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fiaf JTS

Supervision of Analogue Signal Paths in Legacy Media Migration Processes using Digital Signal Processing

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Joint Technical Symposium
DIGITAL CHALLENGES
AND DIGITAL OPPORTUNITIES IN
AUDIOVISUAL ARCHIVING

Motivation

- The deterioration of the carriers, the obsolescence of the playback devices and the disappearing expertise in old media practice, dictate that we have to be more efficient in migrating our audiovisual heritage.
- We have to generate digital preservation files, which must replace the physical carrier for all future use. So, we have to ensure, that the loss on information between the physical carrier and the surrogate file, is minimised.

New technology promises to help solving the trade-off between migration efficiency and media quality assurance.

- Today I would like to like to share with you three full automatic quality assessment methods and I will compare the advantages, as well as limits of each method.
- I also would like to share with you results and best practice of huge migration projects all over the world

Motivation

How can a quality measurement help us in a mass migration process?

Old archive carriers will have artefacts,usually.

To know which defects, are on which position, is fine. This information should go to a quality report.

But even more important for an archive transfer is:

- If the quality is poor, how do you know, whether it is the physical media, or the playback device, which is just degradating you sound?
- Is the signal retrieval within the specified tolerance of the used playback device?
- Are there any transfer errors (static or dynamic)?
- Can I detect, whether the original carrier was produced standard conform?
- Are there media aging effects that forbid playing that carrier right away?
- Is your current collection homogeneous enough to be migrated in a mass transfer?

Significant steps on the way to an archive file

- Live Signal
- Recording
- Emphasis-Filter
- Analog Carrier
- Deemphasis-Filter
- Analog Chain
- AD-Converter
- Digital Chain
- Archive File

usage

aging

signal retrieval

analog processing

conversion to PCM data stream

conversion to File Format

Supervision of Analogue Signal Paths in a Media Migration Process

analogue security gap!

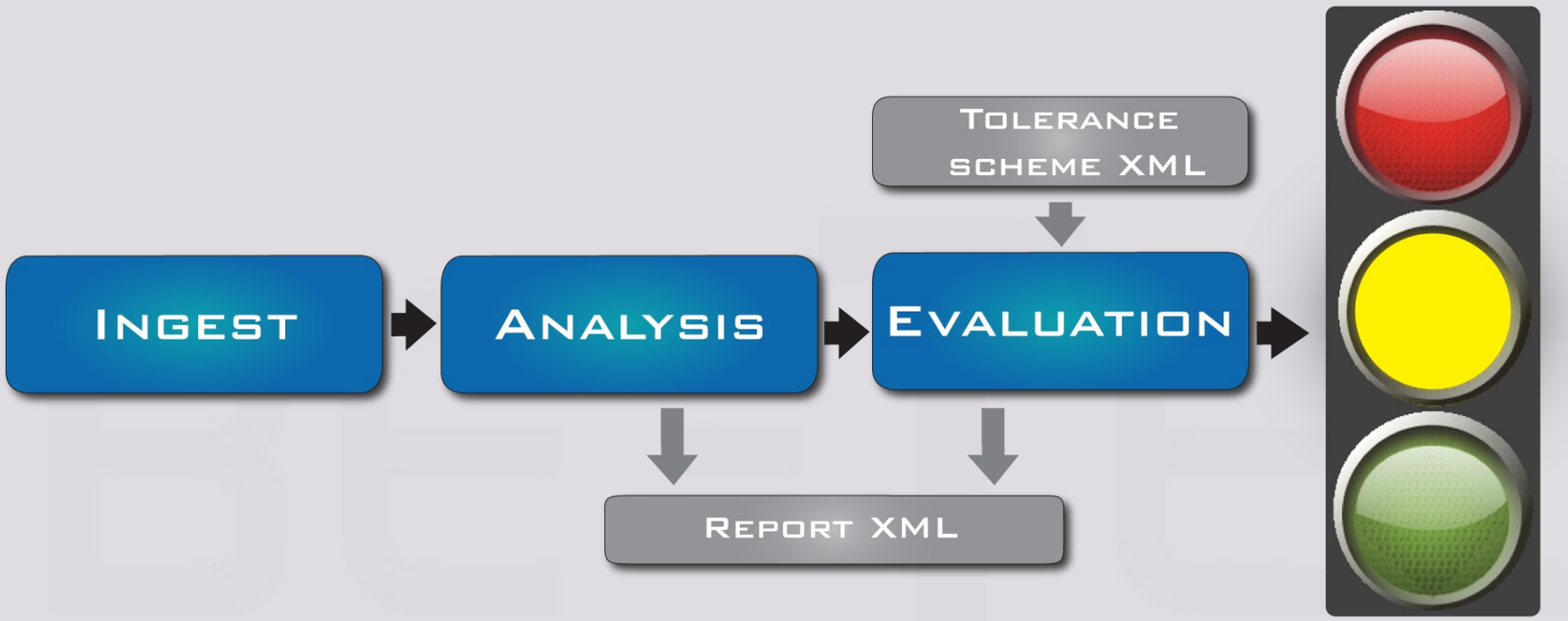
the data integrity should be secured with a hash code

