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Tools for automation of difficult media

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ABSTRACT	This report identifies and documents best practice solutions and possible tools to improve digital preservation of massive amounts of 'difficult media': film rolls, open reel video and audio, audio disks.
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1. Introduction

The PrestoSpace Project commenced on February 1st 2004. It is intended to push the limits of the current technology beyond the State of the Art. It brings together industry, research institutes and stakeholders at a European level, to provide products and services for bringing effective automated preservation and access solutions to Europe's diverse audiovisual collections.

The PrestoSpace Project relies on an assumption that to allow the Audiovisual Archives to progress towards preservation and making accessible their collections, they have to use an industrial approach to massive analogue-to-digital migration plans. The User Requirements phase has demonstrated that this message was well received in most Archives.
Even in the specific case of Film Archives, who use the term 'Preservation' in regard to the long-term storage of physical artefacts, they acknowledge that they have an increasing requirement for making their contents accessible and are interested in an industrial approach for this. The PrestoSpace technical and non-technical developments support an industrial approach of migration, and the current document is an attempt to facilitate this industrial approach, focusing on "difficult media".

All Audiovisual archive media will require attention at the time of migrating to digital media, however some kinds are significantly more time-consuming than others because some operations cannot be automated and require manual intervention. Open reel media or audio disks are good examples, but it could also be very difficult to preserve some complete collections of video cassettes due to sticky tape, the lack of VCR or other specific problems. Even if the process cost is lower than the value of the content, it can be a deciding time factor in the preservation of some of these materials before further deterioration occurs. These media are called "difficult media" in this study.

For these materials, reducing handling and use is often the main priority. Any other solutions that make the preservation easier or more affordable are welcomed. This may result in a hierarchy of issues and very different solutions depending on the media, the average programme duration and condition, the time required to repair, load, unload, clean, process, rewind etc

Even where a collection of material is easy to migrate, it may be very difficult to preserve some items. If the number of items is low in comparison to the total number of preserved items, we are close to using the best process conditions for this kind of media and we speak of "difficult items" rather than "difficult media". An expert will consider various technical solutions to retrieve the content. The migration of each "difficult item" is usually completed entirely manually and becomes an expensive operation reserved only for valuable content.

For the sake of clarification and in this document, difficult media will be defined as:
"Media that are as *collections*, time-consuming and expensive to migrate, and that exist in amounts significant enough that devising improved processes can be profitable".

In the following chapters, we will identify “difficult media” in the range of audio-visual archives materials that are processed by TV archivists. We will study the existing practices and effort breakdown, identifying where time-savings can be achieved, and taking the best ideas to progress towards practical solutions. In specific cases, possible solutions to build new automation tools or to improve existing devices or process will be identified.

In the following chapters, we will identify "difficult media" from the range of audio-visual archives materials that are processed by TV archivists. We will examine the existing practices and effort involved, identifying where savings in time can be achieved; and using the best ideas to progress towards practical solutions. In specific cases, possible solutions including building new automation tools to improve existing devices or processes will be identified.

2. Difficult Media: which and why?

We define difficult media as media for which migration to digital is not easy to automate. Within this category most are "open reel" such as film under all its formats, video tapes and audio tapes, but there are also older media such as direct recording audio disks. These media will be described in the following chapters and proposals for a rationalisation of processes aiming to increase the productivity of the transfer chains will be raised. It is, finally, interesting to note that some media regarded a priori as "easy media", such as certain types of video cassettes (Betacam or ¾"), can show a high rate of defect and could justify their classification as difficult media.

2.1. The difficult film media

Film is a media whose history is long and whose physical structure has evolved several times, unequally undergoing the assault of time.

Film is, in any cases a “difficult media” for its preservation can not be automated, though some films are more difficult to migrate than others.

Film was used for the production of motion pictures since its origins and was also a capture media for television during nearly half a century. 70mm, 35mm, 16mm, 8mm and 9.5mm are the most commonly encountered film formats.

35mm, the format of motion pictures films, has been manufactured on celluloid (“nitrate") since the origins until the beginning of the fifties, when it was replaced by tri-acetate and, for print material, by polyester.

70mm prints obtained from 65mm negatives have been sometimes used for widescreen projection until this technology was abandoned for the benefit of 35mm cinemascope.

16mm, 9.5mm and 8 mm gauge films started to be used by amateurs before WWII, exclusively on acetate base.

16mm was also widely used for television until the introduction of ENG in the late seventies. Today, Super 16mm negative is still the preferred media for the shooting of many TV dramas.

Celluloid, whose decomposition is starting as soon as manufactured, is a highly flammable plastic. Film archives are storing millions of reels of nitrate film and carry on preservation plans of various scales (understanding that the term "preservation", covers different practices for each of the two worlds: it means digitisation for the audiovisual and television world and duplication on polyester base film for cinema archivists).

Acetate films, also known as “safety” films, though not flammable, are subject to the “vinegar syndrome”, an irreversible base decomposition.
In addition, archive films of any kind may be affected by physical damages such as shrinkage, torn perforations and splices or mould germination.

All these factors result in a wide variety of media conditions being found in archives : films have to be sorted (nitrate/acetate, cinema/TV, originals/dupes...) and assessed before any preservation work is undertaken.

Television archives and Film archives are, most of the time, distinct bodies. Post-production methods, and thus the intermediate preservation elements generated during these processes, are different for motion picture films and television films.
The current study will focus on television films, mainly 16mm. The film material preserved in a TV archive is composed of B&W and colour, negative, reversal and positive and sepmag 16mm films.

2.2. The difficult video media

Video media can be classified as difficult if the media cannot be operated automatically. There is a large set of formats, each format requiring most of the time a specific player.
We have limited the following list to the magnetic video media which are difficult by essence. All open reel media must be considered as difficult whatever their condition. The list has been also limited to the most frequently used formats.

Media	Package type	Level of difficulty Low/Mid/ High	Others difficulties
1/4 inch Akaï	Open reel	Mid	Nearly amateur format, small width, few available machines but usually good quality tapes - no DOC (drop out compensator) available
1/2 inch EIAJ	Open reel	High	Nearly amateur format, few available machines, often sticky tapes (last generation of Sony tapes), very low compatibility between machines - 2 different formats usually encountered - no DOC available
1 inch IVC	Open reel	High	Few available machines, often sticky tapes, very low compatibility between machines - no DOC available
1 inch A	Open reel	High	Very few available machines, often sticky tapes impossible to preserve (Ampex tapes are often sticky). Some compatibility issues between machines (position of the gap)
1 inch B	Open reel	Low	Good compatibility, good quality of machines, no major problems. Major problem comes from Agfa sticky tapes
1 inch C	Open reel	Low	Overall easy to migrate - Sony machines very reliable (BVH 2000) - efficient doc (minor problems with some Sony tapes)
2 inch	Open reel	Low	Major problem comes from head clogging - (associated with Ampex, Agfa and BASF tapes) - Some problem with Scotch side reels (decomposition of foam) and "white dust" on Memorex tapes. Requires skilled operator.
1/2 inch Akaï	Cassette	High	Nearly no available machine - Very few tapes to be migrated.
Philips VCR	Cassette	High	Fragile tape due to the box shape: the 2 reels are superimposed - At least 6 formats, each machine being different between Pal and Secam - If stickiness occurs, very difficult to clean the machine: no way to finalise the operation - Many small archives have this kind of tapes.
Betamax	Cassette	Low	No major problem (Overall good quality for machines AND tapes)
VHS	Cassette	Low	No major problem (Overall good quality for machines AND tapes)

V 2000	Cassette	High	Very complex format with narrow track and no CTL - Not reliable VCR - Reversible cassette - Few tapes to preserve
3/4 U-matic/ BVU	Cassette	Mid	Reliable VCR - Operation very dependant on tape quality (All Agfa and some Sony batches)
M2	Cassette	High	1/2" Format from Panasonic; developed as competitor-format to Sony's Betacam-SP; overall good quality (sometimes a higher dropout-rate) but no more machines and spare parts available (incl. head-drums).
19mm D1	Cassette	High	Compatibility between VCRs is the major problem – Tapes have to be cleaned systematically.
D2 – D3	Cassette	Mid	Some broadcasters have experienced tape deterioration after 10 years, leading to tapes snapping when played. Players only available from Panasonic, who will cease to support equipment for this format after 2006. Earliest possible transfer recommended.
Betacam	Cassette	Low	No major problem (Overall good quality for machines AND tapes) though some early tapes have a high drop out rate and are becoming difficult to play
Betacam SP	Cassette	Low	No major problem (Overall good quality for machines AND tapes)
Digital Betacam	Cassette	Low	No major problem (Overall good quality for machines AND tapes) – Format too recent to issue a reliable forecast.
Other today digital formats (DVC, DV..)	Cassette	Mid	Fragility of the media due to the small size of the cassette, and tape formulation.

2.3. The difficult audio media

Physical conditions of audio archives and related problems have been fully detailed in the PRESTO project D3-1 deliverable: “Existing and emerging technologies for audio preservation”. 1/4_inch tapes, 78, 45 and 33 RPM vinyl, shellacs, wax cylinders (though most of these have already been migrated) were concerned.

As this study attempts to concentrate principally on large collections of media, in this document we consider only open reel ¼ inch audio tape and « Direct recording » 78 RPM disks as “difficult media”.

Open reel ¼ inch audio tape handling cannot be easily automated. They always require, more or less, some kind of preparation: re winding, putting new leaders, re-splicing…

In some rare cases, recording quality may have suffered due to external magnetic fields.
The binder may be degrading and lubrication may be lost (sticky shed syndrome) or the substrate may suffer from deformation (shrinkage, binding…). For an optimal playback it is necessary to adjust the play back head alignment (azimuth) before each transfer …

78-RPM direct recording disks are heavy and very sensitive to bumps and climate condition changes. A change in hygrometry after storage in stable conditions can damage the media.

Shrinkage of the lacquer coating due to the loss of plasticiser oil is the first reason of destruction of acetate record. It causes internal stresses resulting in a progressive “embrittlement” that leads to an irreversible loss of sound information (the coating is bound on a shrink proof core).
Nitro-cellulose acetate decomposes continuously generating several chemical reactions: one of these is the release of palmitic acid (a white waxy substance).
They are very susceptible to fungus growth too.

The length of recording per face is very short (around 3 minutes) and a programme may be split on series of several disks with overlaps between disk side.

They usually are unique samples.

For all these reasons, « direct recording » 78 RPM must be considered as the least stable original media for sound recording. They must be handled very carefully and their process cannot be easily automated.

3. Preservation background

Before engaging in research of some ways for optimisation of the preservation processes, it is important to know the models of the practices generally used and to study well the strategies which will strongly impact these processes.

3.1. The “preservation factory” for audiovisual archives.

There are basically two models for migration practices: either the effort is done in-house, where operators do the work, item per item, operation per operation, or the migration effort is subcontracted to one or several facility houses. In the second case, additional effort is necessary in handling and tracking the materials.

In the case of difficult media, migrating is usually not the most time-consuming task: most of the effort is spent in triage, physical examination, physical repair, joining sections, carrying, loading, unloading, editing. Migration in itself is only the concretisation of all this effort.

Facility houses often use a more specialised approach than in-house processes: operators are affected a task which is more delimited. Inputs and outputs are more clearly visible, and may be easier to track. The PrestoSpace model of the Preservation Factory below, attempts to provide a broad view of what is done and where.

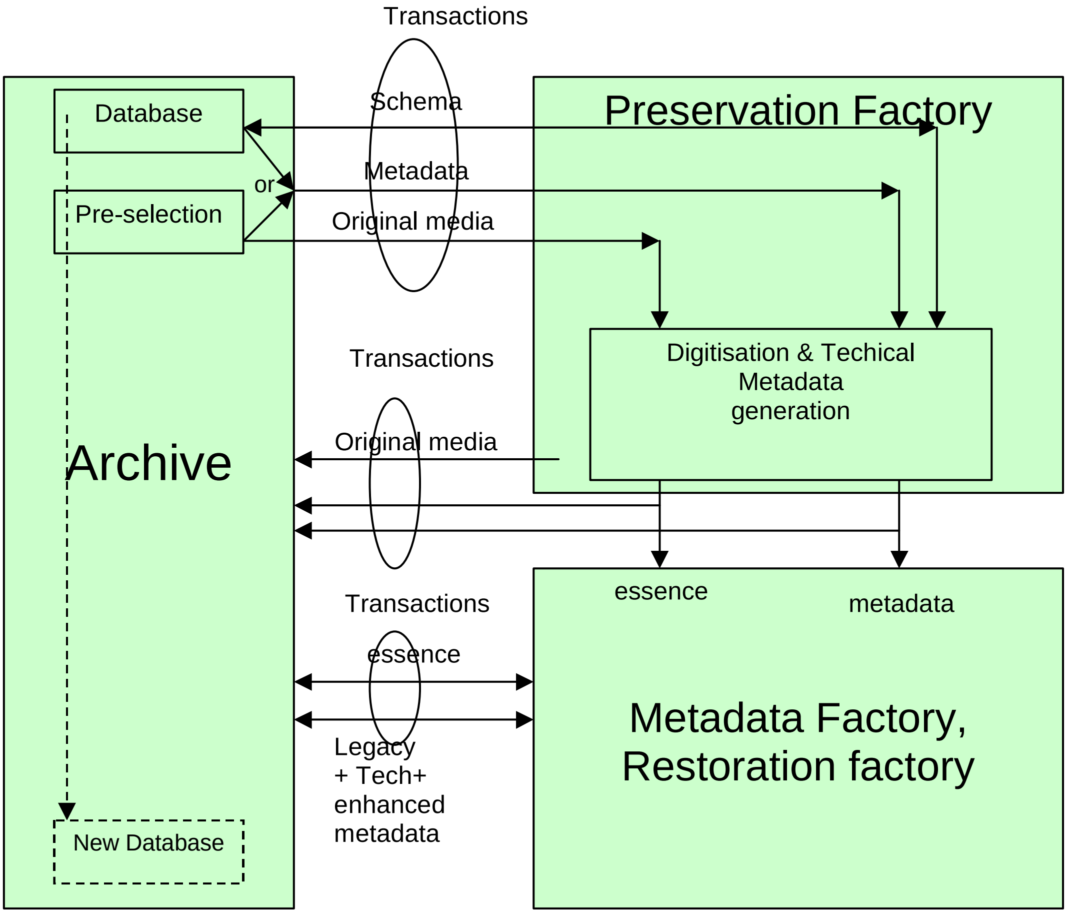


Figure 3-1: The preservation factory model

The functions in a Preservation Factory can be briefly summarised here: the most specific to difficult media are listed in Bold.

