Role/Name="contributor"]/Agent/Name
Date	A date associated with an event in the life cycle of the resource	CreationInformation/Creation/CreationCoordinates/Date CreationInformation/Classification/Release[@date] DescriptionMetadata/CreationTime (date at which MPEG-7 metadata description was created) UsageInformation/Availability/AvailabilityPeriod (date, time and duration of broadcast or date of publication if availability is persistent.)
Type	The nature or genre of the content of the resource	CreationInformation/Classification/Genre
Format	The physical or digital manifestation of the resource e.g., file format or mime type	MediaInformation/MediaProfile/MediaFormat/FileFormat
Identifier	An unambiguous reference to the resource within a	MediaInformation/MediaIdentification/EntityIdentifier MediaInformation/MediaProfile/MediaInstance/InstanceIdentifier

	given context	MediaInformation/MediaProfile/MediaInstance/MediaLocator/MediaUri
Source	A Reference to a resource from which the present resource is derived	Variation/Source/Video/MediaLocator/MediaUri VariationSet/Source/Video/MediaLocator/MediaUri MediaInformation/MediaIdentification/EntityIdentifier MediaInformation/MediaProfile[@master="true"]/MediaInstance/MediaLocator/MediaUri
Language	A language of the intellectual content of the resource	CreationInformation/Classification/Language[@type="original"|"dubbed"|background"]; CreationInformation/Classification/CaptionLanguage
Relation	A reference to a related resource	CreationInformation/RelatedMaterial/MediaLocator/MediaUri MediaInformation/MediaProfile/MediaInstance/MediaLocator/MediaUri VariationSet/Variation/VariationRelationship
Coverage	The extent or scope of the content of the resource	SemanticBase[@xsi:type="SemanticTimeType"]/Time SemanticBase[@xsi:type="SemanticPlaceType"]/Place
Rights	Information about rights held in and over the resource	CreationInformation/Creation/CopyrightString UsageInformation/Rights/RightsID

5. Database structure

The recommended basic structure of the database is shown below:



Explanation of the database chart:

The first level is the **physical archive level**, which is also used for the original documentation of archive contents. A unique identifier (code) that corresponds to the original archive is set on this level along with descriptive elements like its physical form and contents, history, chronology, property, rights, relation to other archives, etc.

The second level is the **entity** level that corresponds to the conceptual content of the original archive. The division of the physical archive into its separate entities is necessary because often an archive includes multiple autonomous information entities. For example, a reel-to-reel recording can include various musical pieces that may be unrelated. In this case, every entity must have its own metadata and separate digitization process. Essentially, a dendroid structure is created with the physical archive at the top. Each entity is also given a unique identifier that can be related to the physical archive's identifier. The rest of the entity's metadata corresponds to those of the physical archive but, here, emphasis is given to the conceptual content (keywords, etc.).

Both the physical archive and main entity are linked to a names and terms reference file that works like a “thesaurus”. This thesaurus can be identical or connected to the material that has already been entered in the Horizon DB.

The next level in the database is the **digitized archive**. In actual fact this is not a different recording but simply an extended version that includes the digitized material and the metadata that concerns the digitization process (methodology, software, analysis, time, type, size, digitizer, etc.).

The digitized archive can have more operational digital derivatives in lower analysis standards in the form of “service files”.

The digitized archive is linked to the **digital storage medium** - a hard drive, DVD-Data, streamer, etc. or a combination of mediums (security copies).

Each digital storage medium has its own unique identifier that enables search and export of the file’s contents.

Finally, each storage medium, especially if it is a portable medium (as in the case of DVDs), is attributed to a physical storage location (e.g. Cabinet 25-Shelf 4).

The physical archive is also related to a similar physical location.

The advantages of this structure are as follows:

- It allows for the cataloguing of archives to be performed independently from their digitization, thus facilitating the organization of the specific work.
- It solves the problem of physical archives that consist of several entities.
- It facilitates the search for storage mediums and storage locations.
- It facilitates the search of both physical and digital archives.
- It facilitates the fold back observation of processes.

6. Unique Identifiers

Every archive must have a unique identifier or an address, like a URL, in order to be detectable within a database.

The recommended form for this identifier, described below, is based on the instructions of the National Library of Australia adapted to the needs of this specific program.

The form is quite flexible and can be used on all categories of database material. In fields where there is no information available or the material doesn’t have a certain attribute (e.g. if it doesn’t belong to an archive), then the field can remain blank. The purpose of this particular form of entry numbers is to achieve homogeneity and better organization of the database files, as well as to enable identification of the content of a file from its entry number alone.

The consecutive numbers will be automatically created by the database and the rest of the options will be located in drop down menus.