QUALITY METRICS -1

- Non-Reference-Based Measure

Blind Error Detection

QUALITY Metrics - Single-Ended Error Detection -1

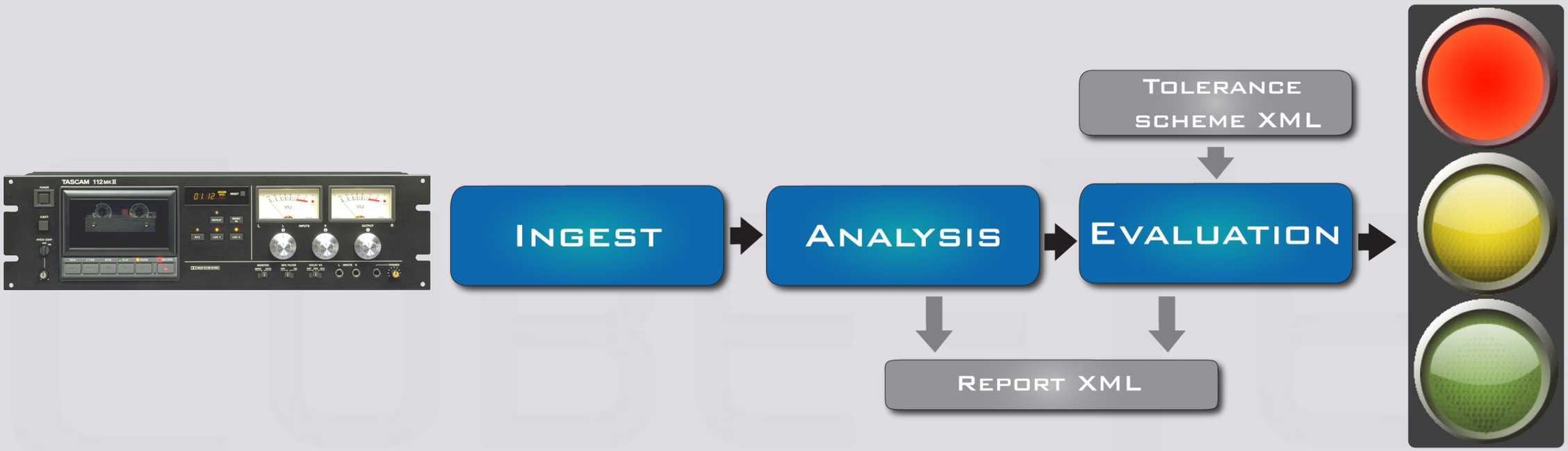


- **Single-ended error detection is a non-reference measure (also called blind detection). It is an objective quality assessment method.**
- **It uses a Single Stimulus and provides Continuous Quality Evaluation (SSCQE).**

Analysis

Audiofile-Inspector (QUADRIGA / Dobbin Processor)

QUALITY Metrics - Single-Ended Error Detection -1



- Single-ended error detection is a non-reference measure (also called blind detection). It is an objective quality assessment method.
- It uses a Single Stimulus and provides Continuous Quality Evaluation (SSCQE)
- This technology can be used in parallel for throughput optimization and it is scalable up to a preservation factory approach.

ANALYSIS

Audiofile-Inspector (QUADRIGA / Dobbin Processor)

Blind error detection is an established technology

(I have presented a similar slide already 10 years ago at JTS 2000 in Paris)

Analog born errors

- Clicks and Crackles
- Buzz / Hum
- Analog Drop-out
- Noise floor
- DC-Offset (Direct Current Transmission)
- Maximum Level
- Azimuth
- Correlation
- Bandwidth
- Dynamic
- Average Level
- Balance

Digital born errors

- Drop-outs
- Digital Overs
- Clicks
- (Digital Zeros)

Content Classification

- Modulation On-OFF detection,
- Pauses in modulation
- Stereo / Mono detection
- Speech / Music detection
- Strange sound detection
- Alignment tone detection

QUALITY Metrics - Single-Ended error detection -3

This family of Quality Metrics uses **a priori knowledge** to define a pattern signal, which has to be detected within the analysed signal. Pattern recognition methods and neural network can be used for that.

How it works: Define a pattern for each type of error event to detect.

Find a signal transformation, where the pattern of the error signal is clearly discriminated from all other modulation in the analysed signal.

(After a perceptual based signal transformation the discrimination often works most robust)

If the measure not works perfectly, you will have two types of mis-identifications:

- False Positives (method detects an error pattern, but there is non)
- False Negative (there is an error pattern, but the method can't find it)

The Non-Reference measure works best, if:

- the error pattern is clearly to define and has a low variance
- the error pattern divers strongly from the analysed signal

Non-Reference quality metrics

Strength:

- It helps to streamline the migration workflow, as it points the operator to critical segments in the analysed signal.
- it adds no additional work to the operator

Weakness:

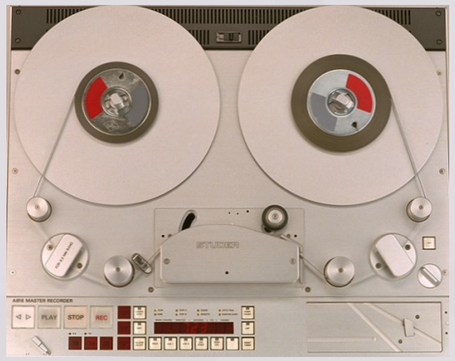
- low sensitive measure
- False Positives / False Negative
- Not very predictable
- Quality of Measure is dependent on analysed signal

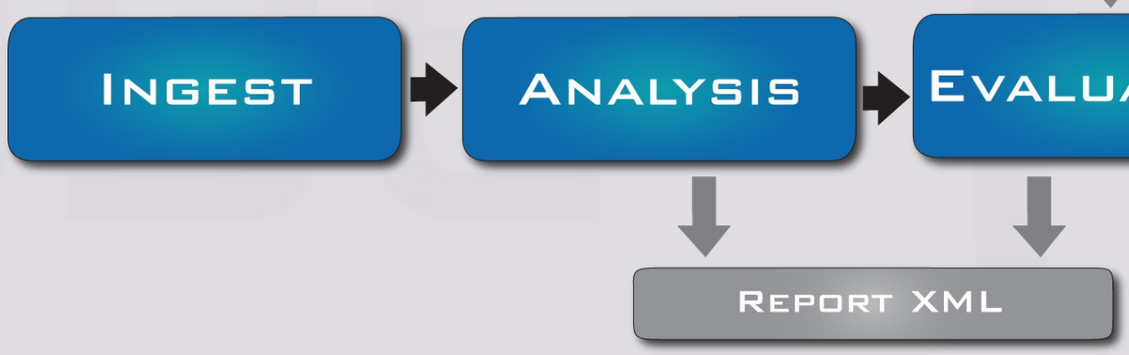
QUALITY METRICS -2

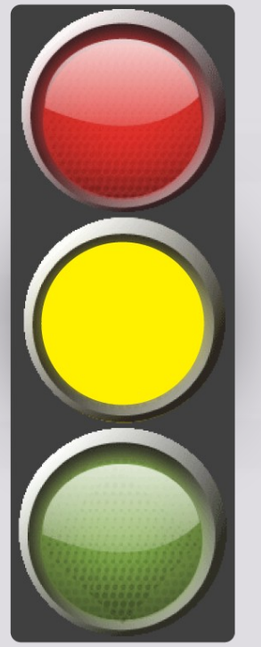
- Reference-based Measure

Using Double Ingest

Reference-based QUALITY Metrics - Assessment using multiple ingests

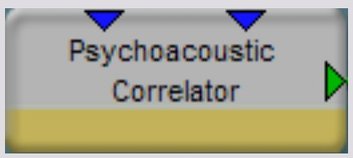






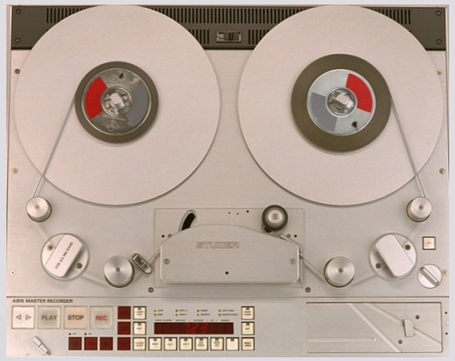
- Automatic signal verification using multiple ingests of the same physical media