- Setting up a service level agreement
- Receiving media, checking in, and acknowledging
- **Examining media (triage)**, and affecting them to one chain or an operator, depending on criteria
- Handling (multiple occurrences)
- **Detailed physical repair** (mainly for film and spliced tape). (involves loading and unloading)
- **Assembling** several physical items in one unique physical media (film newsreels)
- **Synchronising image and sound** (film; sometimes together with physical repair)
- **Cleaning** (using physical equipment: involves handling, loading and unloading)
- Loading
- Transferring
- Unloading
- Physical and logical packaging of the results of digitisation
- Optional additional metadata generation.
- Delivery of the Essence (transferred contents), original media, and Technical metadata.

Within these operations, all may be done in line by one operator, but more often some specialisation is practised, even more when the different systems are in different rooms (examination bench, cleaning machine, transfer machine)…
The actual workflows, detailed later in this document, are very variable depending on the media, the Service Levels, and local practises. In the case of difficult media, the steps are anyway more numerous, and involve more steps than for easier media.

3.2. Preservation strategies

The choice of particular preservation processes and strategies can have a strong impact on operational costs. The decision to migrate is generally made by archivists based on urgency, cultural choices, and available budgets. However, it is down to technicians to inform those who make decisions of the consequences of their choices.
The importance of a good initial choice cannot be enough stressed.

3.2.1. Considerations based on the objective

Several objectives are possible, and there is usually a combination of several of the following aims, but each one of them produces different consequences on the preservation costs.

- **To perpetuate programmes** – to preserve them from passing time and media obsolescence – by transferring them onto new media. It is then necessary to define the expected level of quality from the new generation of copy (type of media, coding and decoding rate), as well as specific treatment process – what must be done in case of a stop due to head-clogging, or if the technician notices a difference of quality during the original recording... If the only preservation criterion is to keep the original information, cost can be reduced by restoring or editing later on.

- **To reduce storage costs** by transferring programmes onto smaller capacity containers. It is quite interesting to take advantage of both the compression rates and storage capacity of new digital tapes. It will be then necessary to pay attention to the kind of media, as well as compression rates and the - fast - evolution of digital storage technologies.

- **To facilitate access to programmes** by making them compatibles with servers or internet streaming formats for example.

- **To allow easier indexation of programmes** by generating additional metadata whose content must be fully defined before. They are 3 main groups of metadata: those extracted from existing database (title, programme reference…), those that can be automatically generated (programme duration, format, subtitles, VITC…), and metadata that require human intervention.

3.2.2. Considerations based on the volume of archives to migrate

This volume question is essential and concerns in particular small archives, or archives with small volume of a particular type of tape.

Indeed, there are currently no standard solutions adopted by Archives for their preservation plans:
Each archive has its own particular requirements for content items gathering, digital encoding specifications, new recording formats, metadata management, ….
Therefore each new project require new study and definition of procedures, some times new digital acquisition stations and new optical or magnetic recording equipment have to be bought for the particular new project

We can consider that – whatever the type of transfer – a preservation project counts 2 different stages:

- **Stage 1**: tests and choice of procedures, acquisition and installation of equipment, creation of dedicated project management and metadata generation software – initial cost is linked to setting up procedures and capital equipment.

- **Stage 2**: production cost per item is also depending on the volume of archive to transfer. Large volumes allow to run 16 to 24 hour a day for a better return on investment

There is a scaling effect which is illustrated on the (synthetic) example below :

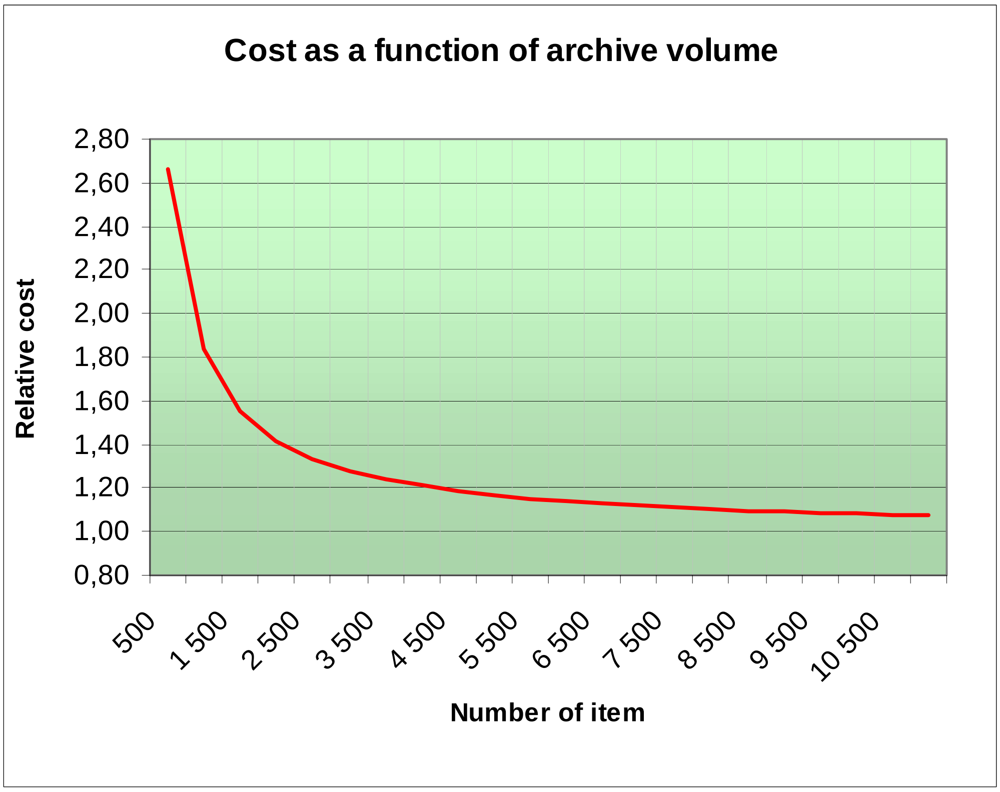


Figure 3-2: Cost as a function of archive volume (synthetic example)

3.2.3. Considerations based on selection

When batches are being constituted, it is important to know, whether or not everything must be transferred. Most of time batches are heterogeneous and contain media that are more or less difficult to deal with.
In an industrial approach, untimely breakdown in the workflow can have dramatic effect on the increase of the cost per item.
Good preparation (cleaning, physical inspection of the media) allows triage and constitution of homogeneous batches (media in good condition for industrial transfer chains and difficult media for restoration chains)
Clear orders have to be given to the provider whether to spend more than the nominal duration of process in the case of a difficult item, or if he can drop it.

The graphic below, based on a real case study, is referring to the measurement of the processing time of 30 000 samples, and shows the impact of pre-selection on average cost. The batch has been divided in 3 categories:

- “Easy” media: 78% - Nominal duration of process time
- Difficult media: 17% - Process time = Twice nominal duration
- Very difficult media: 5% - Process time = 3 times nominal duration

It is important to note that if no selection is made previously, and if and if no instructions are given for stopping the transfer in case of difficulties, the duration of process is 25% above the average nominal duration, which results in increased costs overall.

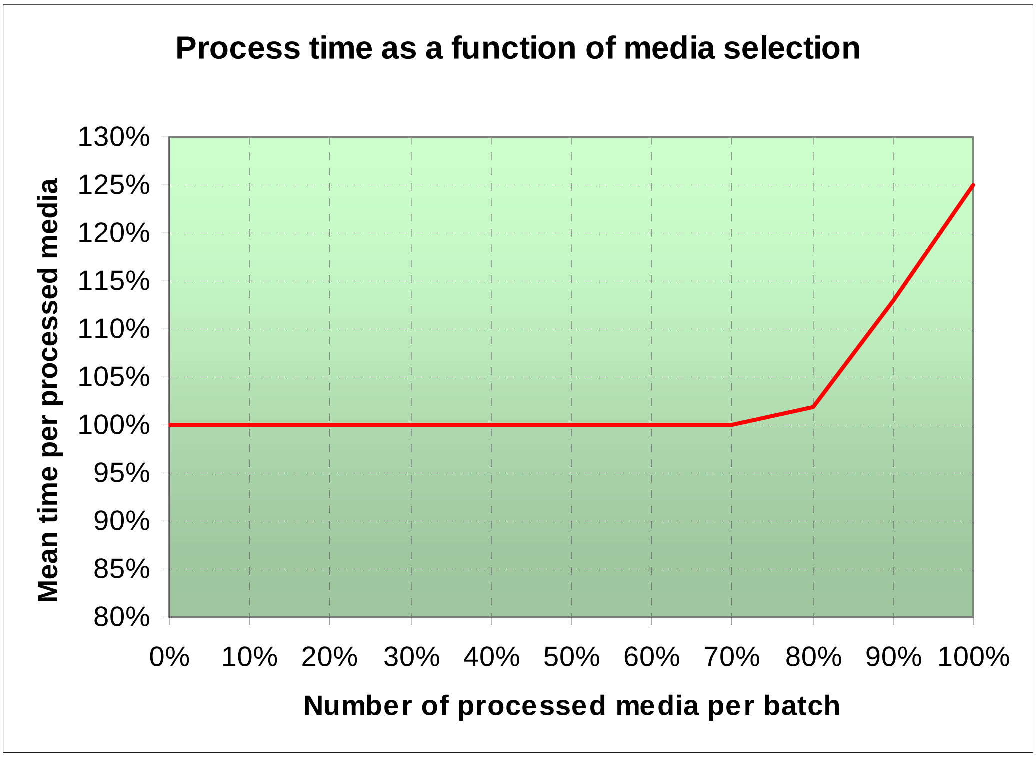


Figure 3-3: Process time as a function of media selection

4. Recommendations

After having listed the "difficult media" and having defined contours of the "preservation factory", this chapter will be devoted to recommendations and "best practices" making it possible to optimise the industrial process of "difficult media" migration within the framework of massive preservation campaigns initiated by archive holders.

The first recommendations will relate to:

- The need to map the archive contents to be preserved.
- Usage of a “triage” approach to select and sort media.
- The best practices to use for media transfer.

When a massive preservation plan of archives is decided, in order to be faster and optimise costs, it could be necessary to define different technical processes, including different types of transfer chains, matching the different physical condition of the original media and adapted to the difficulty to process them:

- Simple preparation and massive transfer through an industrial approach.
- Preparation with mechanical restoration and then massive transfer through an industrial approach (parallel transfer chains to improve speed and reduce costs: see PRESTO-ACS RAI) or conventional unit transfer chains.
- Preparation with mechanical restoration followed by electronic playback on a conventional chain.
- Specific preparation due to damage: baking, cleaning, chemical processes….

4.1. Map out your archive collection

Broadcasters and archive holders must often face a large diversified typology of its films, analogue video and audio holdings: 35mm, 16mm, nitrate, acetate base SEPMAG, COMMAG, low band and middle band 2 inch tapes, 1 inch B and C videotapes, ¾ inch cassettes, ¼ inch audio tapes, 78 RPM disks, audio cassettes….

When they decide a preservation plan of their holdings, they want to know:

- The costs of the plan as precisely as possible.
- What collections / media must be done first: generally, they must take in account and combine two main criteria,
    - a content criterion: interest of the collection / programme
    - the urgency of preservation generally driven by technical criteria: degradation of the media and/ or the disappearance of the playback tools

Generally, all media require some kind of more or less complex preparation step before its digitisation. For example, film often needs to be re-spliced, rewound. Audio synchronisation must be checked, small rolls assembled into larger ones, leaders added… Damaged media need specific preparation and restoration processes. According to the initial situation, the physical state of the media may have a strong impact on the total cost of preservation. This cost may vary in very wide ranges.

4.1.1. Why a technical map?

Knowing the physical state of the media is essential for the determination of the best processes and expected costs.
Making a technical map should help broadcasters and archivists:

- To decide priorities in the preservation plan
- To decide best processes and sort out the media according the type of job to do.
- To set up the financial plans and make them more precise.

4.1.2. What is a technical map?

A technical map is a structured database gathering technical information on the media. Statistics must be extracted from this database giving a clear map of:

- The physical variation of media (items and hours of different types of holdings, classified according several criteria: year of production, type of media (unique, original, copy), colour graded copy or not, manufacturer, location in the vaults, technical criteria (e.g. type of film splice).

- The physical state or condition of the media: Criteria defining levels of degradation: good, fair, poor, sticky, clogging; vinegar syndrome level for acetate films (IPI levels); state of degradation of the adhesive tape or glue splices. Physical state generally varies according to media age and storage conditions.

4.1.3. Does a technical map have to be exhaustive?

An exhaustive technical map gives, directly from the database, some technical information on each item. This is of course very useful, since it will be a tool for selecting and grouping easily items to be transferred. However, the cost and time of setting up such map is often prohibitive. Therefore, a 'statistical' map is often a cheaper and more urgent action to take. It will allow at a relatively low cost to get a good view on the current state of media, although it will not allow direct selection (because it does not have information on each item in the collection, but only on samples). A statistical technical map will be always based on a sampling procedure.

4.1.4. How do we get it?

- Define rules to sample the holdings in order to get statistics close to the reality

- Define the results we want to get.

- Define all the criteria (fields) to create the database.

- Define precise terminology in order to fill the database properly.

- Assign teams to fill this database.

