

# AES 20<sup>th</sup> International Conference Program

Archiving, Restoration,  
and New Methods of Recording

2001 October 5-7

## Technical Sessions

Friday, October 5

9:15 am-9:40 am

### KEYNOTE ADDRESS: PROMOTING GLOBAL ACCESS TO THE AUDIOVISUAL MEMORY OF THE WORLD

Guest Speaker: **Joie Springer**, UNESCO, Paris, France

Since 1980 UNESCO has been actively involved in preserving the audiovisual heritage of humanity by focusing on its fragility and the need for urgent action in member states. It is also exploring the use of information and communication technologies (ICTs) to support the role of archives as guardians of the global memory to avoid collective amnesia resulting from the loss of our cultural heritage.

9:40 am-1:00 pm

### SESSION 1: CARRIER DEGRADATION

- 1-1 Life Expectancy Testing of Magnetic Tapes—A Key to a Successful Strategy in Audio and Video Preservation**—*Dietrich Schüller, Phonogrammarchiv, Austrian Academy of Sciences, Vienna, Austria; and Leopold Kranner, ÖFI - Austrian Plastics Institute, Vienna, Austria*

The worldwide stock of audio and video tapes in archival custody is estimated to be at least 40- to 50-million hours. Tape deterioration, most prominently binder degradation of the magnetic layer, sooner or later calls for the migration of these holdings onto new carriers. This migration, specifically the digitization of analog formats, is extremely labor intensive. The preservation of only a portion of the present worldwide stock will need a volume of labor amounting to tens of thousands of person years. Even wealthy institutions will not be able to accomplish this task in the short term. Thus, the preservation of the audio and video heritage can be estimated to need many years, probably decades. This time horizon calls for proper prioritizing of digitization/migration: immediately endangered materials must come first, and

stable materials can wait. Consequently, valid and easily applicable methods for predicting the life expectancy (LE) of a given tape are the key to a successful strategy in audio and video preservation.

- 1-2 Practical Experience with Long-Term CD-R Archiving**—*Stanislav Psohlavec, AiP Beroun, Beroun, Czech Republic*

Manuscripts have been digitized in the National Library of the Czech Republic. The produced data have been stored on CD-Rs for more than four years. The quality of the discs is controlled in the same manner as factory CD production. The discs are stored in a good environment; the cleanliness as well as the handling of discs are at an acceptable level. In 2000 the quality control of ca. 600 archived discs was performed, and the statistical methods were applied to define the impact of media aging on data integrity. It was demonstrated that for this period, other factors suppressed the importance of the media aging influence. The most important ones are the quality of media and the writing unit. Such an influence can hardly be discovered without measuring. For long-term archiving of data on CD (CD-R), it is necessary to control the quality when placing the media into the archives. It is also important to monitor the quality during the archival storage. The control of the quality of the disc, through verifying whether it is readable after it has been written, is not sufficient for long-term archiving, and it is dangerous for future data integrity.

- 1-3 Recordable Optical Disk Aging and Degradation Process**—*Koichi Sadashige, National Media Laboratory, Voorhees, NJ, USA*

In recent years recordable optical disks—with significantly improved data holding capacity and acceptable data rate, coupled with steep declining cost trends—have become an important type of data storage media. Use of this media now ranges from the cost-driven amateur music recording to quality-oriented computer ➤

and imagery data storage for commercial and government applications. Recordable optical disks are highly complex devices, manufactured through several stages of physical, chemical, and vacuum deposition processes. Their aging and degradation processes are equally complex, influenced by exposure to temperature, humidity, UV/visual/IR radiation, and airborne pollutants. Disk aging and degradation processes are divided into two basic categories. The first category is the type of processes, which are common to all optical media based on the injection-molded organic disk with protective covering. The second category is format specific, and the aging/degradation processes differ from one recording technology to another. Three types of recordable formats—magneto-optics, phase change, and write once read many (WORM)—are the subjects of the paper. Recommended measures for retarding the aging and degradation processes and life expectancy projections based on accelerated test methods are presented.