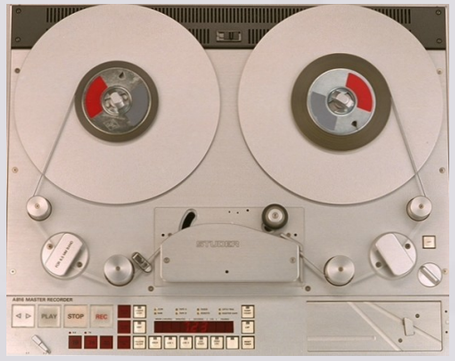
- Phase sync speed compensation
- Level compensation

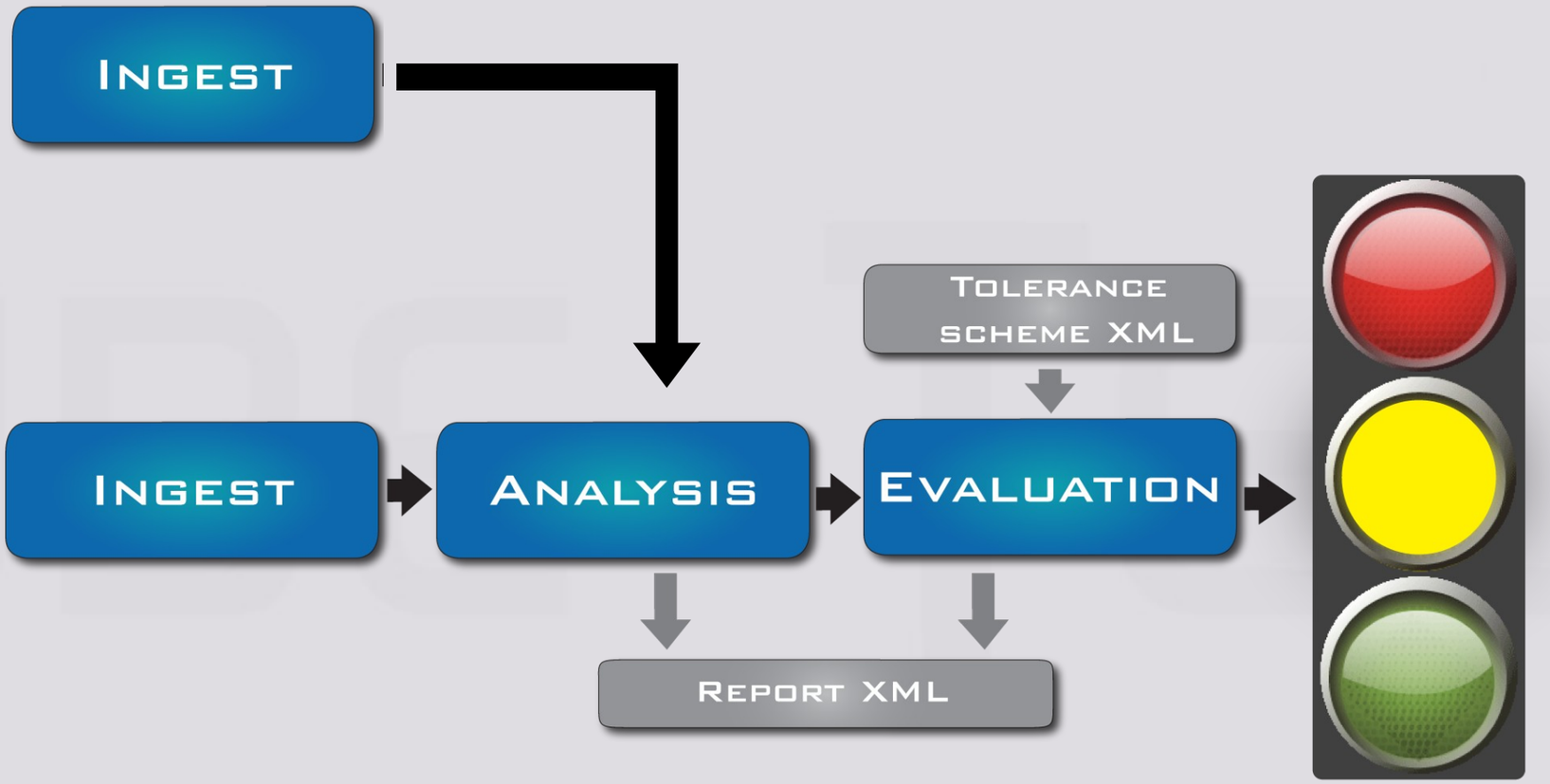


Psychoacoustic Correlator (Dobbin Processor)

Reference-based QUALITY Metrics - Assessment using multiple ingests







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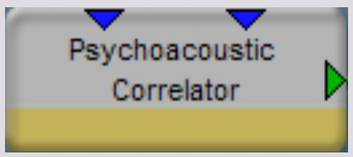

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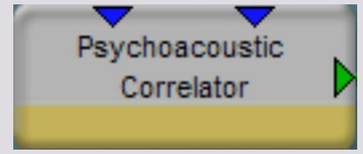


Reference quality metrics

Strength:

- great discrimination between transfer errors and media error (ends guesswork)
- immediate feedback on transfer problems
- great tools to optimize the analog signal path (it helps you to learn much about your playback hardware - it replaces uncertainty and doubt with measuring result)
- detects even small temporary interspersions (for example: from electromagnetic interference)

Weakness:

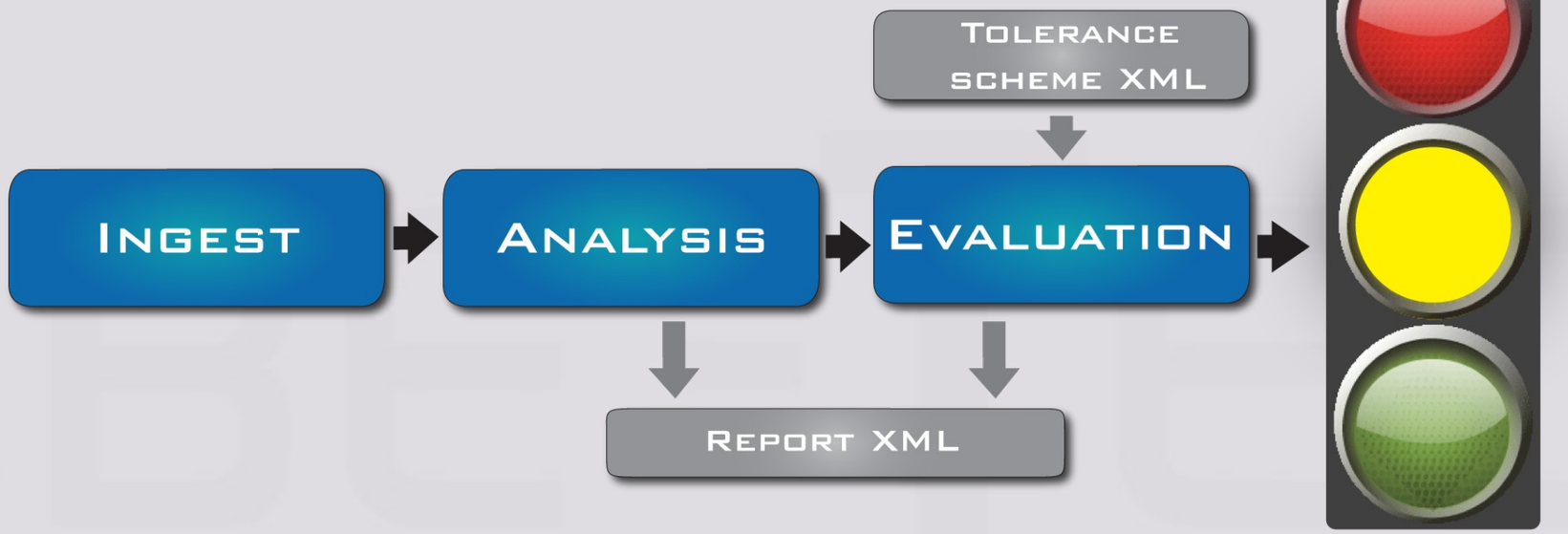
- Huge overhead to ingest analog carrier twice

QUALITY METRICS -3

- Reference-Based Measure

  Using a Calibration Media

Reference-based QUALITY Metrics - Assessment using a Calibration Media



- **Reference-based measure using a mathematically well-defined signal.**
- **A standard conform measure, fully automated supervision of playback machine alignment.**

