Dietrich Schüller

Keep Our Sounds Alive: Principles and Practical Aspects of Sustainable Audio Preservation
(including a glance on video)

Part 2
Signal Extraction from Original Carriers
Based on IASA-TC 04
With Contributions by Nadja Wallaszkovits

Workshop at Inforum 2016
Prague 23 May
Generally accepted principle for audio preservation since 1990, upcoming for video:
• all audiovisual carriers are prone to decay
• all audiovisual systems are threatened by obsolescence
• long term preservation can only be achieved in the digital domain by subsequent migration
• analogue and digital contents must be extracted from originals, analogue converted to digital, and both to file formats
• transfer is time consuming and expensive, and unlikely to be done again
consequently:
• original signals must be extracted and transferred in the best possible quality
Extraction/transfer parameters

- selection of carrier
- cleaning, carrier restoration
- replay equipment
- speed
- replay equalisation
- correction for errors caused by misaligned recording equipment
- removal of storage related signal artefacts
- time factor
Audio
• Historical mechanical formats
• Standard coarse groove discs
• Microgroove discs
• Magnetic tapes
• Digital magnetic carriers
• Optical carriers

Summarising comments on video
Historic mechanical and other obsolete formats
- cylinders
- coarse groove replicated discs
- all instantaneous discs
- selenophon
- magnetic wire

Except for standard coarse groove replicated discs seek expert’s advise - contact IASA Technical Committee:
http://www.iasa-web.org/

Coarse groove replicated discs ("shellacs", 78 rpms, pre 1900 - ~mid1950s)

Acoustically recorded: contact experts
Electrically recorded (=standard): from ~1925
Electrically recorded (standard) coarse groove discs

Selection: find best copy – also outside own collection

Cleaning: ultrasonic vs. “Keith Monks” et al. cleaning agents: distilled water plus wettning agent – NO alcohol

Restoration: no chemical, many mechanical problems

Replay equipment: professional /Hi-Fi equipment market stable

Pick-up systems: magnetic (stylus selection crucial), laser (upcoming), imaging (experimental)
Speed: correct in the analogue domain

Equalisation: recording frequency response is not flat on discs – many different equalisations needed
Consult IASA-TC 04

Correction for objective errors, and
Removal of storage related signal artefacts: do not apply

Time factor: 3-5x and more, depending on record condition and need for cleaning
Microgroove discs (LPs, vinyls)

**Selection:** find best copy – also outside own collection

**Cleaning:** ultrasonic vs. “Keith Monks“ et al. cleaning agents: distilled water plus wetting agent, isopropyl alcohol

**Restoration:** few chemical, (possible interaction with plastic bags): many mechanical problems

**Replay equipment:** professional /Hi-Fi equipment, market stable

**Pick-up systems:** magnetic, dynamic, laser (exotic)
**Speed:** correct in the analogue domain

**Equalisation:** RIAA – check pre-amplifier for accuracy

**NB:** pre1960 LPs may need different equalisation – consult IASA TC-04

**Correction for objective errors,** and

**Removal of storage related signal artefacts:** do not apply

**Time factor:** 2-3x and more, depending on record condition and need for cleaning
Magnetic tape

Selection
- applies to replicated cassettes and tapes (rare) only

Cleaning
- removal of dirt: dry, water, solvents
- removal of dry and bleeding splices
- replacement of leader tapes

Carrier restoration
- partly successful: curing tapes suffering from pigment binder breakdown
- available soon: re-conditioning of brittle acetate tapes

Do NOT lubricate tapes without special advice
Replay equipment
- recording and replay distortions do not compensate, but multiply each other
- choose equipment of latest generation to minimise replay distortions
- equipment must fully comply with format specific parameters: speed
  track width
  equalisation (EQ)
  noise reduction system (NR)

Problem of ever increasing dimension:
Availability of high quality equipment and spare parts
Various quarter inch tape track formats:

- Vollspur
- Halbspur Mono
- Halbspur Amateur-Stereo
- Viertelspur

1. Vollspur
2. Halbspur Mono
3. Halbspur Amateur-Stereo
4. Viertelspur

- 1/1 Spur Vollspur
- 1/2 Spur Mono-Halbspur
- 2/2 Spur Stereo-Halbspur
- 2/4 Spur Viertelspur

Dimensions:
- 6.3
- 2.3
- 2.0
- 1.7
- 2.3
- 1.0
- 1.0
- 0.75
- 0.75
- 1.75

Signal Extraction
Butterfly head – professional stereo 2 x 2.775mm

Recording and replay heads must have the same track width. Any differences cause losses in signal-to-noise ratio, if not an inseparable mix of unrelated signals.
Compact cassette formats

mono

stereo
S/N vs track width

![Graph](image)

- **S/N** vs **track width** graph showing the relationship between signal-to-noise ratio (S/N) and track width. The graph plots the ratio of RG to RG\textsubscript{min} against track width in millimeters (mm).
Equalisation