4.1.5. How to use such technical map?

Properly combined with other results and databases, it is often possible to differentiate the assets between classes, in order to select relatively easily items that comply with some selection criteria:

- Classes where most of items are easy to migrate or require a “Triage” approach.
- Classes of items that can wait, or that require further action.
- Classes of items that require, or not, further mapping.

4.1.6. As a summary

A global knowledge must be got through a **statistical map** of the holdings. Its objectives are to determine the collections that can be massively digitised with simple preparation and the collections that require a specific preparation: re-splicing, cleaning, baking...

4.2. The “triage” approach

A global knowledge is very helpful when a preservation plan (budgets, volumes and technical choices) has to be set , but generally a global knowledge is not sufficient to feed precisely the right transfer chain with the right elements and, so, optimise the productivity. In order to send the right item to the right transfer chain, a more precise step of triage or sorting, according several precise criteria is required and must be performed.

As previously mentioned, a careful selection of the materials to transfer is a key element in a successful migration strategy. An attempt for generalisation can be made here, that suggests that workflow improvements can be achieved when the decisions are made at the right time. One of the most important sources of wasted effort is when an operator is forced to spend more time than planned, stop working, or cancel an item because of unexpected difficulties.

Actually, selection/triage steps have to take place at several places during the preservation process:

- **Pre-selection**: When an archive does the pre-selection for migration batches: consideration of the expected condition of media, based on statistical maps, always result in some selection process.

- **Batch preparation**: At the physical batch preparation stage, if there is a packing/shipping/cleaning step, some visual verification criteria can be applied, and damaged items should be directed to another chain.

- **Check-in**: When the Preservation Factory receives a batch, a check-in procedure should be applied. Errors in labelling, number of items, for example, should be detected and sorted out at this stage.

- **Triage**: The actual triage step, within the Preservation Factory, is intended to visually, or using simple tools (barcode readers for example), decide whether an item is to be processed through a straightforward chain, sent to an 'expert' chain, or put aside for further examination.

- **Migration**: During actual transfer, effort per item should be strictly limited, through the use of continuation thresholds. If some threshold is reached, transfer should be aborted, and the item should be re-directed to an 'expert' chain, or put aside for further examination. This is an 'exception' mechanism.

It is worth considering here the influence of failure rates and the implications it has on the throughput of the “Preservation Factory”. When failure rates are below 1% per item on one chain, the ***'Exception'*** mechanism is satisfying: operators have a consistent task to do, get used to it, and waste little effort addressing tasks they are not supposed to. When failure rate rises to 10%, or more, the operators will have to take important decisions quite continuously: try again? Give up? Adjust? The effort spent in addressing difficult items rises quickly, which easily results in doubling the average cost, or worse.

To avoid this kind of problem, it is suggested here to split the work between:

- Tasks where the rejection rate is high (10%, or more), that are performed relatively quickly and effortlessly (visual check, consistency checks, use of simple measurement tools, quick playback test in some cases, cleaning step if appropriate).

- Tasks where the rejection rate is low (1% or less), that are more expensive to run: typically playback, which often runs real-time, extended physical repair.

The first task will be favourably implemented through a ***Triage*** approach; the second is more reliant upon the ***Exception*** mechanism.

Load balance also has to be taken into account: for example when one operator is managing several transfer chains simultaneously, it is often useful to mix the durations: one chain (or more) can be loaded and started for a long transfer, during which several shorter items can be transferred on another chain.

There is scope here for an in-depth study on the best organisation, based on the different cost/time estimations for each step, and the expected selection and failure rates at each step, which in turn are depending heavily on the pre-selection processes and quality of the mapping. There is probably no 'one-fits-all solution', but common sense and simulations could give useful results for keeping costs down without endangering quality of the results.

The "Triage" step may occur:

- At the archive premises, close to the holdings, in order to get homogeneous sets of items suitable for each type of transfer chain.
- At the subcontractor premises or technical department, by sorting items according to condition, to feed the right chain with the right items, thereby reducing failure rates and maintaining productivity.
- Balancing the Triage job between the two places. This may occur if the archivist does not have the technical and human means to check all the elements before sending them to the subcontractor premises. It will then be the role of the subcontractor to make sure no item is incorrectly dispatched.

Some kind of “light preparation” or mechanical repair may take place during the Triage step: rewind, tighten the tape, put a new leader, replace broken splices etc.

Resulting information from this step will feed the statistical map and make it more precise. Information coming back from the transfer chains may feed and improve the statistical map too.

In some cases, when an archivist has already a more or less good picture of the state of its holdings, merging the two kinds of jobs in one-step, can be useful and may help to organise and start the preservation plan faster.

4.3. Recommended practices for film selection and transfer

The following chapter is about the implementation of the « mapping » and « selection » recommendations applied to the film media. We also list here the best practices commonly used by existing film preservation facilities.

4.3.1. Mapping of a film collection

Any preservation strategy must be based on a precise analysis of the structure of the archive collection to be preserved. The collection will have to be mapped out beforehand according to selection criteria such as those mentioned in this paragraph.

An archive film may be affected by many defects due to ageing or inappropriate manipulations. The importance of these defects, together with other parameters such as the type of splices (tape or cement), used in the film and the kind of production involved (news, drama...) will be some key factors of the preservation costs and durations.

Among these criteria, "vinegar syndrome", an irreversible and transmissible degradation of cellulose triacetate base, is one of the most constraining. Vinegar syndrome in triacetate collections have to be extensively tested in order to separate healthy and "decomposing" films for which an emergency procedure will have to be put in hand.

Another criterion of selection preliminary to the preservation will be the type of program to be preserved. Newsreels are, most of the time, short, reversal, non colour graded films. Kinescopes are B&W homogeneous reels with a high CRT scanning pattern visibility and fiction films can often be found under the form of edited negatives.

The multiplicity of distinct elements available for the same film, such as negative, inter-negative or print, will have also to be considered.

Finally, once mapping carried out, the archive will proceed to an inventory of the elements of each programme, in order to determine which have the photographic qualities and physical state that will make possible to obtain the optimal preservation and digitisation.

The technical film mapping should consequently include the technical characteristics of both picture and sound elements (film and audio formats, type of base and number of elements per program), together with media condition data (vinegar syndrome, splice condition, shrinkage and mould germination) and cataloguing and reference data such as the type and year of production of the programme.

On the following pages, *Figure 4-1 and Figure 4-2*describe the main criteria to be used to map out a film collection.

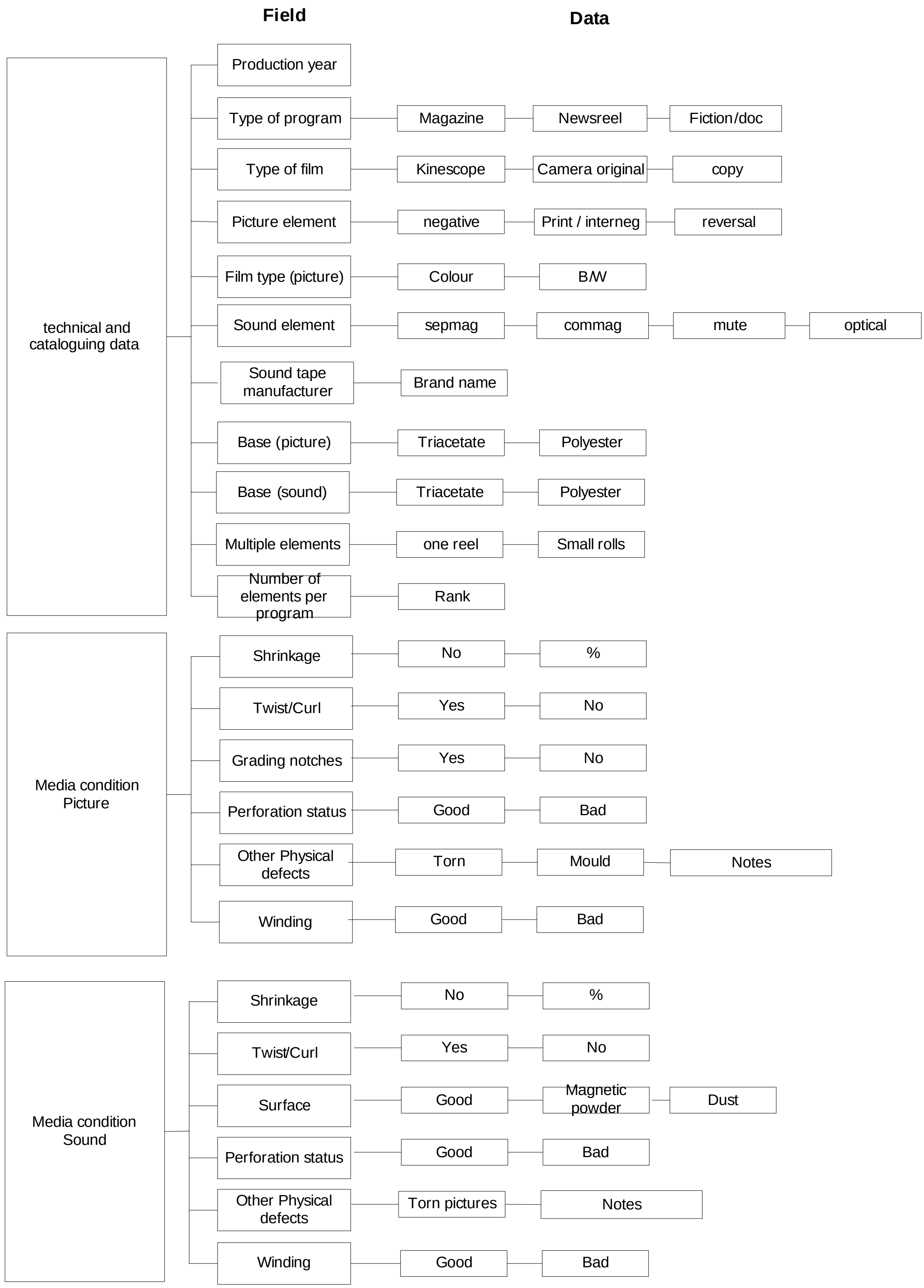


Figure 4-1: A database structure for films mapping and selection

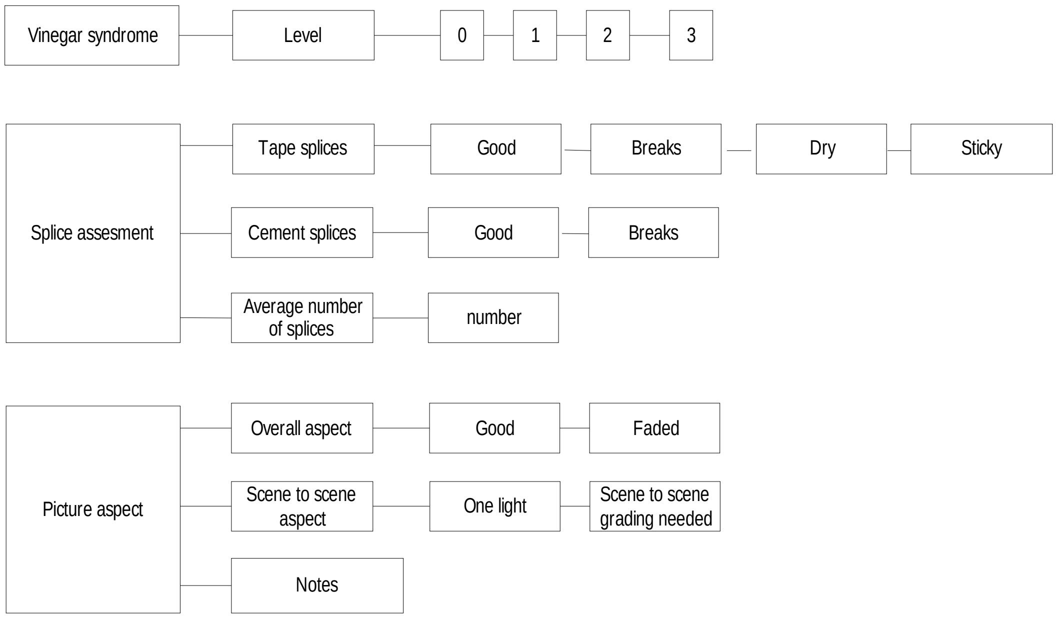


Figure 4-2: A database structure for films mapping and selection (continued)

4.3.2. Film triage and selection

Once the film collection is mapped out, the archivists (or the preservation factory) will proceed to selecting and sorting the films to be transferred.

We define here a set of job recommendations to be carried out before, during and after the preservation process.

Prior to transfer, does the film need:

- Leader replacement?
- Splice or perforation repair?
- Emulsions rewash?
- Solvent cleaning?
- Sepmag copy?

Will the film transfer need:

- Wet gate?
- Colour correction?
- Noise reduction?

After transfer:

- Will the film be stored at low or room temperature?
- Will it be fitted with molecular sieve?
- Will the picture and sepmag bases stored in separated boxes ?

The database structure illustrated in *Figure 4-3: Job recommendations database structure,* is designed to help film archivists to determine the preservation workflow of their elements.

