STANDARDS AND INFORMATION DOCUMENTS

AES69-2022
(Rev. AES69-2020)

AES standard for file exchange - Spatial acoustic data file format

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Revision of AES69-2020

AES standard for file exchange – Spatial acoustic data file format

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Abstract

Binaural listening is growing fast, because of growing sales in smartphones, tablets and other individual entertainment systems. The lack of a standard for the exchange of head-related transfer functions (HRTF) means each company keeps its binaural capture and rendering algorithms private. 3D audio is arising, and binaural listening could be the very first 3D audio vector with sufficient fidelity of HRTF.

The use of convolution-based reverberation processors in 3D virtual audio environments has grown with the increase in available computing power. Convolution-based reverberators guarantee an authentic and natural listening experience, but also depend on the acoustic quality of the applied spatial room impulse response (SRIR).

With a standardized file format for HRTF and SRIR data, each company can contribute its best algorithms, providing good personalized capture and/or rendering, allowing the consumer to choose a combination of technologies for the best quality of experience.

This document standardizes a file format to exchange space-related acoustic data, such as binaural listening parameters in the form of head related transfer functions. The format is scalable to match the available rendering process and is designed to include source materials from different databases.

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Contents

These forewords are not part of *AES69 – AES standard for file exchange – Spatial acoustic data file format.*

Foreword

This standard builds upon an earlier project to define a spatially oriented format for acoustics (SOFA). The SOFA project considered the requirements for a file format storing HRTF data and other spatial descriptions of acoustic systems. SOFA aimed at storing data representing HRTF data in a general way, capable of supporting any data measured with microphone arrays and loudspeaker arrays.

This project was developed as project AES-X212 by Task Group SC-02-08-E led by M. Parmentier. The principal authors were P. Majdak and M. Noisternig.

The following persons were involved in the development of this document in draft:
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Mark Yonge
Chair, SC-02-08 Working Group on Audio-File Transfer and Exchange

Foreword to second edition, 2020

This revision describes the AES69-2020, also known as SOFA 2.0. The revision includes:

- a new spatially continuous representation of emitters and receivers (by means of spherical harmonics, also known as Ambisonics);
- a clarification on the object “Data” consistently defining the dimension sizes of other variables;
- information about ‘sofa’ as a registered media subtype for storage, transfer, and exchange;
- new conventions describing directivity of musical instruments and loudspeakers (with flexibility not being covered by other AES standards);
- new conventions describing multiple-input and multiple-output measurements enabling complex interaction between sources and listeners (such as multiperspective representations);
- new conventions describing HRTFs represented in a spatially continuous way;
- new general conventions in order to describe general measurements;
- updated description of room types.

In rare cases, this revision might break compatibility because it requires that the dimension sizes of the data object determine the dimension sizes in a file. In AES69-2015 (SOFA 1.0), this requirement was not described and the dimension sizes of other variables might have been used and enforced on the Data object.

This revision was developed by Task Group SC-02-08-E led by P. Majdak and M. Noisternig. The principal authors were P. Majdak, J. De Muynke, F. Zotter, and F. Brinkmann. Other contributors were J. Ahrens, S. Norcross, C. Pike, A. Farina, L. Neumann.

Piotr Majdak and Markus Noisternig
Chairs, SC-02-08, 2020-10-24

Foreword to third edition, 2022

This revision describes the AES69-2022, also known as SOFA 2.1. The revision includes:

- Eq. 2: factor removed to be compatible with MPEG-H (ISO/IEC 23008-3:2019);
- the term “spatially continuous” replaced by “continuous-direction” to be more accurate;
- explicit naming rule for expanding attributes to global variables;
- Annex D, General convention: explicitly specified that all dimensions shall be defined;
- Annex D, GeneralSOS added for the sake of completeness;
- Annex D, SimpleHeadphoneIR: update to version 1.1 (more clear separation of global and specific metadata);
- Annex D, SingleRoomSRIR and SingleRoomMIMOSRIR: update to version 1.1 (specific descriptions of Emitters and Receivers defined);
- Annex D, FreeFieldDirectivityTF: update to version 1.1 (more clear separation of global and specific metadata).

This revision breaks compatibility only in the special case of files using the SimpleHeadphoneIR conventions with the EmitterDescription and ReceiverDescription being described as variables. To our knowledge, there are no such files publicly available.

This revision was developed by Task Group SC-02-08-E led by P. Majdak and M. Noisternig. The principal authors were P. Majdak, J. De Muynke, F. Zotter, F. Brinkmann, M. Mihocic, and David Ackerman. Other contributors were J. Ahrens, S. Norcross, C. Pike, A. Farina, L. Neumann.