**1-4 Instability and Vulnerability of CD-R Carriers to Sunlight**—*Drago Kunej*, Ljubljana, Slovenia

Many audio and audiovisual archives use the CD-R medium as a temporary target medium for the transfer of analog recordings. Smaller audio archives, and research audio archives in particular, are usually inadequately aware of the vulnerability of CD-Rs and do not place enough importance upon the correct manner of storage and handling of digital carriers. Therefore, the Institute of Ethnomusicology at the Scientific Research Centre of Slovenian Academy of Sciences and Arts performed a simple test to demonstrate the susceptibility of CD-Rs to sunlight. This paper draws attention to the importance of proper storage and handling of CD-R carriers and emphasizes that the inadequate choice of a disc, its insufficient compatibility with the CD writer, careless handling, and superficial and inadequate testing can quickly jeopardize previously recorded archival material or lead to its loss.

**1-5 The Effect of Pollutants Gases on CDs**—*Léon-Bavi Vilmont*, Centre de Recherches sur la Conservation des Documents Graphiques, Paris, France

Commonly used media for digital information (audio, data, images) compact discs behave variously. Molded CDs are susceptible to a shorter life span, and CD-Rs are said to be durable for over hundred years. Accelerated aging, such as exposure to gas pollutants, has been carried out in order to compare the stability of diverse CD media and to show how CDs can be affected versus the way they were manufactured.

**Discussion**

2:00 pm–2:50 pm

**INVITED TUTORIAL: TOWARD NANOTECHNOLOGY IN DATA RECORDING**

Speakers: **Arpad I. Csurgay**, Budapest University of Technology, Budapest, Hungary  
**Wolfgang Porod**, University of Notre Dame, Center for Nano Science and Technology, South Bend, IN, USA

Beyond the end of the road map of microelectronics, a new paradigm is emerging, taking over the mainstream development of electronics. If the trend of making the elementary units of information processing smaller and smaller continues, microelectronics will be followed by

nanoelectronics. Theoretical studies of realizability and many of the nature examples provided show that the laws of physics present no barrier to reducing the size of computers, until basic components are the size of atoms, and the principle of operation becomes the quantum behavior. "There is plenty of room at the bottom," as Feynman said in 1960. In recent years, a novel nanometer-scale electronic technology, called nanoelectronics, has been emerging. Nanoelectronic discrete devices—such as resonant tunneling diodes and transistors, single-electron transistors, bistable quantum cells, and magnetic nanodiscs—have been proposed and demonstrated. This review paper focuses on the emerging new nanoelectronic devices and circuits and evaluates their potential role in future data recording systems.

2:50 pm–6:00 pm

**SESSION 2: METADATA AND FILES**

**2-1 Metadata System of National Audiovisual Archive in Hungary**—*István Szakadát, Gábor Magyar, and Péter Risztics*, Budapest University of Technology and Economics, Budapest, Hungary (**Invited**)

In 2000 the Center of Information Technology at Budapest University of Technology and Economics prepared a feasibility study on how a national audiovisual archive (NAVA) can be built in Hungary. The most important goal of NAVA has been defined as collecting and archiving the Hungarian television and radio broadcast programs. There are four main topics of the design work: answering questions of archiving of AV materials, designing a metainformation system, collecting the legal (IPR) questions, and making the first draft of the organizational and financial conditions. In this metadata group, the authors designed a general digital archive model. Based on the abstract and general notion of document, the Dublin Core Element Set was used as a skeleton of the minimal metadata system.

**2-2 Mass Transfer, Preservation, and Metadata Requirements**—*Kevin Bradley*, National Library of Australia, Canberra, ACT, Australia

The National Library of Australia has identified the preservation of its digital collections as a priority issue and has instituted various integrated projects and systems to deal with these issues, including storage, metadata repository, and preservation metadata. Its unique sound materials are part of those digital collections. This paper addresses the issues of integration of metadata collection with existing catalog records and databases, the incorporation and linking of such records into existing metadata schemas, as well as the implications of preservation metadata records and the possible preservation paths they facilitate and document.