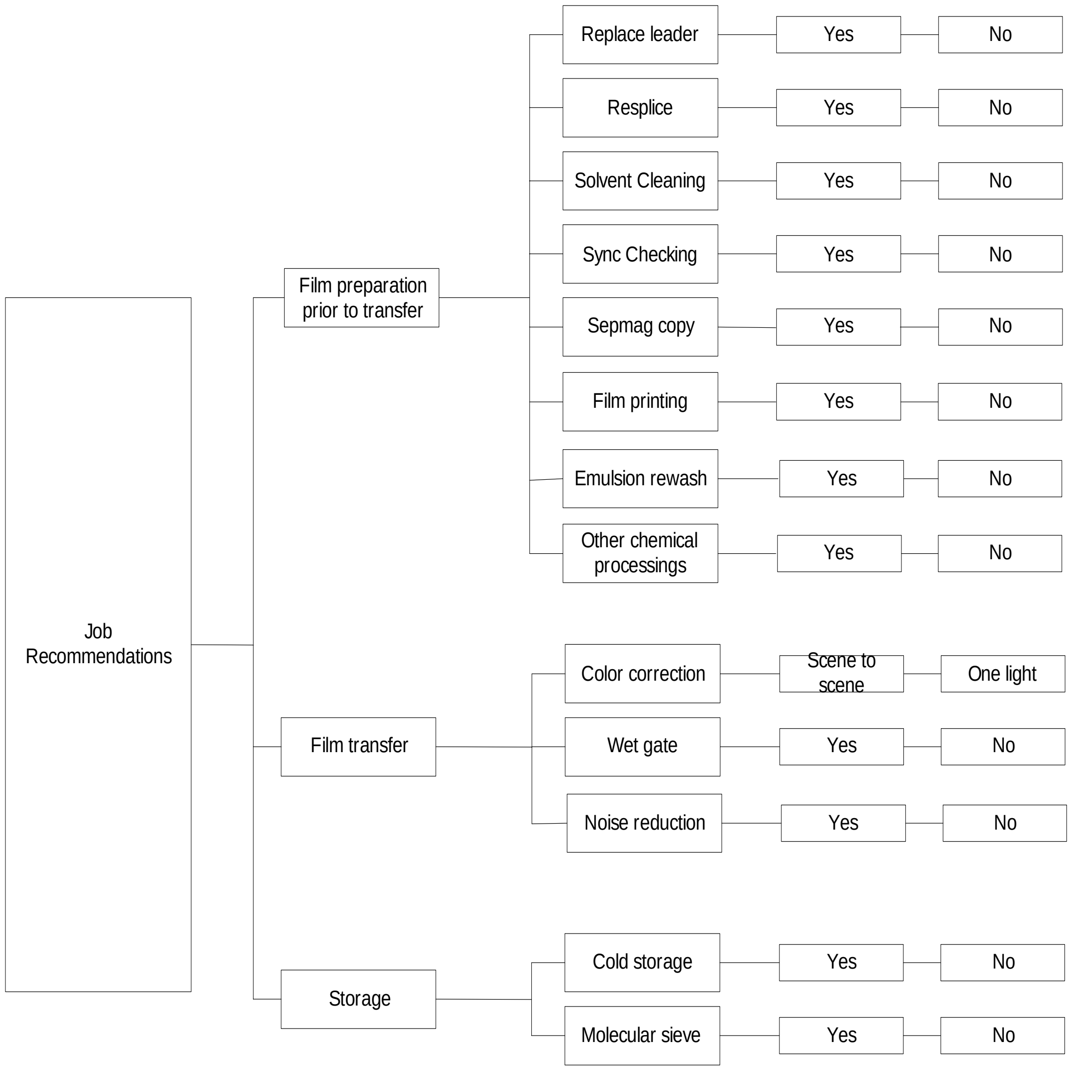


Figure 4-3: Job recommendations database structure

4.3.3. Film transfer best practice

Once the archive has been mapped, the films sorted and the preservation workflow defined, films are now ready to be prepared and transferred.

Following is a "best practice" workflow diagram of film preservation as commonly used by existing preservation facilities.

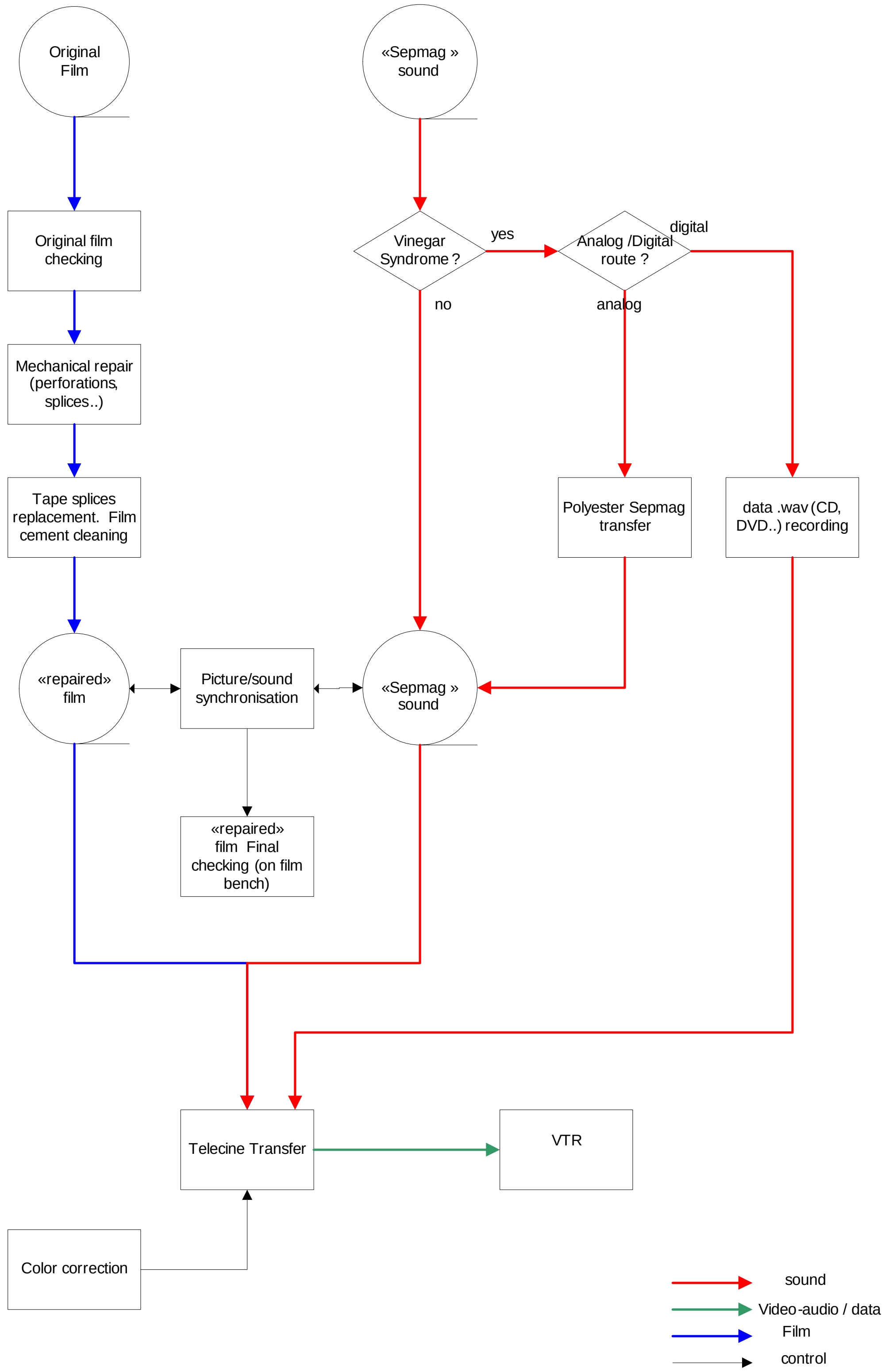


Figure 4-4: TV archive films preservation workflow

4.4. Recommended practices for video media selection and transfer

The following chapter is about the implementation of the « mapping » and « selection » recommendations applied to video media. We list also here the best practices commonly used by existing video preservation facilities.

4.4.1. Mapping of a video collection

The most frequently met defaults or impairments are usually due to physical and chemical damages. They are also the most difficult ones to deal, causing waste of time. For example, head clogging of the machines requires long and fastidious cleaning processes. The mechanical effort made by the player can also destroy completely the tape. Very often, this kind of fault makes the transfer impossible.

Experience shows that this kind of problem concerns specific batches produced during a particular period by a particular manufacturer. Those batches are usually homogeneous. It is then interesting to draw a list of those defaults in order to associate them to a particular manufacturer batch, as it is likely that other tapes from the same batch might as well be damaged. By setting up a database, it will become easy to find out whether or not, one tape could be difficult to transfer and also the reason why. It will then be easier to decide if the media is worth being transferred or not.

For the statistics to be useful, and to facilitate Triage, the database must be filled with the following fields:

- Cataloguing and identification data of the media. Generally this information exists in the legacy data base and can be imported for example material ID, recording date and tape use, duration of the programme, recording standards and formats.

- Information or features about the tape: generally visual checking is required to collect information about the manufacturer, the commercial name of the tape, the serial number.

- Data about the tape or cassette condition: visual inspection is required and collected information could be useful in order to prepare the best manner to make transfer easier.

- Storage condition: this information could be useful to set the relationship of the current state condition and past preservation climate condition and use. However this is only possible if the preservation history exists and can be tracked.

- Playback information: visual inspection gives interesting information but is generally not sufficient. Playback, at least of the beginning of the tape, is required to know if the tape could be played easily or not. Information like RF level, drop out, stickiness and head clogging are generally noticed very fast after few minutes.

The following example gives sample database structure, but some fields may be not relevant, and some others might be added, depending on kind of collection.

There currently is no easy tool to assess the degradation level of a video tape and its life expectancy (for example tools are available to measure the vinegar syndrome of acetate films). In the near future, researches performed by the CRCDG, within the PrestoSpace project (WP6 Media condition assessment), should be taken into account by using the recommended methods, techniques and tools, to assess the degradation of a tape and include them in the database.

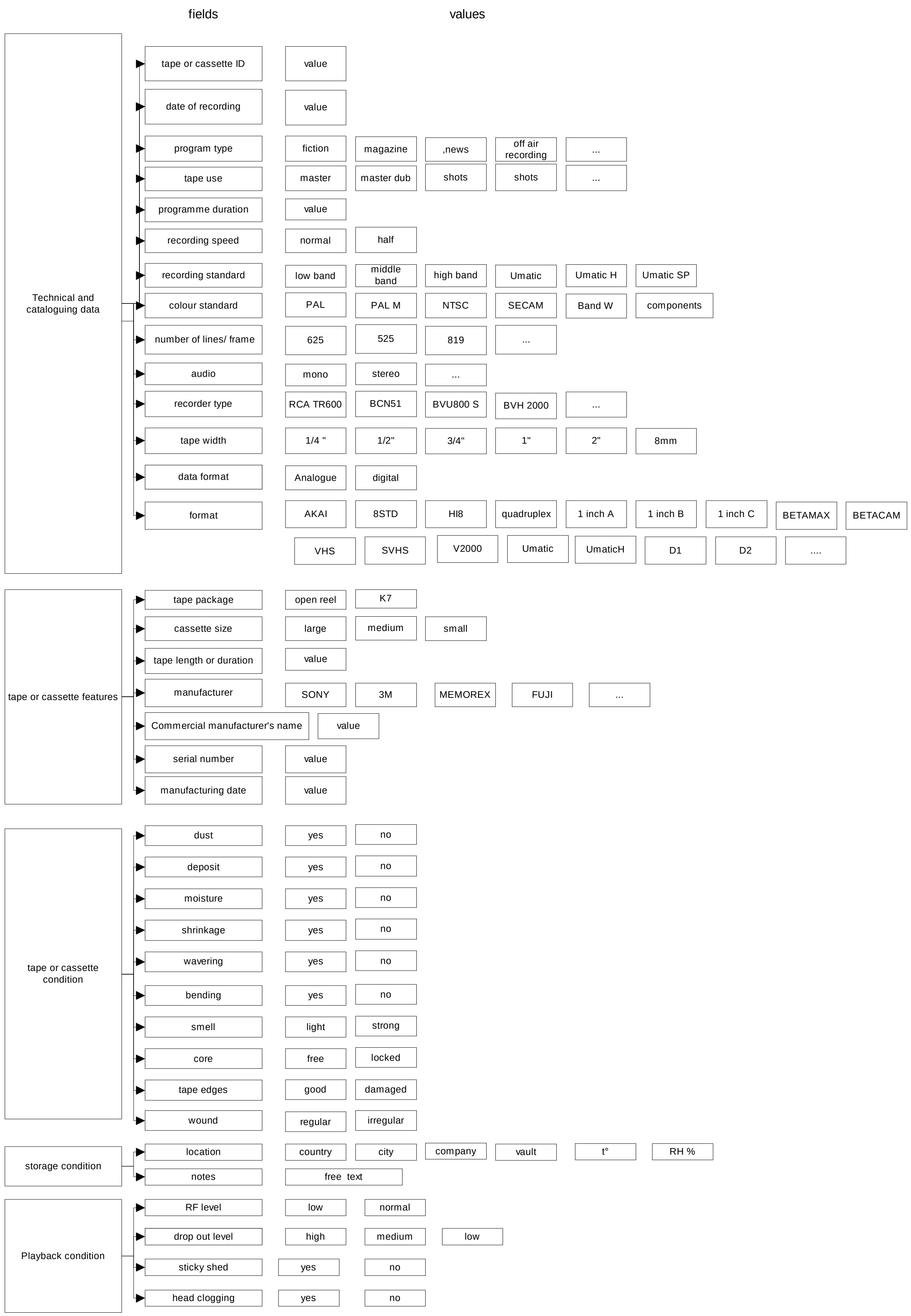


Figure 4-5: A database for video media mapping and selection

4.4.2. Visual selection of video media

This kind of selection is empirical and depends on how the state of the tape appears.
Except when it is obvious that the packaging has been seriously damaged, it is necessary to open it, in order to check the tape itself in order to make an assessment. This operation is usually done a couple of minutes before the transfer. When a tape is suspected not to be transferable, it is then put aside from the normal channel of transfer. Later on, a new checking will be done in order to decide the appropriate restoration process.

The main things to check when the boxes are open are:

- **Mould**: the main characteristics are a kind of white powder associated to a strong smell. Tapes presenting this kind of default must be cleaned through a mechanical cleaner. Mould usually does not prevent the tape from being transferred.

- **Glue** or trace of glue: this is one of the most difficult defaults to get rid of, and most of times make it impossible to carry on the transfer. Actually, the glue sticks to all the constituting parts of the tape, which can be a serious damaging cause for the playback equipment.