PHYSICAL ARCHIVE LEVEL

File Name (Carrier)	Sub-file	Section	Archive type	Consecutive number
Codification of the carrier-file where the archive is located at the moment of digitization	Codification of sub-file	Codification of section	Codification of the type of the physical archive	1 2 3 . . .
E.g. IEM (IEMA file)	E.g. CMC (Contemporary Music Composers)	E.g. IXE (Iannis Xenakis)	E.g.. rtp (recording-tape)	E.g. 8

File	Sub-file	Section	Type	C/N
IEM	CMC	IXE	rtp	8

IEM.CMC.IXE.rtp.8

ARCHIVE CONTENT LEVEL (ENTITY)

If the specific archive consists of more than one autonomous part (e.g. pieces in a recording) the following element is added to the code:

Series
The subsection series within the archive (e.g. the 5th different song, article, etc. in a row)

File . Sub-file . Section. Type . C/N . Series C/N

IEM.CMC.IXE.rtp.8.5

DIGITIZED ARCHIVE LEVEL

After the digitization of the archive, the identifier of the digitized entity is produced by adding the format of the digital file to the previous code.

Format of digital file
Code of digital file (e.g. tif, wav, avi)

IEM.CMC.IXE.rtp.8.5.wav

(The code of operational copies is produced the same way; by adding the corresponding format (mp3, jpg, pdf, etc.)in place of the format of the basic copy)

- The entity in the example is located in IEMA's archive, sub-file Contemporary Music Composers, section Iannis Xenakis.
- It was created from a reel-to-reel recording with consecutive number 8.
- It is the *fifth* (5) autonomous part in the recording and it is digitized in wav format.

This code can be translated by the appropriate table into a serial number or barcode.

The advantages of this system are:

- the easy production of unique identifiers
- it is easy to read and understand and also functions as a concise informational label
- it provides documentation of historical origin

7. Proposed document codes

Recordings in general	r(ec)
78 rpm records	r78
33 rpm records	r33
45 rpm records	r45
Tapes	rtp
Cassettes (not published)	rms
Cassettes (commercial)	rmp
Mini-Disk	rmd
DAT	rdt
Audio VHS	rvh
Audio ADAT	rad
Audio Hi8	rh8
Scores in general	s(co)
European notation manuscripts	sme
Byzantine notation manuscripts	smb
European notation (printed)	spe
Byzantine notation (printed)	spb
Graphic manuscripts	smg
Graphic (printed)	spg
European notation (digital)	sde
Byzantine notation (digital)	sdb
Graphic (digital)	sdg
2-dimensional Images in general	2dp
Photographs (printed)	2ph
Film (negatives, slides, microfilm)	2pf
Sketches - drawings (manuscripts)	2md
Sketches - drawings (printed)	2pd
Carte-postal (published)	2pc
Paintings	2tb
Texts in general	t(xt)
Manuscript texts in general	tms
Typed-Printed texts in general	tpr
Texts in general (digital)	txd
Manuscript catalogues	tmk
Printed* catalogues	tpk
Catalogues in digital form	tdk
**Manuscript letters	tmm
Manuscript notes	tmn

Manuscript work analysis	tma
Manuscript reviews	tmc
Manuscript publications	tmj
Manuscript poetic texts	tmp
Manuscript literature	tml
Manuscript essays - studies	tmd
Printed letters	tpe
Printed notes	tpn
Printed work analysis	tpa
Printed reviews	tpc
Printed publications	tpj
Printed poetic texts	tpp
Printed literature	tpl
Printed essays - studies	tpd
Publications	**prn**
Books	pbo
Magazines	ppe
Newspapers	pjl
Concert programs	pcp
Articles	par
Abstracts – Newspaper and Magazine Clippings	pcl
Posters	paf
Brochures	pin
Catalogues	pca
Motion pictures in general	mov
Video VHS	mvh
Video analog beta	mvb
Video open reel tape	mvt
Video Hi8	mh8
Mini DV	mmd
DVCPRO	mdp
Digital beta	mdb
Film 8mm normal	mn8
Film super 8 mm	ms8
Film 16mm	m16
Film 35 mm	m35
3-dimentional objects in general	3do
3D Musical instruments	3in
3D Sound objects	3so

3D Sculptures	3sc
3D Inscriptions	3re
3D Amphorae etc.	3va

* printed = typed or created by a printer

**the shadowed area is an analysis of the previous six categories for optional use.

8. Comments on the fields

The fields of a database can be divided into eight main categories:

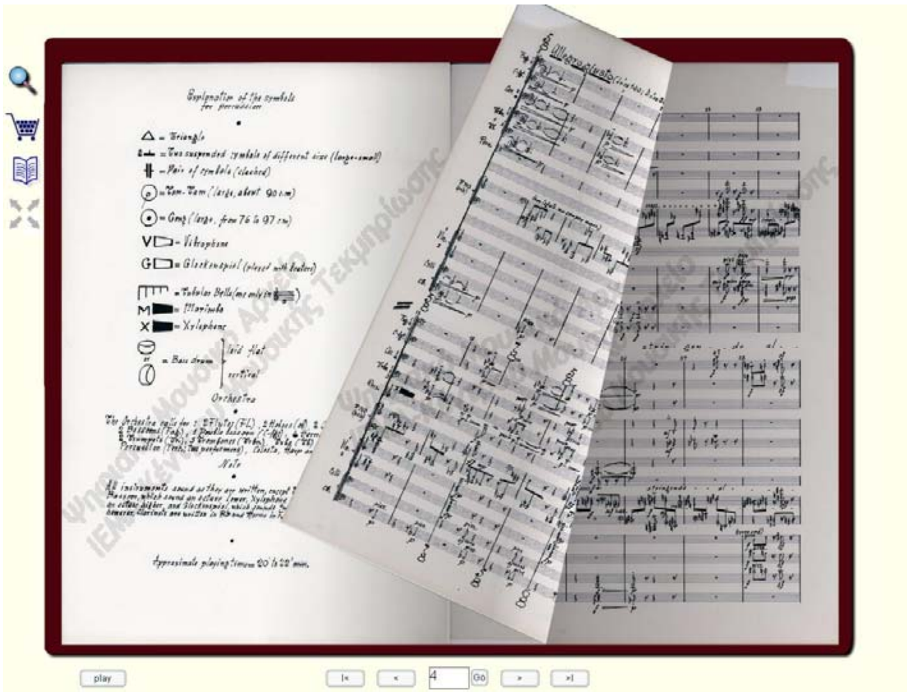
- ***Free entry fields:*** the user enters the corresponding value in the field.
- ***Automated entry fields:*** the system determines the value and enters it automatically
- ***Entry-from-list fields:*** the user selects a predetermined value from a list that appears in a drop-down menu (e.g. archive format)
- ***Fields filled from lists with predetermined values and added possibilities:*** the user selects a value from a list or adds a new value to the list (e.g. keywords)
- ***Compulsory fields:*** the user must enter a value in these fields to complete registration (e.g. sub-file name)
- ***Locked fields:*** the values cannot be changed after they have been filled (e.g. recording creator)
- ***Multiple value entry fields:*** the user can enter multiple values in format similar to XML schema (e.g. in the performers' field he can enter Piano:AAAAA; Violin:BBBB; Viola:CCCCCC;)
- ***Automated entry fields from internal information or communication with other databases:*** the user selects the automatically entered data through a graphic selector.
- ***Multimedia content fields:*** the user defines the file (its location) that corresponds to the digitized material.

9. Multimedia preview

Multimedia preview is a significant process for file projection and usability of the archive.

- The database must support preview for **all kind** of digitized documents.
- For previewing is better not to use the master files but **service files in low resolution**.
- Preview can be made either with path reference or using **special preview application**.
- There are two kinds of previewing. A) for **internal use** and b) **for the public**. While in the first case we can preview the hole document, the second case is restricted by the intellectual property rights.
- Important is that preview capabilities are integrated and supported by the **related entries**. For example, in case of a digitized score preview in image format (tiff, pdf or jpg) there must be access to *corresponding recordings* available on the same page to enable the user to see and listen to the musical work simultaneously.

- Entries that contain digital images must have thumbnail images on the preview page to provide users with some idea of their content. The same technique will be selectively used for collective entry catalogues that contain images.
- For entries that contain multimedia material, users must be able to activate that content in the preview page by the provision of playback controls (PLAY, II, STOP, >>, <<).



Score preview application with possibility of simultaneous hearing of the recording

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- *Historic American Sheet Music Project*
- *Levy Sheet Music Collection*
- *Sheet Music from Canada's Past*
- *Virtual Gramophone: Canadian Historical Sound Recordings*

GATEWAY TYPE SERVICES

- *Anthem: a Network for Music in Wales*
- *Cecilia: mapping the UK music resource*
- *Encore!: towards a UK catalogue of performance sets*
- *Ensemble: towards a distributed national library resource for music*
- *European Musical Navigator*
- *HARMONICA*
- *Jukebox*
- *Music Libraries Online*
- *Music Library of the Future*
- *PADS*
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WEB DELIVERY OF MUSIC & MANIPULATION OF DATA

- *CANTATE*
- *New Zealand Digital Music Library*
- *OMRAS (Online Music-Recognition and Searching)*
- *VARIATIONS*
- *VARIATIONS2*
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RESOURCE DESCRIPTION IN MUSIC

- *ABC Harmony*
- *MAENAD (Multimedia Access for Enterprises across Networks and Domains)*
- *MPEG Standards*
- *Music Markup Language*
- *Public Domain Music*

http://www.iema.gr/

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