ANALYSIS

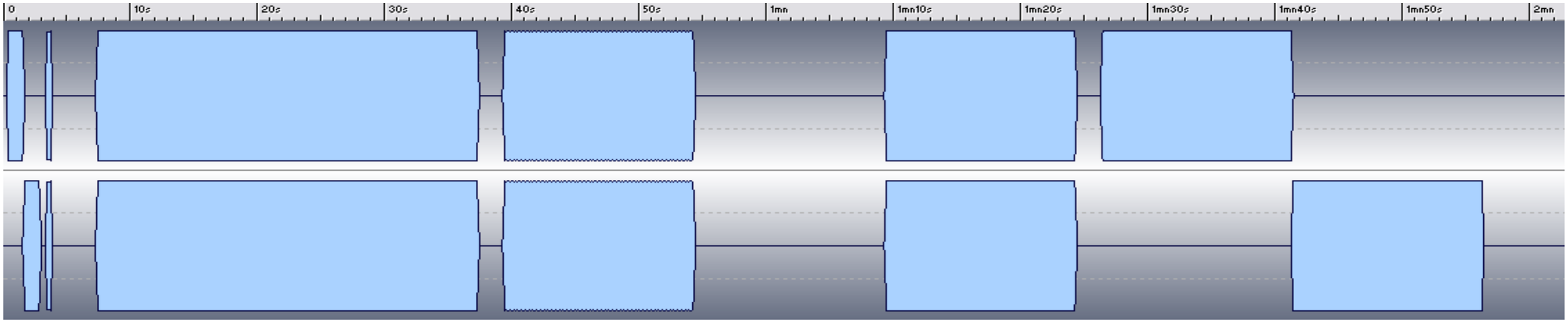
Calibration-Inspector

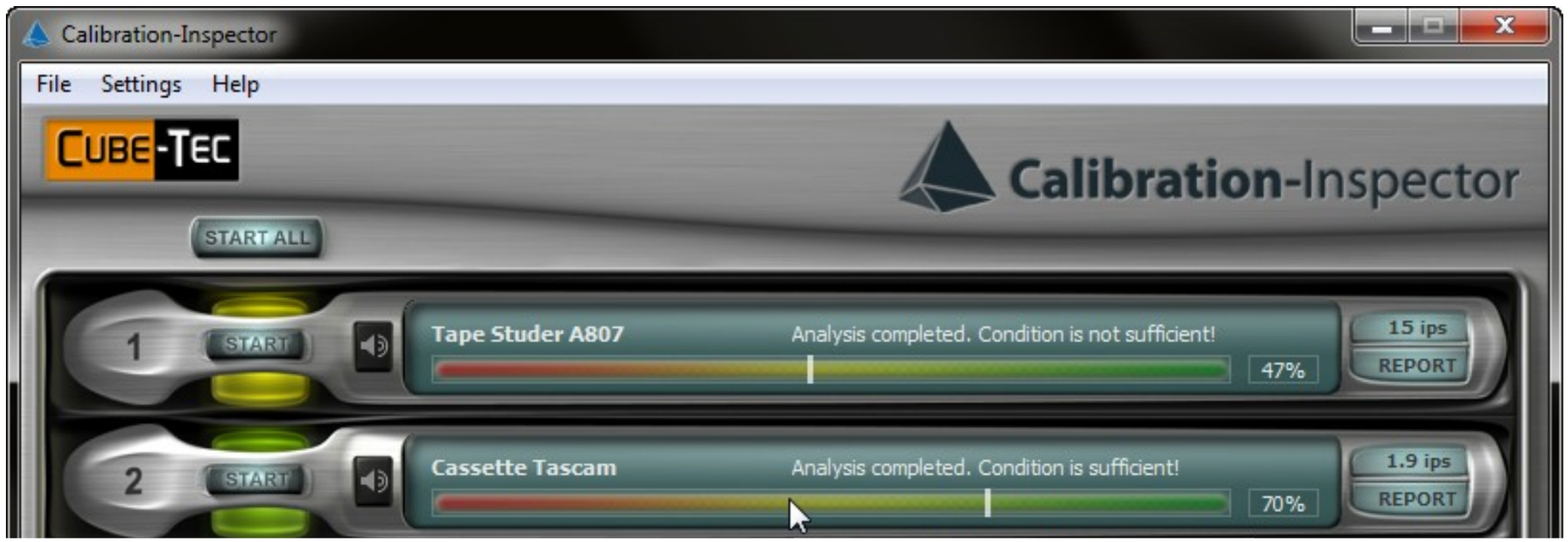
CUBE-TEC

Calibration Media

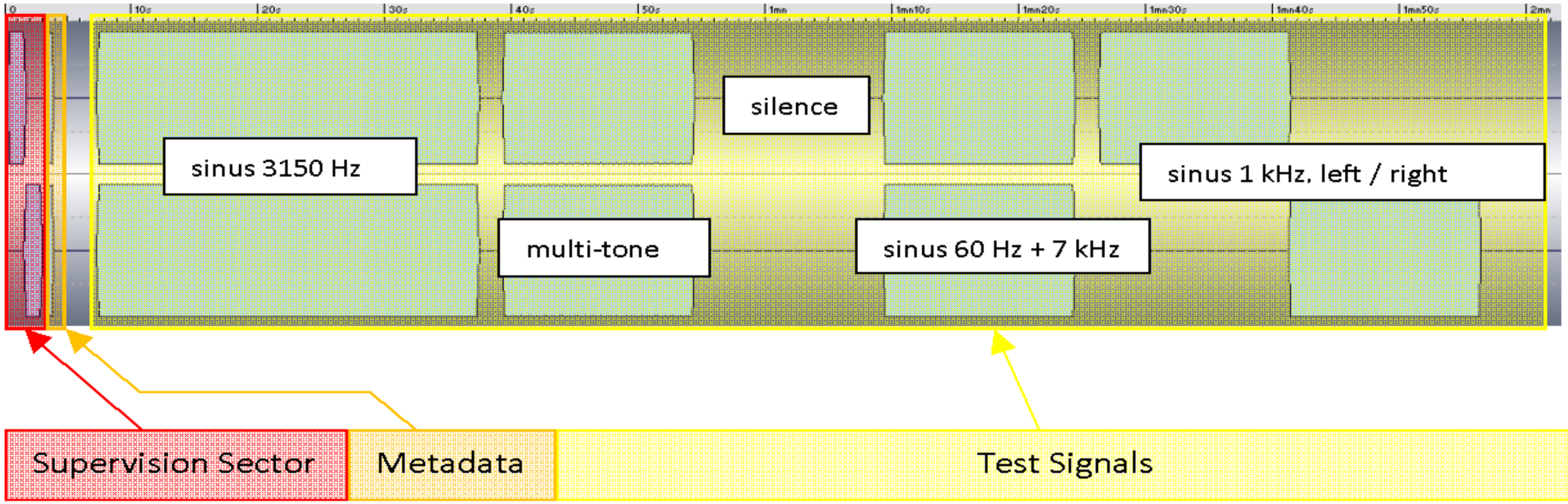
- Reel-to-Reel Calibration Tape (38 cm/s, 320 nWb/m, CCIR-IEC1, +6dBU)
- Audio Cassette Calibration Tape (4.76cm/s, 250 nWb/m)
- Vinyl Test Disc (micro groove) (33.3 rpm, RIAA)
- Shellac Test Disc (coarse groove) (77.92 rpm, lateral, 3180/450/50µs)

Test Tone sequence





Test Tone sequence



short version 20 sec instead of 2 min.

Speed Deviation :: Deviation from the anticipated tape speed in percent.

Wow & Flutter :: Maximum deviation from mean tape speed in percent. Values are calculated from weighted/unweighted (linear) and two-sigma/maximum/RMS results. For weighting, the filter according to DIN IEC 60386 is applied.

Harmonic Distortion :: Total Harmonic Distortion (THD) in percent. Distortion power in relation to power of fundamental frequency.

DC-Offset :: Power of the constant component of a signal in relation to the power of the whole signal in percent.

Azimuth :: Signal delay between two channels in milliseconds.

Balance :: Relation between signal power of two channels in dB.

Crosstalk :: Relation between power of signal A – being present in channel B – and the power of signal A – being present in channel A – in dB.

Frequency Response :: Exceeding of warning level is a measure which increases if frequency areas exceed the warning level of the tolerance scheme. Exceeding of critical level is the same for the critical tolerance. Values equal to one indicate that the tolerances were not exceeded.

Browser-based View on the Measurement Results

XML Export - Windows Internet Explorer

C:\Users\tm\Local Settings\Temp\Cube-Tec\xml2html\2010-01-15 08_35_51 CI-Report_Slot02_[User]Cassette Tascam (90699).xml.html

XML Export

CUBE-TEC INTERNATIONAL

Evaluation | Info | About

Evaluation

Overall Result 70.24 %

Summary

Tolerance scheme: C:/Cube-Tec/SharedConfig/CI_Tolerances/CI Tolerance - Tascam 122.xml
Result within tolerance 17 times.
Warning level was exceeded 4 times.
Critical level was exceeded 0 times.
Evaluation of current condition: 70.24 %
The condition of your machine is sufficient!

Results

Mesurand	Tolerance	Channel	Measurement Result	Evaluation Result		Comment
Frequency Response [More Details]		1 2			80.44 % 81.33 %	
Speed Deviation	|x| <= [0.25 , 0.5] %	1 2	-0.0677 % -0.0677 %		90.97 % 90.97 %	
Wow, Flutter (weighted, two-sigma; DIN IEC 60386)	x <= [0.05 , 0.065] %	1 2	0.0550 % 0.0550 %		55.50 % 55.52 %	
Wow, Flutter (weighted, max.)	x <= [0 , 0] %	1 2	0.0997 % 0.0996 %			UNOBSERVED: Result was not evaluated.
Wow, Flutter (weighted, RMS)	x <= [0.03 , 0.04] %	1 2	0.0291 % 0.0290 %		67.64 % 67.80 %	
Wow, Flutter (linear, two-sigma; DIN IEC 60386)	x <= [0 , 0] %	1 2	0.142 % 0.141 %			UNOBSERVED: Result was not evaluated.
Wow, Flutter (linear, max.)	x <= [0 , 0] %	1 2	0.368 % 0.396 %			UNOBSERVED: Result was not evaluated.
Wow, Flutter (linear, RMS)	x <= [0 , 0] %	1 2	0.0731 % 0.0722 %			UNOBSERVED: Result was not evaluated.
Amplitude Modulation (max.)	|x| <= [0 , 0] %	1 2	-21.5 % -15.6 %			UNOBSERVED: Result was not evaluated.
Amplitude Modulation (RMS)	x <= [0 , 0] %	1 2	2.37 % 0.733 %			UNOBSERVED: Result was not evaluated.
Total Harmonic Distortion	x <= [0.7 , 1] %	1 2	0.113 % 0.101 %		94.62 % 95.20 %	
Second order Harmonic Distortion k2	x <= [0 , 0] %	1 2	0.0686 % 0.0156 %			UNOBSERVED: Result was not evaluated.