- **Irregular rewinding**: Those irregularities can be due to inappropriate machine setting: pack sides are not homogeneous and tape edges are not be well aligned. This can also be due to a lack of tension during the rewinding: the spool is not circular and has humps and hollows on its surface. At last, the tape might have been folded during the rewinding. All those rewinding irregularities do not prevent the tape from being transferred, but processing them a lot of care. First of all, it is needed to forward and rewind the tape completely several times on a well set machine, until the aspect of the tape is regular (perfectly aligned rounds). If tension during rewinding is not tight enough, the first rewinding will have to be done at slow speed. If the tape has been folded, it will be necessary to check that the folding has disappeared after rewinding and that there is no twist left (the shiny side must always be in the same direction). Once the tape is properly rewound, it is important to wait 48 to 98 hours before carrying on with the transfer.

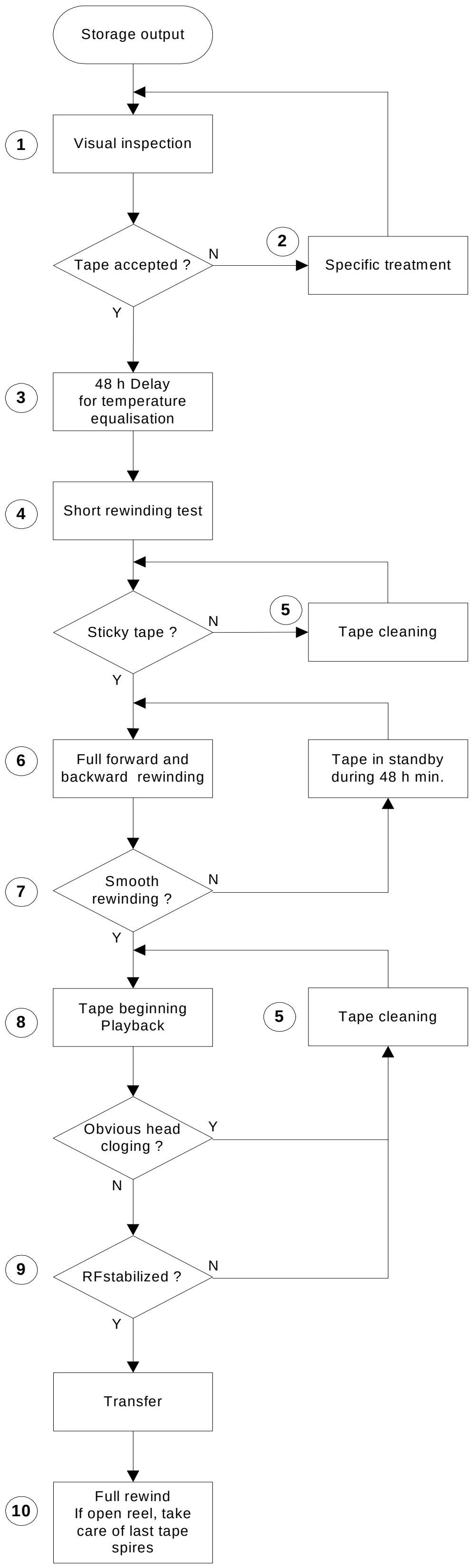
- **Tape's edge state**: Finally, it is important to check the tape's edge state, which could have been folded or damaged.

We can draw the following simplified decision tree to summarise these checks:

Figure 4-6: Simplified decision tree for video media selection

4.4.3. Video media transfer best practice

After this visual selection step, we have to play the media and check RF level and head clogging. As a consequence, most of the time, the following video preservation workflow is used.



① Visual inspection

② Specific process
The process, which is to be applied, depends on the result of the inspection … each encountered problem must be associated with its own specific operation

③ 48 h Delay for temperature equalisation
This delay allows tapes to slowly reach the temperature of the room and of the machines dedicated to transfer, in order to avoid strong thermal constraints. This delay could vary depending of the kind of tape: Heavier is the tape, and longer is the delay. For tapes like 2 Inch, 48 hours is a minimum, and 1 week should be preferable.

④ Short rewinding test
This test informs the operator how much sticky is the tape. This test is done for the very first part of the tape, just to check its overall quality and to know if it's possible to rewind the tape. This test must be accomplished with a VTR tape transport and not with a cleaning machine such as Recortec: The motors could be so strong and the tape so stuck to the guides than permanent deformation could occur making the tape definitely unusable. Using VTR tape transport allows gentle handling instead. Note that it is not necessary than the tape passes in front of the playback heads. Direct path between the 2 reels could be better.

⑤ Tape cleaning
Tape cleaning is a generic term meaning than some process is applied to the tape surface. It could span from a simple rewinding to a sophisticated chemical processing.
In a transfer room, most of the used treatments involve cleaning machines such as RTI or Recortec.

⑥ and ⑦ Full forward and backward rewinding
This operation is useful to be sure than the tape is correctly rewound and that no bump will occur during playback. If the operator notes that the rewinding is not regular, the tape must be rewound again backward and forward several times and must then rest for 48 hours before being played.

⑧ and ⑨ Tape beginning playback and checking of RF level
During this phase, the operator checks the electronic readability of the tape. If he detects obvious head clogging, or if the RF level is not stabilised, the tape must be cleaned again.

⑩ Full rewind. After the transfer, the tape must be rewound continuously, with no stop, to avoid irregularities.

Figure 4-7: Video media preservation workflow

4.5. Recommended practices for audio media selection and transfer

The following chapter is about the implementation of the « mapping » and « selection » recommendations applied to audio media. First we give some general rules to conduct the mapping and selection of the collections. Then we do a brief study of the different processing cases that drive the tape selection. The recommended workflow of the audio tape transfer is shown, and finally a case study is used to illustrate the best practices generally used for ¼ Inch audio tapes preservation.
In the last part, we give also some guidance lines for selection of the 78 RPM direct recording disks but they are considered as original media and require careful handling in all cases

4.5.1. Mapping and preparation of audio tapes collections

Prior to the transfer of ¼ inch audio tapes, two kinds of jobs are required.

- A global knowledge must be obtained through a statistical mapping of the holdings. Its objectives are to determine what parts of the collection can be massively digitised with simple preparation and what tapes require specific preparation: re-splicing, cleaning, baking... Global knowledge is very helpful if a preservation plan (budgets, volumes and technical choices) must be set, but generally a global knowledge is not sufficient to optimise productivity by feeding precisely the right transfer chain with the right tapes.

- In order to send the right tape to the right transfer chain, a more precise step of triage (sorting according to precise criteria) is required.

This triage step may take place:

- At the archive premises, close to the holdings, in order to get homogeneous sets of tapes suitable for each type of transfer chain.

- At the subcontractor premises or technical department, by sorting tapes according their condition to feed the right chain with the right tapes, thereby reducing failure rates and maintaining productivity..

- Balancing the Triage job between the two places. This may occur if the archivist does not have the technical and human means to check all the elements before sending them to the subcontractor premises. It will then be the role of the subcontractor to make sure no item is incorrectly dispatched.

During this sorting step some “light preparation or mechanical repair” jobs can be undertaken. For examples: rewind, tighten the tape, put on a new leader, re-splice if a splice breaks, or any similar work.

Resulting information from this step will feed the map and make it more precise. Information coming back from the transfer chains may feed and improve the statistical map too.

In some cases, when an archivist has already a good view of the state of its holdings, merging the two kinds of jobs in one-step must be useful and may help to organise and start the preservation plan faster.

4.5.1.1. Some criteria to map out ¼ Inch audio tapes collection

The technical mapping produces a structured database of information about the media in order to get statistics. It may include:

Cataloguing and reference data:

- References of the tested tape (stock number)
- Vault: name and location in the vault
- Year of production
- Type of programme: news, magazine, fiction, documentary, concerts, off air, recordings…
- Original, copy…

Technical data:

- Recording speed
- Track width
- Number of tapes / programme
- Duration
- Mono/ stereo
- Recording equalisation
- Manufacturer: PYRAL, BASF, 3M …
- Type of base: acetate, polyester, and vinyl chlorure (?)
- Forms of packaging: free on a core or in “reels ”
- General state: good, fair, poor, damaged
- Type of physical damage: clogs, breaks, “tiling” tapes, shrunk tape…
- Edited/non edited
- Edited tapes: dry splices, greasy splices…
- Number of splices (per hour of programme)
- Vinegar syndrome for acetate tapes: IPI level

4.5.1.2. The preparation and triage database

A preparation and triage database is linked with this technical database; it aims to give recommendations:

- Define the type of preparation that each tape requires (if repair cannot be done or is not done immediately)
- The type of performed job (if repair is performed during the step)
- Recommend the best transfer path

A detailed sample of a database structure for storing this information, based on a real case study in INA, is given later in Figure 4-11 A database structure for 1/4" audio tapes mapping and selection.

4.5.2. Transfer of ¼ inch audio tapes

Even if ¼ Inch tapes are “open reel” media, there are some possibilities to improve the transfer process with parallelization.

3 cases may be considered to drive the selection:

- Tapes have to be transferred on a conventional transfer chain.
- Tapes can be transferred on a parallel system composed of several transfer units managed by one operator.
- Tapes have to be transferred in a restoration suite.

In all cases, knowledge of the technical condition of the audio holdings is essential to decide the most suitable process. This can be got through the technical map out and expertise of the holdings.

4.5.2.1. Transfer on conventional transfer chain

When some of the media require a permanent monitoring and, sometimes, set-ups during their playback, they have to be processed on “single” or “conventional” transfer chains.

A conventional transfer chain is a single transfer chain operated by one technician that drives and monitors all the preservation process: playback of the original tape, digitisation and recording onto the new digital media. A final quality control step takes place at the end of the process.

Preservation on a conventional transfer chain requires a mean working time of 1.5 to 2 hours per hour of programme.

The following drawing (figure 4-8) shows the principle of a “conventional” transfer chain from ¼-inch audio tape to CD/DVD -R:

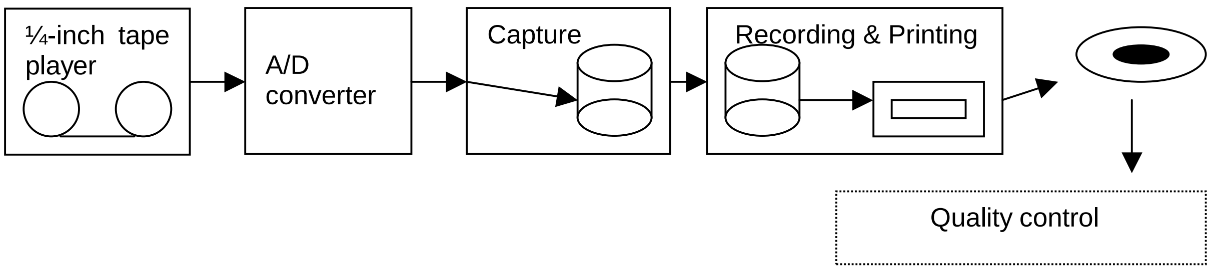


Figure 4-8: A conventional transfer chain for 1/4 Inch audio tapes

4.5.2.2. Transfer on a "parallel" system

When media are in a good state they can be processed with an « industrial approach » on “parallel” transfer chains. This kind of transfer allows a more efficient approach. It has been described by RAI and ACS in the presto Project deliverable D3.1, and principles are reminded there.

A “parallelized” transfer system is a more or less automated “factory “ and composed of several transfer units (3 to 5) that an operator can operate simultaneously. Automated control functions and printing must be available to help the operator. Such a system may lead to increase productivity by a ratio from 3 to 5 while reducing the costs by at least 30 to 50 %

To achieve such goal, some technical criteria must be respected to feed the system:

- Tapes have to be in a pretty good condition:
- Tapes have to be clean (avoiding head clogging).
- Tapes should not be sticky.
- Tapes have to be smooth and “flat” (without wavering or shrinkage).
- Tapes have to have a leader and be perfectly rewound.
- To maintain productivity, the tapes that are loaded on the different players must have durations compatible with the workload : on average enough starts, stops, and quality checks that will keep both the operator and the players active, without generating overload. E.g. all tapes in the 20-minute range, or a mix of shorter and longer durations.
- The recording level must be homogeneous all along each tape in order to avoid level adjustments during transfer.

- The recording azimuth must be constant all along the tape (azimuth set-up must not be required during the playback).

As a general consideration, every parameter that can lead to stop the transfer and restart, loose productivity and must be avoided.

The following diagram shows the principles of a system composed of four parallel playbacks. An industrial approach may include several similar systems.