Recording frequency response is not “flat” on tapes
• different norms CCIR (IEC) vs NAB
• different for speeds
• historical EQs

Replay frequency response must compensate recording curve
Correct equalisation difficult to assess if unknown
Equalisation curves for various consumer tape formats

- **Equalisation curves** for various consumer tape formats are shown in the diagram.
- The curves represent different tape formats and their equalisation properties.
- The diagram includes points for specific delays and equalisation levels.
- The axes are labeled with frequency (Hz/kHz) on the x-axis and equalisation (dB) on the y-axis.
- The curves indicate how the equalisation changes with frequency for each format.
- The formats are identified by specific points and labels, such as **BP19**, **BP9.5**, and **BP4.75**.
- The equalisation levels are marked for different delay times, such as **3180 + 50 μs a**, **3180 + 90 μs b**, **3180 + 70 μs c**, and **3180 + 120 μs d**.
- The diagram uses a graph to illustrate the relationship between frequency and equalisation for each format.
## Tape equalisations including historical EQs 1

<table>
<thead>
<tr>
<th>Tape Speed</th>
<th>Standards Organisation</th>
<th>Year of Publication</th>
<th>Time Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 ips, 76 cm/s</td>
<td>IEC2 AES</td>
<td>(1981) current standard</td>
<td>$\infty$</td>
</tr>
<tr>
<td>30 ips, 76 cm/s</td>
<td>CCIR IEC I DIN</td>
<td>(1953-1966)</td>
<td>$\infty$</td>
</tr>
<tr>
<td>15 ips. 38 cm/s</td>
<td>IEC I CCIR DIN BS</td>
<td>(1968) current standard</td>
<td>$\infty$</td>
</tr>
<tr>
<td>15 ips. 38 cm/s</td>
<td>NAB EIA</td>
<td>(1953) current standard</td>
<td>3180 $\mu$s</td>
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</table>
### Tape equalisations including historical EQs 2

<table>
<thead>
<tr>
<th>Speed</th>
<th>IEC 1</th>
<th>IEC 2</th>
<th>(1968) current standard</th>
<th>(1965) current standard</th>
<th>(up to)</th>
<th>(up to)</th>
<th>(up to)</th>
<th>70 µs</th>
<th>50 µs</th>
<th>100 µs</th>
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</thead>
<tbody>
<tr>
<td>7 1/2 ips, 19 cm/s</td>
<td>DIN (studio)</td>
<td>DIN (home)</td>
<td>1965</td>
<td>3180 µs</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>CCIR</td>
<td>EIA</td>
<td>1966</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td>RIAA</td>
<td>(1963)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(1968)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>7 1/2 ips, 19 cm/s</td>
<td>IEC 2</td>
<td>Ampex (home)</td>
<td>(1967)</td>
<td>∞</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50 µs</td>
<td></td>
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<tr>
<td></td>
<td>NAB</td>
<td>EIA (proposed)</td>
<td></td>
<td></td>
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<tr>
<td>7 1/2 ips, 19 cm/s</td>
<td>CCIR</td>
<td>IEC</td>
<td>(up to 1966)</td>
<td>∞</td>
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<td>(up to 1968)</td>
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<td></td>
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<td>BS</td>
<td>(up to 1965)</td>
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### Tape equalisations including historical EQs

<table>
<thead>
<tr>
<th>Speed</th>
<th>System</th>
<th>Standard</th>
<th>Impedance</th>
<th>$Z_{in}$</th>
<th>$Z_{out}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3⅓/4 ips 9.5 cm/s</td>
<td>IEC2</td>
<td>(1968) current standard</td>
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<td>3180 μs</td>
<td>90 μs</td>
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<td></td>
<td>NAB</td>
<td>(1965)</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>RIAA</td>
<td>(1968)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3⅓/4 ips 9.5 cm/s</td>
<td>DIN</td>
<td>(1962)</td>
<td>3180 μs</td>
<td></td>
<td>120 μs</td>
</tr>
<tr>
<td>3⅓/4 ips 9.5 cm/s</td>
<td>DIN</td>
<td>(1955-1961)</td>
<td>∞</td>
<td></td>
<td>200 μs</td>
</tr>
<tr>
<td>3⅓/4 ips 9.5 cm/s</td>
<td>Ampex (home)</td>
<td>(1967)</td>
<td>∞</td>
<td></td>
<td>100 μs</td>
</tr>
<tr>
<td></td>
<td>EIA (proposed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3⅓/4 ips 9.5 cm/s</td>
<td>IEC</td>
<td>(1962-1968)</td>
<td>3180 μs</td>
<td></td>
<td>140 μs</td>
</tr>
<tr>
<td>3⅓/4 ips 9.5 cm/s</td>
<td>Ampex</td>
<td>(1953-1958)</td>
<td>3180 μs</td>
<td></td>
<td>200 μs</td>
</tr>
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</table>
## Tape equalisations including historical EQs 4