Piotr Majdak and Markus Noisternig
Chairs, SC-02-08, 2022-09-02

Note on normative language

In AES standards documents, sentences containing the word “shall” are requirements for compliance with the document. Sentences containing the verb “should” are strong suggestions (recommendations). Sentences giving permission use the verb “may”. Sentences expressing a possibility use the verb “can”.
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AES standard for file exchange - Spatial acoustic data file format

0 Introduction

0.1 General

A spatial acoustic transfer function describes the spatial filtering of the incoming sound, due to the listener's anatomy for example. Previously, spatial-acoustic data have been stored in various incompatible formats, making an exchange of this data difficult. This document describes a format for storing spatial acoustic data with a focus on interchangeability and extensibility and provides a basis for a wider generalized interchange of space-related audio data.

In this document, the term ‘transfer function' (TF) describes any filter, regardless the actual representation or interpretation. TF may, for example, refer to:

- The frequency domain representation of free-field head-related transfer functions (HRTFs);
- The time domain representation of free-field HRTFs, that is head-related impulse responses (HRIRs);
- The time domain representation of HRTFs measured in reverberant spaces, that is binaural room impulse responses (BRIRs);
- The Quadrature Mirror Filter (QMF) domain representation of free-field HRTFs, that is the set of QMF parameters; or, even more generally;
- The time domain representation of spatiotemporal room impulse responses, that is spatial room impulse responses (SRIRs).

If not otherwise stated, we do not distinguish between such terminologies and refer to all those filters as transfer functions.

Specifications given in ‘conventions’ (that is in-detail descriptions of the data exchange format for a given data set) shall use the correct terminology, for example using HRIR instead of HRTF when the data are represented in time domain.

The following requirements are identified:

- Description of a measurement setup with arbitrary geometry; that is, not limited to special cases like a regular grid, or a constant distance, or even spatial discrete points in space;
- Self-describing data with a consistent definition; that is, all the required information about the measurement setup must be provided as metadata in the file;
- Flexibility to describe data of multiple conditions (listeners, distances, and so on) in a single file;
- Partial file support and network support;
- Available as binary file with data compression for efficient storage and transfer;
- Predefined descriptions for the most common measurement setups, which are referred to as ‘conventions’.

A TF measurement setup is described by various objects (4.2) and their relations (4.3); the information is stored in a numeric container (4.4) and structured by the measurement.

A measurement consists of data (4.6) describing a TF for a single condition, for example an HRIR, and is described by its corresponding dimensions (4.5) and metadata (4.7). All measurements are stored in a single data structure. Conventions for a consistent description of measurement setups are provided in Annex D of this document.

0.2 Patents

Attention is drawn to the possibility that some of the elements of this AES document may be the subject of patent rights not identified herein. The AES shall not be held responsible for identifying any or all such patent rights..

0.3 Documentation conventions

A `Courier` typeface is used in this document to identify computer listing examples to distinguish them from regular text.

1 Scope

This document standardizes a file format to exchange space-related acoustic data in various forms. The format is designed to be scalable to match the available rendering process. The format is designed to be sufficiently flexible to include source materials from different databases.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8601:2004, *Data elements and interchange formats – Information interchange – Representation of dates and times*, International Standards Organization, Geneva, Switzerland

ISO 80000-2:2009, *Quantities and units – Part 2: Mathematical signs and symbols to be used in the natural sciences and technology*, International Standards Organization, Geneva, Switzerland

ISO 80000-5:2007, *Quantities and units – Part 5: Thermodynamics*, International Standards Organization, Geneva, Switzerland

ISO/IEC 10646:2012, *Information technology – Universal Coded Character Set (UCS)*, International Standards Organization, Geneva, Switzerland

ISO/PAS 17506:2012, *Industrial automation systems and integration – COLLADA digital asset schema specification for 3D visualization of industrial data*. International Standards Organization, Geneva Switzerland.

ITU-R TF.460, *Standard-frequency and time-signal emissions*, International Telecommunications Union, Geneva, Switzerland.

RFC 3339, *Date and Time on the Internet: Timestamps*, Internet Engineering Task Force, www.ietf.org.

RFC 3986 (also IETF STD 66), *Uniform Resource Identifier (URI): Generic Syntax*, Internet Engineering Task Force, www.ietf.org.

NetCDF-4 published and maintained by Unidata, Boulder, CO., US.
http://www.unidata.ucar.edu/software/
(See Annex A)

sofa media subtype as registered by the Internet Assigned Numbers Authority (IANA),
https://www.iana.org/assignments/media-types/audio/sofa
(See Annex B)