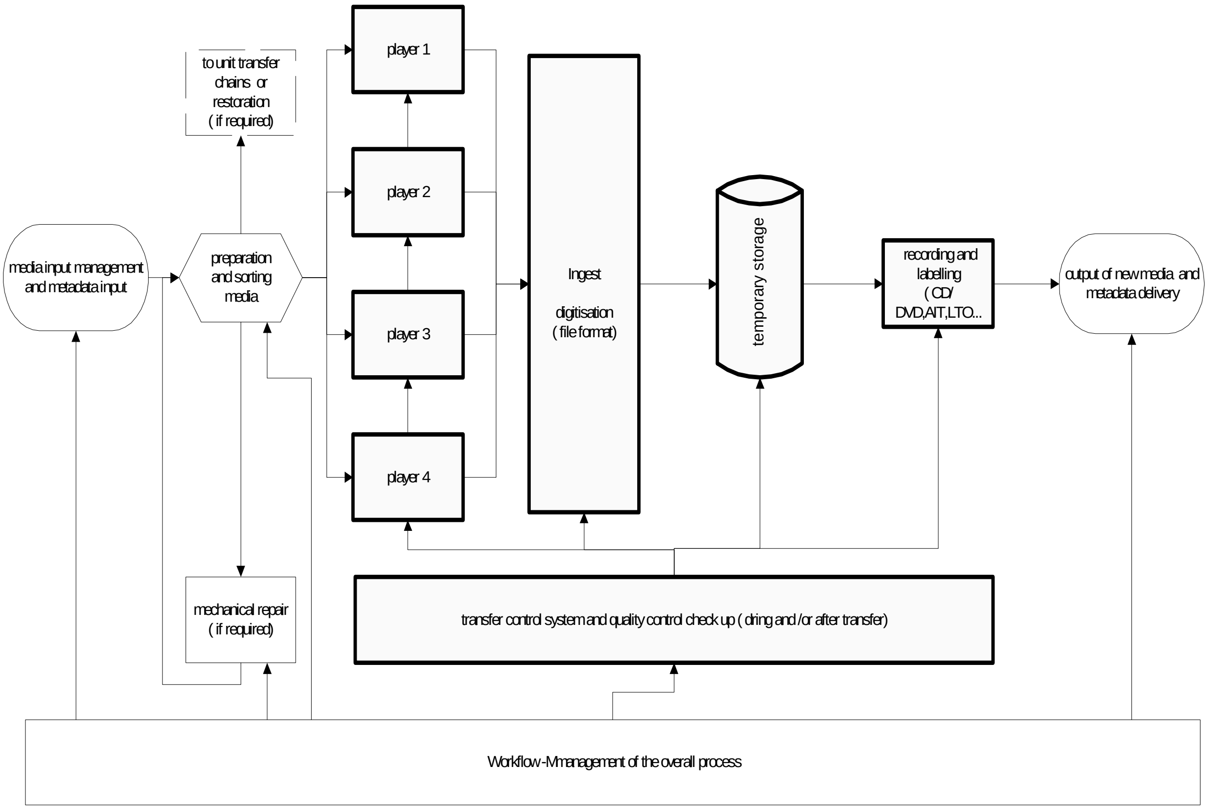


Figure 4-9: A sample transfer chain composed of 4 parallel playbacks

4.5.2.3. Transfer in a restoration suite

When some of the media are in too poor condition, they have to be processed by expert operators with some restoration steps. The restoration suite may include specific processes that can take place before or during the transfer:

- Chemical means with cleaning products
- Baking
- Re-splicing
- Editing
- Electronic restoration tools: noise reduction, de-crackling…

4.5.3. ¼ inch audio tapes transfer workflow

The following workflow diagram summarise the principle of a workflow leading to the tree types of tape processing and using the mapping and the triage steps discussed previously in this document.

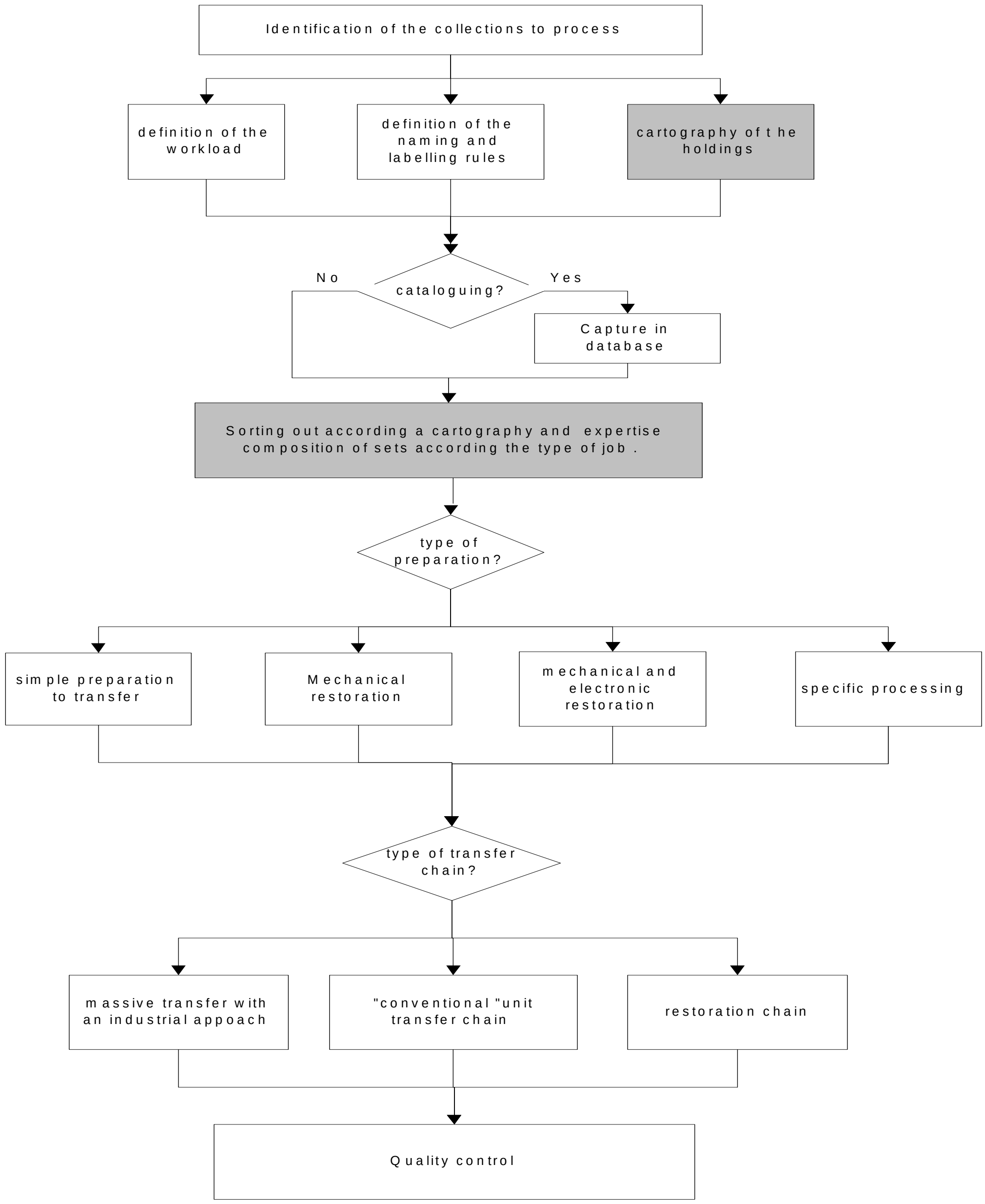


Figure 4-10: 1/4" audio tapes transfer workflow

4.5.4. A case study of ¼ inch audio tape collection preservation.

In order to speed up their preservation plan for audio tapes, INA decided to develop with their subcontractors an industrial approach for 'good condition' parts of the ¼-inch tapes holdings, while keeping traditional transfer chains for more difficult tapes and restoration suites for very difficult tapes.

INA decided to perform the cartography and the preparation of the tapes in one-step and therefore, only one database was developed. This database gathers four categories of information:

- Cataloguing and technical reference data (ref. database structure)
- Data about physical condition of the media
- The type of job that has been performed during this preparation step
- Recommendations

Figure 4-11 A database structure for 1/4" audio tapes mapping and selection describes the principles of the database used in order to perform both the mapping and the triage and preparation of the tapes. This database can be linked to the legacy and or media database in order to import and export data and avoid manual capture of data.

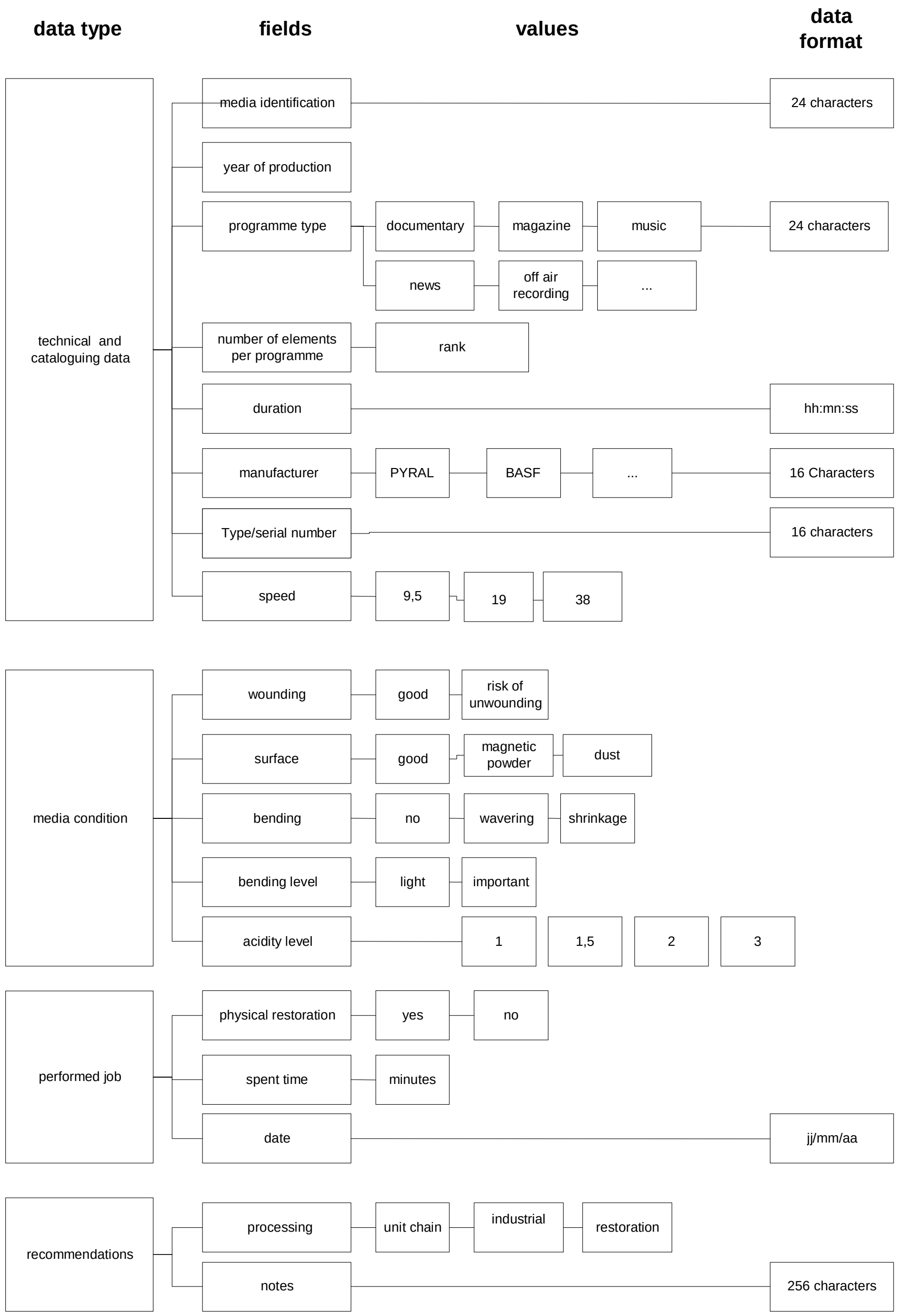


Figure 4-11 A database structure for 1/4" audio tapes mapping and selection

Figure 4-12: Mapping and Triage of ¼" audio tapes show a diagram that explains preparation of the tapes and represent a sequence of questions the operator must answer:

- Is this tape referenced in the legacy or media database?
- Is its duration known?
- Is the recording speed known?
- Is its winding correct?
- Is its surface clean?
- Is there some kind of tape deformation?
- Is there any vinegar odour?
- Is the tape spliced?
- Are the splices in good condition?
- Can I do some kind of quick job to repair and put the tape in good condition?
- Will repair on the tape be too long?

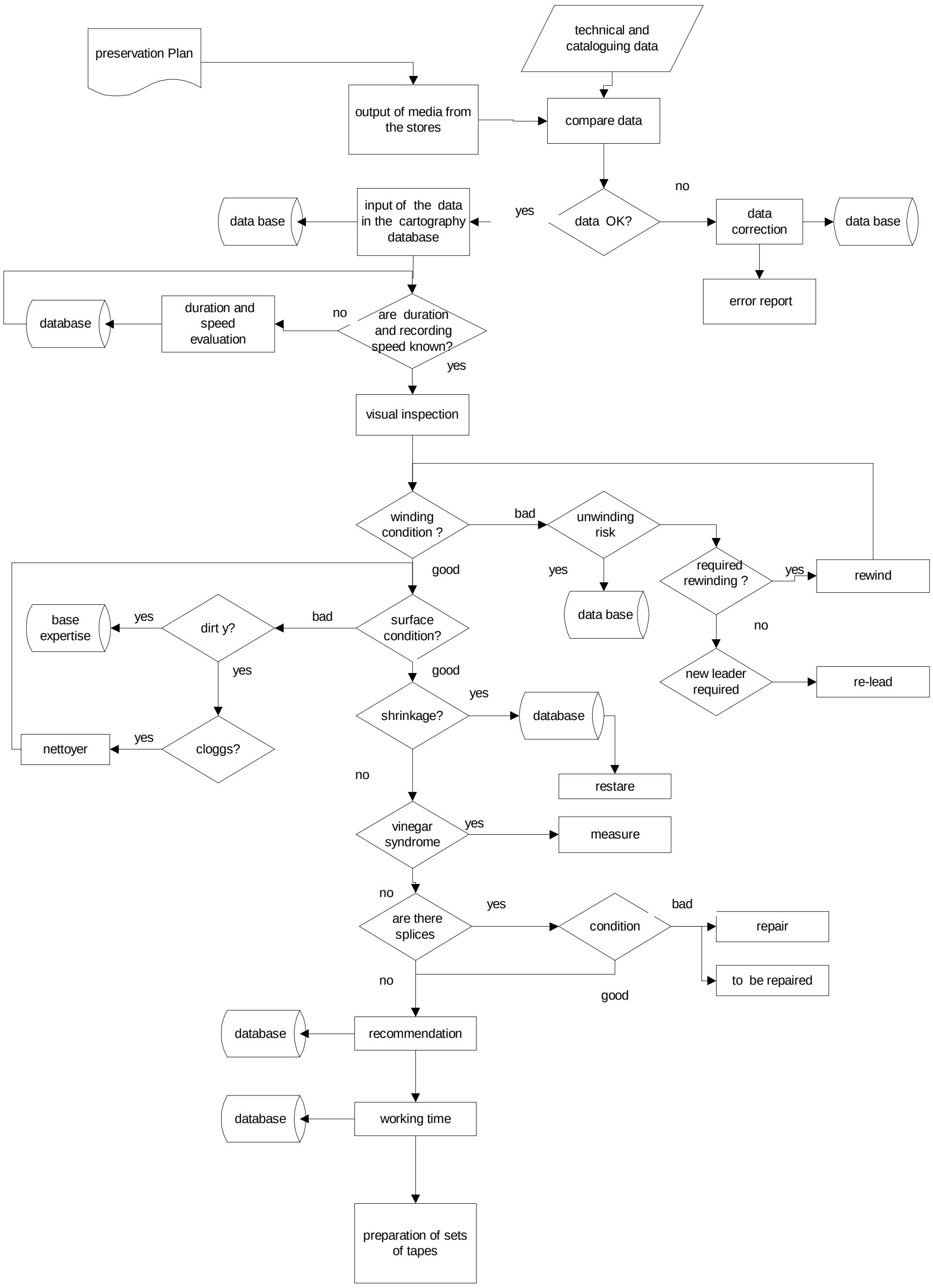


Figure 4-12: Mapping and Triage of ¼" audio tapes

4.5.5. Best practices for direct recording 78 RPM disks

As previously explained in 2.3 direct recording 78 RPM disks must be considered as the least stable original media for sound recording. They must be handled very carefully and their process cannot be easily automated. Recording on each face has duration of 2 to 3 minutes with overlaps, so the continuity of the programme must be reconstructed (by non linear editing).