**2-3 Metadata—The Basis of Asset Management**—*Siegbert Herla*, Institut für Rundfunktechnik, Munich, Germany

For an economic realization of future asset management systems based on online archives working in a global network structure, the right course shall be set. Therefore during the digitization and capturing process of single-carrier archives, attention is already being paid to the registration of relevant metadata, along with the re-recording of sound and video data. The description of sound and video content, their technical quality, and status information are equally important as the situation of rights and a unique material identifier for worldwide

unique identification of source material. In addition, the continuous gathering of metadata shall accompany the audio and video material on the road, and platform-independent file formats, such as BWF and MXF, are needed.

**2-4 Subject Description for Sound Effects in the Image and Sound Effect Database—*Suvi Päivikki Karhula*, Tampere Polytechnic Library, Tampere, Finland**

The paper introduces the subject description method for the sound effects, combining the analysis of the content in the sample of sound effects and the study of the utilized subject description approaches. The subject description of the sound effects has not been studied so far, and it still seems an important field when the intelligent content-based systems recognizing sounds can not completely reach the semantically meaningful content. The DIIVA project was launched in 1997 to compile an image and sound effects database to serve the Tampere Polytechnic Library. The goal of the database is to support art and media studies and cover various subject fields.

**2-5 Protective Nonlinear File Structure—*Dániel Stocker*, Budapest, Hungary**

A new audio file structure has been developed to create a mediate layer between raw pulse-code modulated files and the binary-coded, highly redundant data contained by the storage media. This file structure, together with a unique shuffling procedure called transposing of n-dimensional blocks, ensures high resistance against coherent data loss. Tests have proven that data corruption results in damage of quality and not of quantity.

**Discussion**

**Saturday, October 6**

**9:00 am–1:00 pm**

**SESSION 3: BROADCASTING SYSTEMS**

**3-1 Digital Audio Archiving in Public Broadcasting—*Markku Petäjä, Jouni Frilander, Pekka Gronow, and Antti Järvinen*, YLE - Finnish Broadcasting Company, Yleisradio (Helsinki), Finland (Invited)**

This paper presents the Digital Radio Archive Project of the Finnish Broadcasting Company (YLE), which is currently in its implementation phase. Results from first-test operations and earlier project phases are presented. YLE holds significant historical audio archives, which are used in daily production in more than 20 locations around Finland. A major part of production at YLE is done using computer-aided radio (CAR) systems. The reasons for the implementation of a digital audio archive are the need for a centralized archive of production material from CAR systems and the aging of analog tapes. For these reasons, a significant part of the project has focused on work processes and the integration of archival system and CAR systems.

**3-2 Introducing Computer-Based Audio Archives in German Public Broadcast Stations—A Report about Experiences and Actual State—*Andreas Matzke*, Consultant, Berlin, Germany**

In 1992 public broadcasters in Germany started to describe the needs for computer-based audio archives. They had to take into account a very special situation, e.g., the need of a rather strong cooperation among so many different broadcasters and the large amount of audio carriers in their archives. The paper describes the

actual state of commitments that have been made regarding audio and related data formats, the types of data carrier within the mass-storage system, and the exchange of archive content between the broadcasters. Chances and limits for the integration of digital audio carriers, such as CD and DAT, within computer-based archives are discussed, along with the strategies for save operation as well as high availability and aspects of content protection.

**3-3 Radio Archive Online—*Lars Gaustad*, Media Lab, National Library of Norway, Mo i Rana, Norway**

The paper describes the development of the cooperative work done by the National Library of Norway and the Norwegian Broadcasting Corporation to digitize and create online access to the 50 000 hours of recordings kept by the radio archive. It includes the technical aspects of the digitization, choice of suitable sound formats as well as the implementation of existing metadata in the creation of Web interfaces for easy access by the radio journalists, and a policy for safeguarding the contents in a HSM mass-storage system for future generations. A brief encounter with the online deposit of current radio transmission is also discussed.