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>15/16 ips 2.38 cm/s</td>
<td>undefined</td>
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</tr>
</tbody>
</table>
Noise reduction systems
• Dolby A - professional
• Dolby SR - professional
• Dolby B consumer - Compact Cassettes
• Dolby C consumer - Compact Cassettes
• Telcom C4 - professional
• Hicom consumer – Compact Cassette
• dBX – (semi) professional

Encoded tapes must be appropriately decoded –
Problem: Noise reduction system difficult to determine if unknown – best indicator: steady background hiss
Imperative *before* replay of originals

- compensation for misaligned recording heads - azimuth error, vertical head position
  
  _use magnetic suspension to check track width and vertical head position_

- removal of storage related signal artefacts - print through
  
  _wind tapes in the fast wind mode 3 or more times to minimise print through_

Both corrections impossible once signal has been transferred to another carrier!
Head and tape path adjustments

Azimuth: head gap 90° to tape movement

Vertical head position

Inclination

Tangential adjustment

Tape tension

Bandandruck

Tangential-einstellung
2x2mm stereo head from a semi-professional recorder

Note: mal-produced head and multiple misalignment of original mounting
Magnetic powder to make tracks visible
Minimisation of print through

Rewind tape in fast wind mode at least 3 times before reply

Print through also affects linear audio tracks of video tapes, but not the video signal or any digital signals.
Transfer of digital audio contents from streaming (EIAJ, R-DAT) to file formats

• 3-tier error correction: full – interpolation – muting
• transferred signals must (should) be free of interpolated errors
• tape path adjustment and/or cleaning may considerably improve error rate
• check error status and keep a record of unavoidable interpolations
Time factor (technical transfer only) for one operator:

Classical scenario for magnetic tape - fairly uniform and technically regular holdings: 3x
(1 hour of analogue original needs 3 hours of work)

“Factory” transfer in broadcast archives: much faster – 1 operator runs 3-4 transfer stations
• high investment in equipment, for highly uniform holdings only
• generally unsuitable for heritage collections
3x and more for:

- analogue tape (heritage) holdings in NSAs and ResSA
- historical digital formats (EIAJ)

Additional time element: transfer of metadata
Optical carriers

**Selection** for replicated CDs/DVDs as for LPs

**Cleaning and restoration** with greatest care only, accompanied by error testing before and after work

**Selection of replay equipment** less important than with analogue originals, may, however, influence retrievability of –R and –RW disks

**Speed, equalisation, correction for errors caused by misaligned recording equipment, and removal of storage related signal artefacts** do not apply
Time factor

CDs and DVDs can be transferred at higher speeds than real time

Be **careful**, however: check consistency of error correction at higher transfer speed
Video signal extraction: specific problems 1

**Tape cleaning:** crucial element for heavily used tapes – cleaning machines for several formats available

**Replay equipment:**
- variety of television standards: SD: Historical b/w, NTSC, Secam, PAL – variety of HD standards
- vast number of historical obsolete formats
- variety of different versions within one format, e.g. U-Matic: LB, HB, SP
- variety of different sound representations within one format
- rapidly shrinking market
Video signal extraction: specific problems 2

High level technical expertise needed to maintain and adjust replay equipment – hire retired television engineers as consultants

Improved signal retrieval from composite formats by direct component extraction possible – implementation, however, not yet available for all formats
Digital video target formats: Television archives practice vs archival principles:

In the past, TV-archives generally transferred analogue and linear digital holdings to data reduced (“compressed”) production formats, e.g. DigiBeta or MPEG-50 formats.


Research archives pioneered, followed by national and television archives.
Outsourcing

• originating from North America, outsourcing of archival services has become widespread standard
• commercial companies must comply with archival standards, such as IASA-TC 03, 04, etc.
• general problem of commercial services: professional control
Summary general

• signal retrieval from original carriers determines the quality for the rest of a document’s life
• employ all skills at a given time to retrieve signals at best possible quality
• transfer technology may improve, digital storage capacities will increase, and expectations will rise accordingly, therefore….

…keep the originals whenever possible – you may wish to come back!
IASA Technical Committee
Standards, Recommended Practices and Strategies

http://www.iasa-web.org/

Juha Henriksson & Nadja Wallaszkovits: Digitisation workflow for analogue open reel tapes
http://www.jazzpoparkisto.net/audio

Franz Pavuza: Short Guidelines for Video Digitisation, 2008
http://www.tape-online.net/Short_Guidelines_Video_Digitisation.pdf

IASA-TC 06: Guidelines on the Production and Preservation of Digital Audio Objects, ed. by Kevin Bradley (forthcoming)
Thank you!

dietrich.schueller@oeaw.ac.at
www.pha.oeaw.ac.at