Reference quality metrics

Strength:

- detects transfer errors
- highly sensitive measure
- checks standard conformity - compliance to inhouse quality Metrics
- detects slow degradation processes over weeks or months
- flags playback machine maintenance

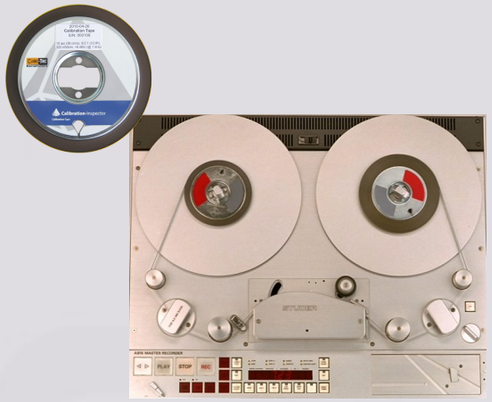
Weakness:

- single check - no continues supervision
- not usable for non standard aligned recordings and machines
- no available calibration media of less used archive formats
- limited life time of calibration media

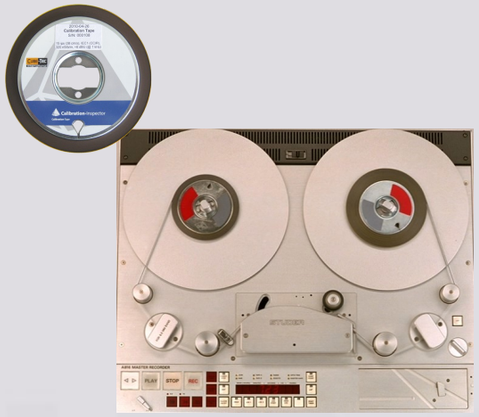
Which method is best?

- Is there a way to get the best out of the three assessment methods without having the drawbacks?
- Is there any combination so that these methods complement each other?

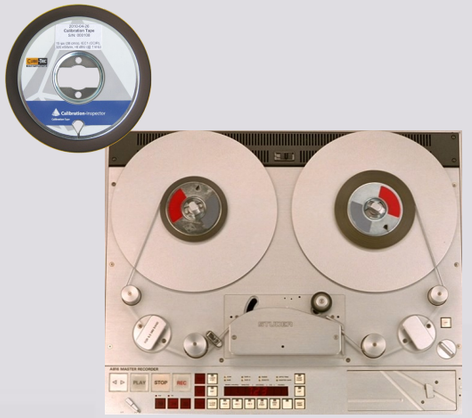
Overall quality Assessment Workflow **Step-1 Calibrate**