4.5.5.1. Selection and triage of 78 RPM disks

Generally two cases based on the surface state must be considered:

- The disk is not very damaged: the coating is continuous. The disk can be played without risk to destroy it. A more or less systematic job can be performed for example by a specialised service provider.

- The disk is too damaged: most of these disks are so damaged that they cannot be easily transported. The coating is crackled and any playback may destroy the recording. Each situation is specific. These disks must be handled in house by skilled sound engineers only.

Therefore the only possible preparation is to sort disks according the two cases in order to send them to the right chain. It is worth noting that a playback device that would not require a stylus to touch the disk surface, and that would be robust to a reasonable amount of pollution by particles, would greatly facilitate the process, and would allow a much more efficient workflow.

5. Improvement tracks

Even if “automation” and “difficult media” may sound contradictory, improvement tracks may exist. They will affect tools, services and preservation workflow.

Examples will be found in the following paragraphs:

- New transfer tools can be developed to optimise the productivity of the film, audio and video preservation process.
- A set of databases should be created to facilitate the exchange of information about playback systems and technical troubleshooting.
- Improvements in existing preservation workflows may also be proposed.

The reader will not be surprised that several of the Improvement Tracks proposed here are already being developed within the PrestoSpace Project.

5.1. Tools

5.1.1. Tools for preservation of film media

5.1.1.1. A telecine faster than real time and with better allowance regarding the physical defects of archive film

It is recalled here that, independently of the 'cinema' movies, which deserve a higher quality of digitisation and safer storage conditions, the current amount of endangered film material in Audiovisual archives requires massive migration plans to be initiated quite quickly, with digitisation devices that have enough quality, but also a reasonable cost of ownership.

The cost of film transfer is directly linked to:

- The high cost of hardware which is unlikely to drop down significantly in a near future due to the high level of concentration among telecine manufacturers
- The time spent in transferring : real-time to VTRs, plus colour grading steps required because of the lower dynamic range of video compared to film.
- The high cost of physical repair and preparation of the film reels before transfer

The mechanical repair and assembling of small news rolls take a long time (in average 10 working hours for one hour of news programmes stored on original reversal tape spliced films)
This means that the cost of the physical restoration and preparation before transfer is 50% more expensive that the cost of telecine transfer itself.

Two ways to lower these costs can be explored:

1 – To avoid the mechanical assembling of small news rolls in a unique reel of about 30 minutes duration which take a long time (about 3 working hours). This operation is done to reduce the telecine operating time (load and unload time) due to the high cost of this equipment.
If telecine hardware cost is strongly reduced each small roll can be transferred separately and, if needed, the assembling can be done in the digital domain.

2 The film transfer costs could be reduced if the telecine hardware is able to speed up the transfer itself. This cannot be accomplished in the video domain but remains possible in the “data” domain.
Film preservation factories would then require the development of “datacines” designed to accommodate shrinkage, fragile films, torn perforations, and able to do transfers at speeds up to 3 or 4 times the reel sped.

It is expected that, given the high enough primary dynamic range of the device, and of the files generated, the colour grading step, very time consuming, could be done directly from disk using software tools, or delayed until absolutely necessary. It is also estimated that the synchronisation of the Sepmag soundtrack should also be possible in software.

Hereafter is a set of draft performances required for such a scanner :

- Price tag should be significantly lower than existing telecine technology
- 35mm and 16mm (negative & reversal, colour and BW)
- should not lose frames
- robust to film shrinkage
- tolerant (stable) to splices (including less-than-perfect tape splices)
- robust to any punched edge marks (notches) (sync marks…)
- robust to damaged sprocket holes
- robust to tape in excess on edges at splices
- robust to twisting and curling
- HD output resolution or better (1920 x 1080)
- File output : 12 bits, or 10 bits with automatic dynamic range adjustment, or better
- Real-Time, or faster

Also desirable:

- 4th channel for detecting/storing/repairing defects : Infra-red or other
- optional optical sound playback
- optional robustness to kinescope Moiré

5.1.2. Tools for preservation of audio media

5.1.2.1. Requested tools for audio tapes

New magnetic head for auto-azimuth and auto-tracking.

Playing back 1/4 inch audio tapes using conventional audio machines require a careful adjustment of the head azimuth. Failure to do so results in high-frequencies losses. The current procedure for this operation is to play back a section of the tape, visualise on an audio vector scope the balance between the two channels, and adjust so that the vector view looks symmetrical. This operation is usually assisted by a spectral view of the audio contents, and the adjustment is made to maximise the high-frequencies content. On conventional playback decks, adjustment cannot be realised on-the fly. Some physical modifications of the playback heads can allow this operation on the fly, allowing an easier set-up before playback (but not during the actual transfer). Sometimes, because of a physical tape distortion, the azimuth is changing continuously, which renders high-quality playback virtually impossible.

New advances in magnetic tape playback can now allow reading tapes using much more than two tracks. If several narrow tracks are read on a conventional recorded stereo of dual-mono tape, it will be possible to obtain, directly from the recorded signals:

- The actual azimuth used for the recording
- The position and width of the tracks

These two data will be exploitable to re-regenerate, without any physical intervention, the audio signals, with azimuth and tracking adjusted dynamically.

This track is currently being explored by a PrestoSpace team composed of Hi-Stor and Reply.

Correction of wow and flutter defects.

It could be assumed that some tapes may suffer from wow and flutter effects due to mechanical instability of the recorder. GUT (Gdansk University of Technology) has developed some digital signal processing methods for wow and flutter defects restoration.

Two of them are based on the medium features analysis –the method for scanning power-line hum, and the method for tracking high-frequency bias. It is essential for the first method to analyse the digitised audio material disturbed with *pre-recorded* power-line hum. Therefore, any low-pass filtering should be omitted during digitisation process (the nominal frequency of power-line hum equals 50Hz in Europe and 60 Hz in the USA). Also high-class audio equipment should be involved to ensure that only negligible level of *newly generated* hum will be introduced to digitised audio material.

The second method for wow and flutter restoration is based on the high-frequency bias (HFB) tracking. Tracking of such a high frequency component in the signal's spectrum requires usage of a dedicated hardware interface, and employing A/D converters with high sampling rate (192 kHz) for digitisation.
Another drawback is the bandwidth of tape player's magnetic head. In practice, the nominal frequency of the HFB signal is about 100 kHz for ¼'' magnetic tapes. Usually, the bandwidth of the tape player's head is too narrow to reproduce the HFB signal. To overcome this problem the tape player's head should be replaced with for example a new opto-magnetic head like the ones used for auto-azimuth this will allow us to reach the 100 kHz bandwidth limit.

Unfortunately, due to the time influence, the HFB may have vanished in magnetic recordings or may not be present due to the original tape quality. In such a case, digitisation employing 192 kHz sampling rate will be unreasonable because this involve costly equipment and multiply four times the size of digital file and consequently the storage cost. It is very important to reserve such treatment to valuable content on a restoration chain. The operator has to determine if the HFB signal is present in the magnetic recording during audio tape selection to determine if wow and flutter correction could be possible and feed it to a restoration chain. It will be based on the spectral view mode of the audio content. Obviously, to obtain this feature, the spectral analyser should allow analysing the signal in an appropriate frequency range over the one usually possible with standard audio equipment.

According to the value of tapes affected by wow and flutter effects, we will have to adapt the transfer workflow and install the required equipments in the audio transfer chains in order to restore them.

5.1.2.2. Requested tools for audio disks

78-rpm disks currently require considerable effort from operators to transfer, because the operator needs to clean thoroughly the disk, ensure that the proper stylus is used, and that the stylus is in appropriate condition. Even in that case, the stylus damages the groove, which can make playback destructive. Cracked lacquer disks cannot be played currently.
Cleaning disks is a tedious and sometimes risky operation, since any hardly-visible crack (along a groove for example), renders the disk inappropriate for the use of liquids for cleaning and rinsing. Therefore, a careful examination of each disk is a pre-requisite for this operation.
In many cases, transferring one disk requires several complete passes, and then selecting and editing the best sections for the digital master: the first passes usually exhibit more plops and crackle, as they actually remove most of the dust, the later passes can present losses that reflect the (unrecoverable) damages to the disk due to the stylus.
Therefore, improvements to the robustness of the playback process to plops and crackle could result in immediate savings, because the cleaning effort could be reduced.
When considering one side of a 78-rpm disk hardly exceeds 3 minutes, any improvements in the handling, cleaning, and setting up steps, would be of immediate benefit.

Using optical methods would prevent exposing the unique records to the damage of inappropriate or damaged stylus, and result in much better playback. It is stated here, subject to feasibility studies, that such process would significantly improve the quality and the efficiency of 78 rpm to digital audio files transfers.

This track is currently being explored within PrestoSpace by a Research team from INA.

5.2. Services

5.2.1. A database to facilitate exchange of playback equipments

One of the major problems faced by institutions dealing with archive transfer is the availability of archive playback equipment.

Basically, it is imperative to have:

- Functioning playback equipment
- Spare parts for reparation and maintenance
- Technical specifications for production and maintenance

Old formats or those which had a “short active life” are very difficult to deal with, as one of the things listed above is often missing.

Most of times, technical managers are not able to easily find the needed elements.

However, as all those broadcast formats had an international diffusion, any missing part or information might be available abroad. We could then consider the drawing of a sort of list which inventories all available parts or technical specifications available from any member of PrestoSpace, where we could find all sort of things that are available for free, for rent or for sale. That list would need to be updated on a regular basis and available to members through a flexible medium such as Internet.

5.2.2. A pragmatic knowledge base for video tapes and troubleshooting.

As we all know, the main difficulty with magnetic tapes transfer is due to physico-chemical degradation and choking (clogging) of machines. Experience shows that those degradations do not affect all videotapes in the same way. Some brands, formats or batches from a particular manufacturer are more affected then others.

The creation of a database of all the information related to one particular batch (problems, solutions, best playback equipment…) would enable technicians to make a selection of potentially difficult elements and rationalise the operations of transfer:

That database could be fed by different sources:

- Manufacturers themselves with their own archives
- Dedicated research organisations
- Users (operators) after each transfer

The feeding of information will be faster and more exhaustive if it is done by every member of PrestoSpace. The use of the Internet could ease the updating and the use of that database. It could be a sort of forum, where all technical troubleshooting ideas are listed and inspired by the software developers FAQs for example.

5.2.3. Harmonisation of Levels of Service

As mentioned earlier in this document, the viewpoint of the Service Providers is that all potential customers are different and have different expectations with respect to the service they require from the provider.

This has consequences on the initial costs of setting up Service Level Agreements, as:

- The customer and the provider have to reach a common level of understanding
- They have to agree on the expected Service
- The Service Provider has to adjust his production tools to the expected Service
- Solving misunderstandings discovered at a later stage is often difficult and costly

Without overlooking the diversity of all the customers needs, these four steps have a considerable cost to both sides. Tools to help the customer and the provider to reach easily an agreement, based on some level of standardisation have to be considered.

It is suggested here that Reference Service Levels are defined, that will describe precisely a series of possible Service Levels for migration of media. These Reference Service Levels should define precisely:

- Statement of objective of the migration
- Status of the material
- Specifications of the material to be transferred
- Specification of tools for analogue to digital conversion
- Technical specifications of files, media, encoding standards
- Specification of bit error rate of resultant digital media (if applicable)
- Naming, labelling and packaging
- Technical specification of new media recorder(s)
- Processing of mechanical problems of original material
- Preservation process for difficult material
- Quality control before during and after transfer
- Specifications for transport and storage of material (including return delays)

These Reference Service Levels will be long documents, therefore it is suggested here that only two or three of them are defined for each kind of source media. These Reference Service Levels should then be used as references for the customer and the provider, in the view of progressing easily towards a Service Level Agreement. Ideally, the final Service Level Agreement should be only a slightly amended version of the Reference Service Level.

5.3. Workflow improvements

5.3.1. Archive films preservation workflow possible improvement

The highly manual nature of film preservation prevents its workflow from being fully automated. However, it may be improved to some extent. Within the following example, an additional link was added to the Figure 4-4, in order to allow deciding at the repair stage, whether the transfer can be run as 'one-light', or requires finer colour correction. Colour correction “alerts”, under the form of a preview list, can be collected at the final quality control of the repair stage and sent, as a metadata, to the transfer suite in order to facilitate colour correction.
The use, in the workflow, of the archive datacine (see 5.1.1.1), would allow us to be able to perform “faster than real time” transfers, and including a mpeg encoding would highly speed up the process. In addition, the datacine suite should allow the possibility of generating technical metadata.