**3-4 An Integrated Solution for Digitalization, Archiving, and Restoration of Large Audio Collections—*Christoph M. Musialik and Ulrich Hatje*, Algorithmix, GmbH, Waldshut-Tiengen, Germany; and *Christophe Kummer and Peter Kuhnle*, NOA Audio Solutions GmbH, Vienna, Austria**

There is a growing demand to rescue large historic audio collections stored on different analog media. The huge amount of historic recordings stored in audio libraries will take hundreds of years for high-quality transfer to new, reliable digital media. It is too long a time period, considering that in some years irreparable defects can occur; and it is too expensive, since highly qualified experts are required for getting professional results. This paper describes a system (already implemented as prototype) that allows easier and more cost-effective transferring and archiving of large audio collections. This system is also suitable for automatically embedding metadata coming from existing database systems, handling large wave files (over 2 GB), and automatically restoring digitized and archived audio files.

**3-5 New Technology for Broadcast Archive Preservation—*Adam Lee and Richard Douglas Wright*, BBC Information & Archives, Brentford, Middlesex, UK**

The BBC, nine major broadcast archives, and seven technical partners are developing new technology for archive preservation, which is supported by the European Commission. A survey of media status and preservation work is complete, which includes detailed requirements for new technology and mapping the preservation process for re-engineering. An optimized process has been developed for the efficient creation of future archives incorporating mass storage and electronic delivery. The survey covers problems with existing preservation technology, management, and funding. User requirements were established, identifying key link technologies to address those areas of the preservation process that are costly and time-consuming or prone to failure. Details of those key link technologies currently under development are presented.

**3-6 Application of Speech-Rate Conversion Technology to Video Editing—*Atsushi Imai, Nobumasa* ➔**

*Seiyama, Takeshi Mishima, Tohru Takagi, and Eiichi Miyasaka*, NHK Science and Technical Research Labs., Tokyo, Japan

This paper describes the application of speech-rate conversion technology to video editing. In video editing it is common to search through the material at several times normal speed. However under these conditions, the original speech is unintelligible. The speech-rate conversion system maintains the original pitch and timbre of speech despite playing it back at a faster rate, which is varied adaptively to permit fast listening in real time. In listening tests, users were able to comprehend speech played at up to 5 times normal speed, which was incomprehensible without adaptive-rate conversion (even when pitch shifted to restore the original pitch).

#### Discussion

2:00 pm–5:00 pm

### SESSION 4: MASS TRANSFER

#### 4-1 Preservation of the BBC Radio 1 Archive—*Allan Michael King and Adam Lee*, BBC, London, UK

The BBC Radio 1 Archive, which started in the 1960s, comprises over 40 000 tapes and DATs. The majority of the tapes are unique master recordings of pop music and interviews. The catalog data was on legacy database systems and incomplete. Given the historic and commercial value of the archive, it was decided to provide improved access and protection by digitization. The main transfer, to CD and DVD-R, started in 2000 January. The paper examines the solutions adopted to address issues of efficient mass transfer, choice of digital media, improved access, migration of legacy data, file formats, and metadata.

#### 4-2 High-Speed Digitizing for Analog Tape Mass Archives—*Harald Viering*, Otari Europe GmbH, Meerbusch, Germany

Otari's DAS system, designed for multichannel high-speed transfer, allows uninterrupted, sequential duplication in real time, 2x or 4x speed, and 24 bit. It connects up to four stereo or eight mono tape players. Files are temporarily stored on removable hard disks in 16-bit standard wave file or BWF format. The process delivers excellent audio performance, exceeding typical broadcast tape recorder specifications. Handling is simple and fully automatic and requires no specially trained operators. Labor cost and time savings, compared to real time, allow a return on investment in less than two years.

#### 4-3 Optimized Workstation for the Transfer of Large Collections—*Joerg W. Houpert*, Houpert Digital Audio, Bremen, Germany

The audio workstation takes on a key role as the interface between the different analog and digital players and any mass-storage system in transmitting large collections of single-carrier archives. With a suitable design, the audio workstation has great potential to eliminate latent sources of error by automatic processes and to greatly gain in efficiency by optimizing every step of the process. The capturing workflow of digital interim archive formats, such as CD-R, DAT or U-matic, clearly differs from the workflow of analog sound carriers such as tapes or discs. Costs can be saved by parallel, ob-

served transmission in less than real time. QUADRIGA was optimized with regard to these aspects.