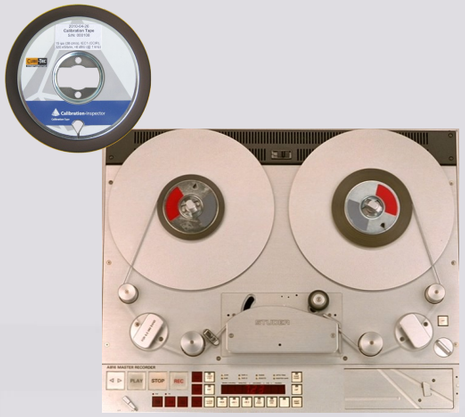
ANALYSIS



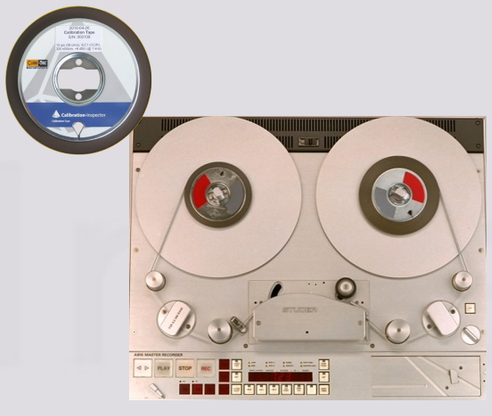
ANALYSIS



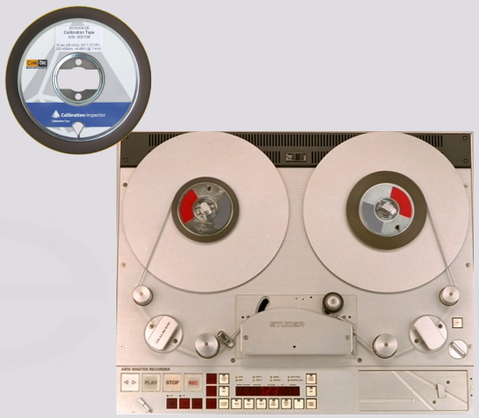
ANALYSIS



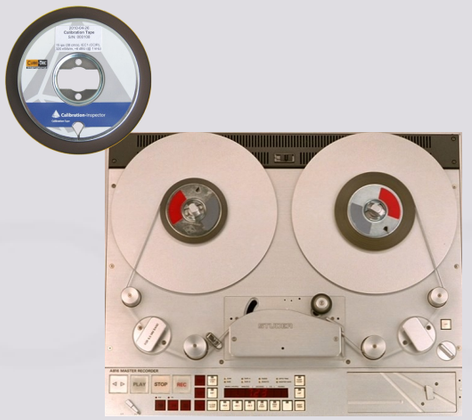
ANALYSIS



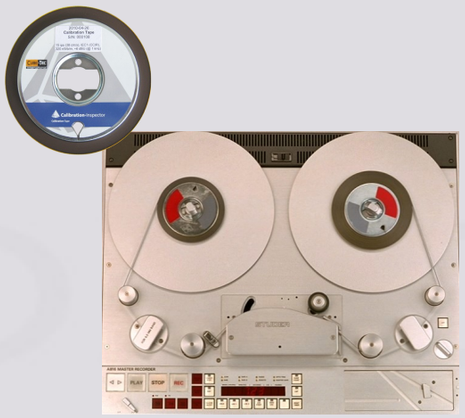
ANALYSIS



ANALYSIS

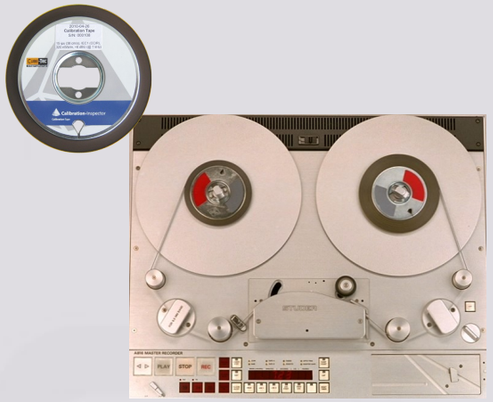


ANALYSIS

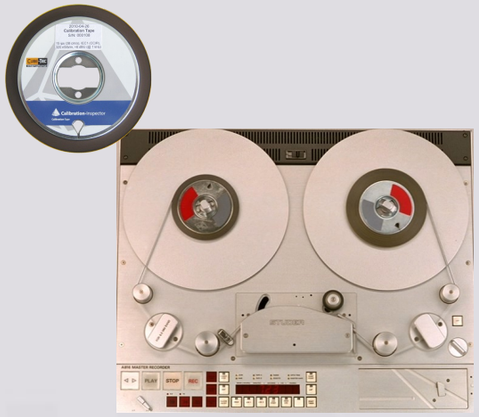


ANALYSIS

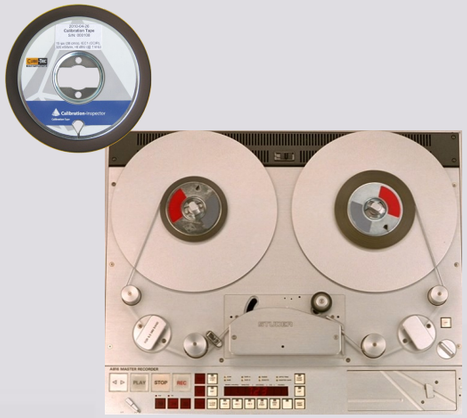
Overall quality Assessment Workflow **Step-1 Evaluate Calibration**



EVALUATION



EVALUATION



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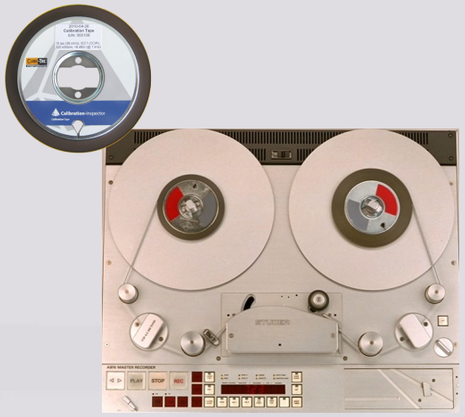
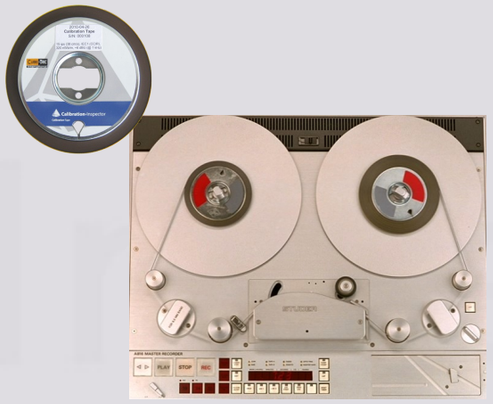


EVALUATION



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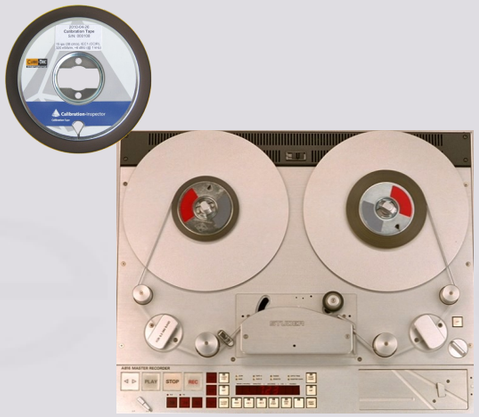

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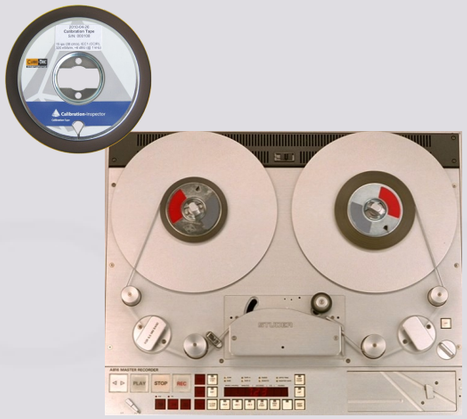

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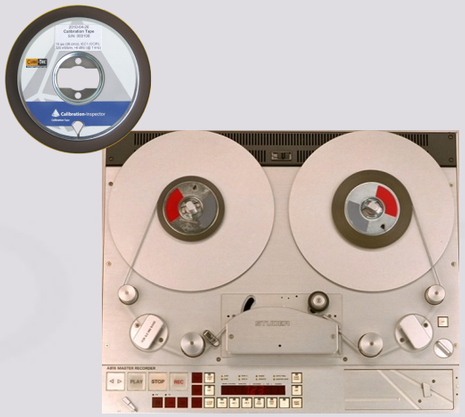