Following is an example of improved film transfer workflow:

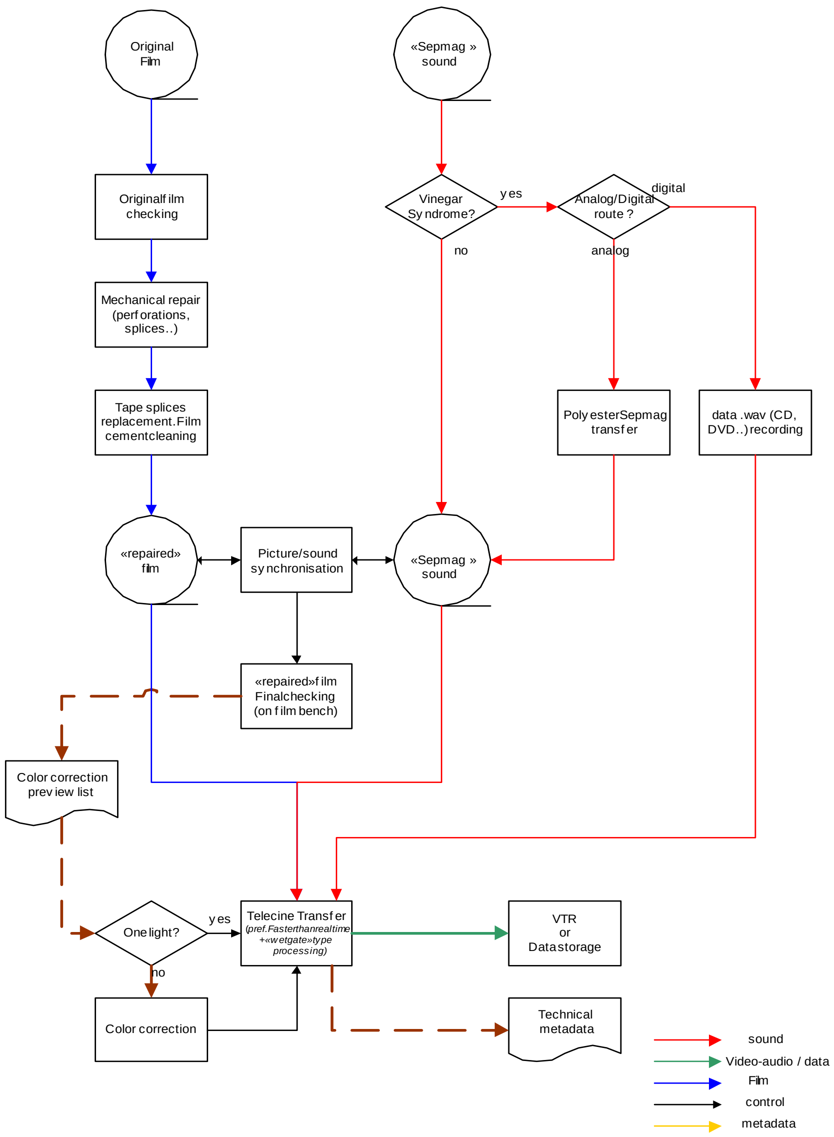


Figure 5-1: Possible film workflow improvements

6. Pitfalls

When attempting to optimise the preservation processes, it is also possible to fall into some pitfalls which will produce the opposite effect. We try here to identify some of them :

6.1. The All-Technology Pitfall

Difficult media are very often difficult by their diversity in terms of media condition, and also by the fact any kind of manipulation (sorting, checking, cleaning, loading, and unloading) must be made by hand. The temptation here is to try saving migration effort by trying do establish technological devices for replacing human manipulations and/or human expertise. It may work. But the risks are high that developing such devices may prove too complex, or that these devices, despite working, may actually not save time and money. The risks here are multiple:

- Identifying incorrectly the key points where effort could be saved: one could imagine a tool for automatically lacing audio tape for example. But it may not save time because an experienced operator does not spend considerable time doing this operation, or because he is also doing other operations simultaneously (checking tape condition for example).
- Setting up machinery that effectively saves time for one operation, but that shifts complex operation somewhere else in the chain. This could happen if no verification of the results is made by the machine.
- Solving only a sub problem: if the function of the machine is to care for a problem that only affects for one item out of 10, then it is not useful, and time-consuming to pass every item trough this process.
- Not being able of making a machine that properly works, unsupervised.
- Underestimating the variety of the item conditions, within one batch, and between batches. Variety within one batch will slow down the process if a good triage approach is not used. Variety between batches may easily render a whole chain inappropriate for next batch, and even if a triage approach is used, starvation or overload could happen on one chain or another.

On the other hand, significant improvements in the efficiency can be obtained using a non-technological track: a well-dimensioned and flexible workflow, standardisation in the procedures across different customers, triage approaches at a scale large enough to get over the variety between batches, appropriate level of expertise and clear instructions to operators, could result in significant savings.

6.2. Underestimating development and installation delays for the transfer chain

There are 3 main phases in the development of a migration chain :

- Phase 1: Objective definition. What do we want to achieve? What kind of media will the archives be saved on? What quality is needed? Which metadata? ...
- Phase 2: Investment plan, development and installation. Project management at different levels: facilities organisation costs; media costs; acquisition of playback and recording equipment; software development and human resources recruitment.
- Phase 3: Production – Beginning of transfers.

If the first phase is about dialogue between the preservation factory and the contracting authority, the preservation factory has the entire responsibility for the organisation of the second phase.
Although this phase is very important, duration and difficulties are usually under-estimated.
The preparation of this stage has consequences on major aspects of the entire project:

- Project duration
- Quality control
- Total cost

Service Providers very often estimate that managing this kind of project is only a sort of “copy and paste” of something that has been achieved for another institution. However, it is not that simple. The time needed to adapt software is not respected and technicians training can be unsatisfactory...

The points below are a sort of non-exhaustive checklist of things that should be verified before starting a transfer process:

- Definition of all the technical specifications: validation by both preservation factory and contracting authority
- Software development: Specifications, adaptation, tests and validation
- People training
- Equipment inventory – State and availability, acquisition of spare parts
- Definition of production and quality control processes
- Designation of a project management team
- Evaluation of storage space needed / available

There is a natural tendency to focus on what we can do and avoid talking about what we can’t do. It happens frequently that one or several points from the list are not considered during the preliminary phase.

Any of the points listed above which are not taken into account might have heavy consequences both on costs and on Service Levels.

6.3. Under-specification and over-specification of the final result

One of the obligations of the "preservation factory" will be to seek an optimal productivity in order to keep the cost of preservation as low as possible and to ensure the processing of the required volumes. Quality constraints need not be neglected. It is the archive's responsibility to define with precision these various parameters. The archive must seek to avoid two main pitfalls: «under-specification" and "over-specification" of the results.

To "under-specify" means, for example, not to specify the type of MPEG encoder to be used and not to fix the encoding parameters to be applied for a digitisation. It can also be not to specify if the transfer of a film must be carried out with or without scene to scene colour correction, or not to fix thresholds at beyond which a program will not have to be preserved within the framework of an industrial process setup, etc... Under-specifications may generate frequent disputes and rejections of work.

"Over-specifying" the results may reduce the productivity of the "preservation factory" to a scale where its objectives can not be reached. One example of "over-specification" is when too narrow audio level tolerances are fixed for the preservation of 1/4" tapes or when it is specified that every splice must be replaced during a process of film physical repair.

7. Conclusions

To optimise media transfer, identifying key points where effort could be saved must be the first priority. Sorting the simple from the difficult is at least as profitable as to having new tools. In fact we need less the new tools than new approaches and methods which permit significant improvements of the efficiency. The concepts of ‘collection map out’ and ‘workflow triage and selection’ must be applied first, followed by the parallelisation of operations and before searching any automation solution. Doing an appropriate training of operators should be also very useful with the help of a ‘knowledge base’ to feed the right media to the right transfer chain or to a pre-process. A fine tuning of the workflow should also be profitable to avoid backward loops and to maintain feedback to the triage and selection steps. Finally simple automation system or/and new technology to reproduce the media can sometimes be used.
By doing this in the right order, one should be able to maximise number of collection’s items treated while maintaining a reasonable cost.

Despite this short study does not cover all the aspects of the migration of difficult media, we hope that it will usefully complement the D13.1 PrestoSpace Deliverable (‘Planning for digitisation and access’) about business case and estimations of costs that these documents will become the references guides for anybody that have to plan a media-transfer project.

8. Glossary

Term	Description
CTL	CTL - Control Track Longitudinal : one of the oldest way of maintaining a time reference on a video tape. Unlike actual timecode, CTL only allows to determine positions on the tape by counting the number of pulses forward or backwards. The reference point inevitably changes when the tape is unloaded of the VTR switched off.
Difficult Media	Media that are *as collections*, time-consuming and expensive to migrate, and that exist in amounts significant enough that devising improved processes can be profitable. Open reel media or audio disks are good examples.
DOC	'Drop Out Compensator': the video tape technology is prone to short losses of signal due to dust or tape problems (drop-outs). To make these faults less visible to the eye, the drop-out concealment devices replaced the lost signal by the signal from the previous line, or the 2nd previous line (SECAM).
Exception	In the Audiovisual preservation domain : designates cases where a migration chain cannot process an item because of unexpected difficulties due to the media. To maintain the productivity, within a Preservation Factory, exceptions should be limited by the use of a prior Triage mechanism.
Kinescope	Kinescope or film recordings : Early TV programs could not be recorded on VTRs, because these devices did not exist, or because of the price of video tapes. The only way of keeping an archive of the broadcast programmes was to record them on film, using a CRT and a film camera.
LTC - Longitudinal Time Code	A time of time code which is written on a specific longitudinal track of a video tape. Very reliable at nominal speed.
Migration Batch	A set of programmes or items stored on analogue media that are prepared and delivered to a Preservation Factory for migration, associated with the relevant metadata.
Molecular Sieves	Molecular sieves are (in the Audiovisual domain) packet of chemical compounds that act as absorbers of acetic acid and moisture. They are believed to delay the 'Vinegar Syndrome' if placed within film boxes and replaced often enough.
Open Reel	Reel-to-reel or open reel tape recording refers to the form of magnetic tape recording in which the recording medium is held on a reel, rather than being securely contained within a cassette. In use, the "feed reel" containing the tape is mounted on a spindle; the end of the tape is manually pulled out of the reel, threaded through mechanical guides and a recording head assembly, and attached to the hub of a second, initially empty "take-up reel."
Pre-selection	The process, usually run by Archives, that consist of selecting the items or programmes to be migrated, and setting up priorities for the order in which migration has to be performed.
Preservation Factory	Facilities where massive A-to-D migration of audiovisual contents is performed
PrestoSpace Factory	Generic term for designating facilities that are one or more of the following : Preservation Factory, Restoration factory, MAD Factory.
Reference Service Level	A comprehensive and agreed definition of what a Service Provider or a Factory should deliver to a customer. It is expected that the PrestoSpace project will deliver a set of pre-defined Reference Service Levels that should give customers (Archives) and providers (Factories) a common language, and come easily to a Service Level Agreement, if possible. Each of the Reference Service Levels will list not only the source and destination carriers and formats, but also the levels of quality, procedures for quality controls, delivery procedures, amounts, delays, number/duration of attempts before giving up on one item/batch, metadata to be exchanged in both directions, level of restoration/documentation if any...
Restoration Factory	Facilities where massive digital restoration of audiovisual contents is performed.
MAD Factory	Facilities where massive documentation of audiovisual contents is performed.

Reversal	Positive film, used directly for news gathering, or TV productions.
Service Level Agreement	A comprehensive and agreed definition of what a Service Provider or a Factory has to deliver to a customer. This Service Level Agreement should ideally be defined based on one of the pre-defined Reference Service Levels proposed by the PrestoSpace project.
Service Provider	A commercial company providing digitisation, migration, restoration, and/or documentation services to customers (Archives). Service Providers are good candidates to be the first Preservation/Restoration/MAD Factories. Some partners in PrestoSpace? (Vectracom, Centrimage, NOB, ST Hamburg), were already Service Providers at the time of PrestoSpace kick-off.
Sepmag	Sep(arate) Mag(netic Track) - A film or television programme for which the sound is recorded on separate magnetic perforated material (16mm, 35mm) and run in synchronism with the picture. By extension, the separate magnetic perforated material itself. Due to the catalytic power of oxide, Sepmag materials are much more affected by Vinegar Syndrome than acetate picture materials.
Technical Metadata	Metadata that are generated during the migration process. These include reports automatically generated by playback equipment and measurement tools, as well as any other input filled in by operators in the Preservation Factory.
Timecode	Time code - a reference to chronological time put on one of the tracks of videotape to aid in finding frames during editing. Time codes mean that one does not have to rewind the tape to the very beginning and fast forward to a time value but instead can advance to that point from any starting point. However, the technology allow discontinuities, duplications, and jumps in time codes along a tape, which may results in errors.
Triage	In the Audiovisual domain : designates the working position where it is decided, item per item, based on simple visual cues and other guides, the processes (migration chains) that will be affected to each item, in a view of making the best use of the available resources.
Vinegar Syndrome	Safety motion picture film is almost always made of cellulose acetate plastic. A key issue in preserving this type of film is controlling the form of decay known as "vinegar syndrome." The symptoms of vinegar syndrome are a pungent vinegar smell (hence the name), followed eventually by shrinkage, embrittlement and buckling of the gelatine emulsion. Storage in warm and humid conditions greatly accelerates the onset of vinegar syndrome. Once it begins in earnest, the remaining life of the film is short because the decay process speeds up as it goes along.
VITC - vertical interval time code	A time of time code which is written on two lines of each video field, outside of the normal displaying area. Very precise at low speed, cannot be read at high speed.