#### 4-4 True Measure of Storage System Data Holding Efficiency—Terabytes per Given Floor Space—*Koichi Sadashige*, National Media Laboratory, Voorhees, NJ, USA

Established expressions for the data storage device efficiency, such as megabytes per square inch or square micrometer of media surface per data bit, do not accurately represent the true measure of today's data storage system efficiency. For today's data storage systems, mass-storage systems in particular, the meaningful way to express data storage efficiency is in the amount of data that can be stored in a given floor space, e.g., terabytes per square foot or square meter. The relationship between the physical volume of representative data packages, such as a magnetic tape cartridge/cassette or optical disk, and the maximum data stored in these packages should be the starting point of the efficiency comparison. Since the data packages are stored in a library system or disc juke box, the next step of efficiency computation is the translation of the data package volume into the occupied floor space. In computing the floor area, the space for the record/playback drives and robotics for the movement of the data packages should be included. It is significant to note again that the areal data recording density, while not to be ignored, is not the most influential factor in achieving the highest data storage efficiency. Other factors, such as the choice between a single-spool tape cartridge or a two-spool tape cassette or the use of magnetic tape instead of optical disk, become highly important. Capability of the emerging very high-capacity optical disk formats, including the next-generation recordable DVD, multilayer recording disk and holographic optical disk, are also discussed. Their performance is examined from the view of continuously improving magnetic recording devices. A discussion of the declining cost trend of future storage media is also included in the paper.

#### Discussion

4:40 pm–6:10 pm

### SESSION 5: RESTORATION, PART 1

#### 5-1 A High Performance, Low-Cost Wax Cylinder Transcription System—*James Bruce Nichols*, Los Altos, CA, USA

This paper describes BURP-ONE, a low-cost yet high performance wax cylinder transcription system. Using readily available parts, together with low-cost (or free) software, the BURP-ONE system gives archivists a pragmatic means for preserving the treasury of antique recordings that lay moldering in vaults and attics. The paper outlines a practical methodology for quality restoration of wax cylinders, which can be followed by archivists of limited technical means. Audio samples will demonstrate the results of the various restoration stages including declicking, dethumping, equalization, dehisssing, and denoising. The resulting transcriptions represent a breakthrough in price/performance for serious audio archival work.

#### 5-2 Optical Retrieval and Storage of Analog Sound Recordings—*Stefano Sergio Cavaglieri*, Fonoteca Nazionale Svizzera, Lugano, Switzerland; and *Ottar Johnsen and Frédéric Bapst*, Ecole d'Ingenieurs de Fribourg, Fribourg, Switzerland

Cutting a disc was in practice the only means for preserving sound until the introduction of magnetic tape in the early 1950s. Discs, and in particular shellacs, are extremely fragile. Their handling requires much care and technical skills. Conventional replay equipment is becoming obsolete very quickly. Digital technology, as a storage medium, does not improve the content's quality or extend its life. The proposed optical retrieval and storage technique is the solution for where the sound is extracted without mechanical contact with the often fragile discs. The authors take a picture of each side of the disc using a special analog camera, then the obtained film is stored. When someone wants to listen to the sound, the film is scanned, then the image is processed to extract the sound of the record.

**5-3 The Attraction of Optical Replay of Mechanical Recordings**—*George Brock-Nannestad*, Preservation Tactics, Gentofte, Denmark

The paper discusses the many approaches to optical replay of mechanical disc or cylinder records. There is a distinction between direct optical reading of the groove and the optical detection of the stylus movement. The former method is advantageous because it does not interact mechanically with the record material. The latter one is advantageous where the groove has been interrupted and where optical tracking may be difficult.