EVALUATION

Overall quality Assessment Workflow **Step-2 Ingest with Blind Analysis**

ANALYSIS

ANALYSIS

ANALYSIS

ANALYSIS

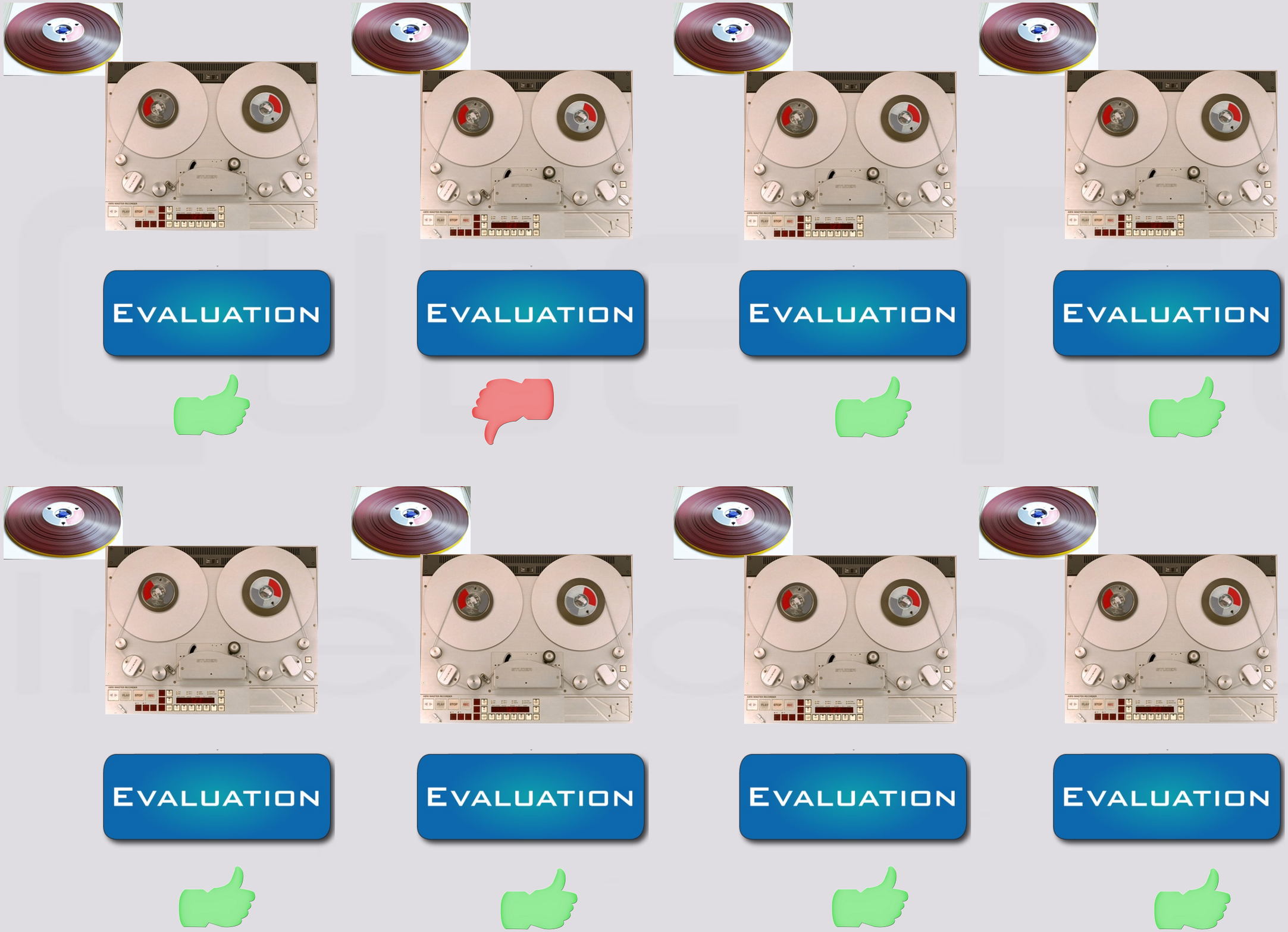
ANALYSIS

ANALYSIS

ANALYSIS

ANALYSIS

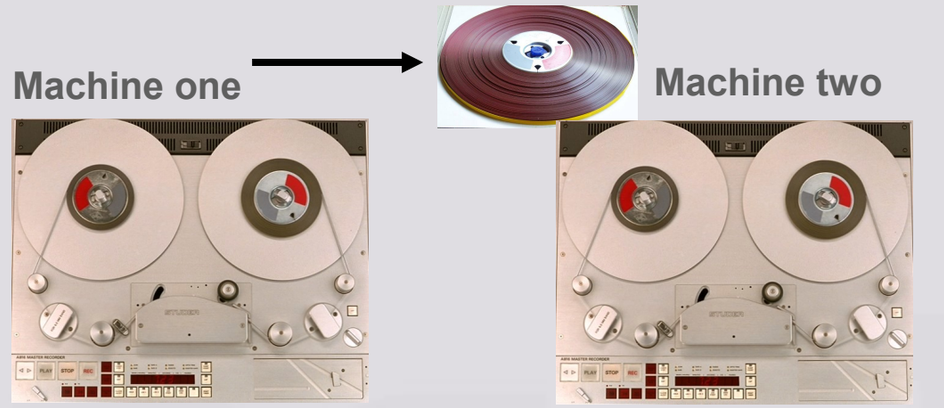
Overall quality Assessment Workflow **Step-2 Evaluation**



Overall quality Assessment Workflow **Step-3 Re-digitize**

Media Error -> no Transfer Error

Overall quality Assessment Workflow Step-3 Re-digitize



No Media Error

Overall quality Assessment Workflow Step-3 Re-digitize

Automation of QC reporting

- The presented methods will enable a precise specification of the required signal transfer quality and will continuously document the technical quality of the used playback devices and analog to digital converter.

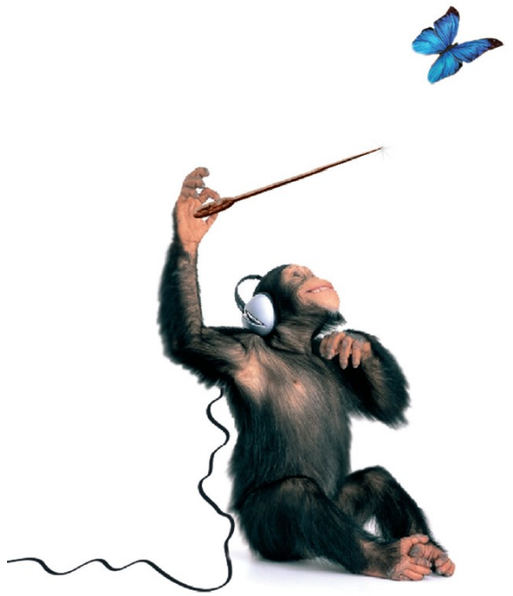
- This is also helpful for a digitisation service provider to document the achieved level of service.

An outlook on corresponding measuring technology on the motion picture side:

- Blind detection methods are in video signal assessment also state-of the art. There are solutions from different vendors.
- Automatic signal verification using multiple ingests of the same physical media is not standard up-to-now. There are a lot of Full-Reference based analysis (Video quality expert group VQEG Objective Quality Models) There are also Reduced Reference Algorithms, but there is a different focus, as these methods are designed to compare a processed version with an uncompressed (reference version).
- Full automatic reference-based error analysis using calibration media. Sure alignment tapes for VTR are standard. As far as I know, there is no quality automation system to support mass-migration based on calibration media.

The End

Thank you
for listening!



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