**Sunday, October 7**

**9:00 am–1:00 pm**

**SESSION 6: RESTORATION, PART 2**

**6-1 Reduction of Modulation Noise in Analog Full-Track Recordings Using Multitrack Replay Techniques**—*Franz Lechleitner, Bernhard Berg, and Markus Dorfer*, Phonogrammarchiv, Austrian Academy of Sciences, Vienna, Austria; and *Heinrich Pichler*, Technical University, Vienna, Vienna, Austria

Modulation noise is a well-known phenomenon in magnetic recording systems using analog signal representation. Modulation noise has been defined as “noise that exists only in the presence of a signal.” In addition, the modulation noise is a function of the instantaneous amplitude of the recorded signal. Based on statistical methods, noise reduction should be possible. The paper describes the test equipment, test procedure, and results. The test system is based on a full-track recorded tape. The playback process uses multiple-track playback and provides the ability to correlate the different output signals. The output signal of each track was digitized and processed. Based on this procedure, noise reduction is possible.

**6-2 What Are the Sources of the Noises We Remove?**—*George Brock-Nannestad*, Preservation Tactics, Gentofte, Denmark

Reissues of analog recordings—commercial and to a certain extent scientific—perform certain cleaning operations on the raw signal obtained from a sound carrier, such as mechanical recordings, film sound tracks, and magnetic recordings. In many cases, background noises are removed based on different statistical properties of noise signals and on the intended signal. However, the models of noise sources are often simplistic and based more on computational expedience than on characteristic features derived from the mechanism that has generated the noise. In order to improve future endeavors to remove noises without touching components of the intended signal,

the paper provides insight into the mechanisms for noise generation.

**6-3 J\_PITCH: A New Pitch Correction System for Degraded Historical Audio**—*James Bruce Nichols*, Los Altos, CA, USA

Historical magnetic tape recordings often exhibit annoying pitch irregularities, which in extreme cases can render a recording unintelligible. Some factors that contribute to pitch defects include power supply fluctuations, especially battery charge and condition; tape reel diameter; tension; and stretch. The pitch irregularity is often a time-varying nonlinear function of the defect contributors. While several methods exist that treat pitch defects, it is difficult in practice to objectively identify secular pitch defects. In particular, determining the correct pitch of a human voice is by nature subjective. This paper describes J\_PITCH, an operator-assisted pitch-correction system. J\_PITCH automatically corrects pitch defects by augmenting traditional spectral pitch analysis with an interpolative heuristic based on the operator's subjective observations.

**6-4 Restoration of Nonlinearly Distorted Audio with the Application to Old Motion Pictures**—*Tamás B. Bakó and Balázs Bank*, Budapest University of Technology and Economics Dept. of Measurement and Information Systems, Budapest, Hungary

In this paper a robust and efficient method is presented for restoration of nonlinearly distorted movie sound tracks. The method is based on the *a priori* knowledge of the film density curve, which is assumed to be a static nonlinearity. The parameters of the inverse characteristics are estimated by searching for an output spectra similar to the human voice. Tikhonov regularization was applied to avoid noise intensification during the restoration process. The proposed method has been successfully applied to old motion picture audio tracks.

**6-5 Resynchronization of Multiple Audio Sources**—*Christopher Hicks*, CEDAR Audio Ltd., Fulbourn, Cambridge, UK

This paper concerns the synchronization of multiple copies of a degraded audio source. Typically it may be required prior to applying a multichannel restoration algorithm to more than one copy of, for example, a vinyl disc. The requirement that multiple sources be realigned to subsample accuracy is justified. Methods for estimating the time offsets are compared; and a new, robust Bayesian algorithm is presented. Finally, a mechanism for performing the signal resampling is outlined.

**6-6 Wavelet- and Self-Organizing Maps-Based De-clacker**—*Alvaro Tuzman*, Universidad de la República, Montevideo, Uruguay

A declacking algorithm based on the wavelet transform and self-organizing maps (SOMs) is presented. Both tools complement each other to improve performance. The SOMs provide a higher level of processing; and the wavelet transform is used to analyze the signal transients. The transient detection is based on the local properties of the music signal and the noise. An expert operator selects typical types of clacks. After that the optimum projection basis is selected, the detected clacks are organized by the SOMs, then the music signal is processed a second time.

**Discussion**