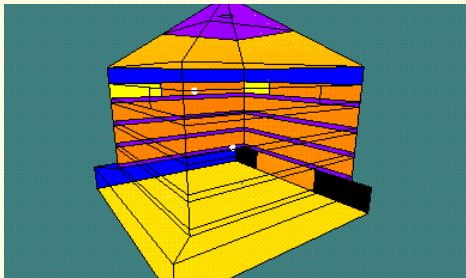
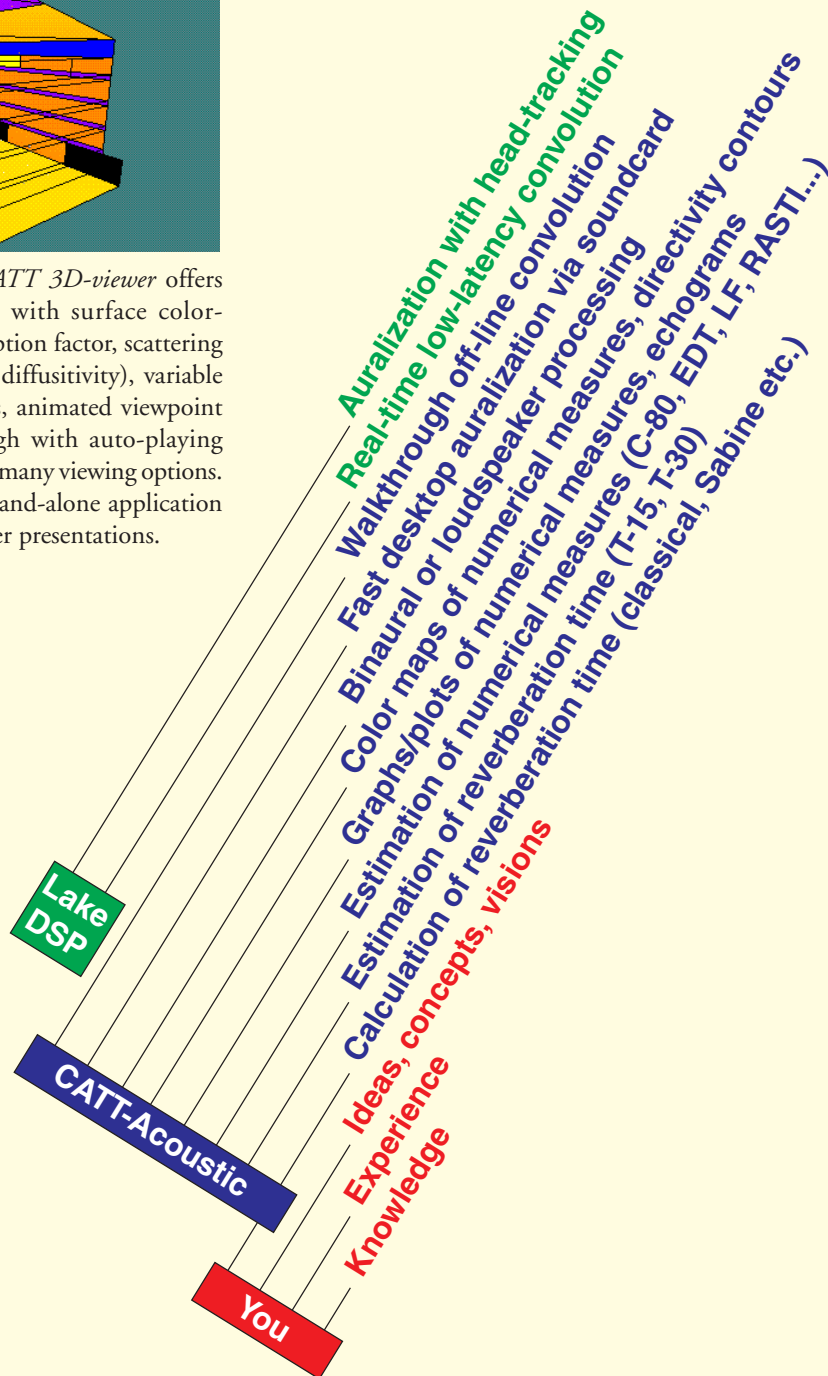


CATT-Acoustic™ v8

Room Acoustics Prediction and Desktop Auralization



The *OpenGL*-based *CATT 3D-viewer* offers enhanced 3D-viewing with surface color-coding (material, absorption factor, scattering coefficient, specularity, diffusivity), variable lighting, viewpoint lists, animated viewpoint transitions, walkthrough with auto-playing auralized WAV-files and many viewing options. The viewer is a small stand-alone application that is ideal for customer presentations.

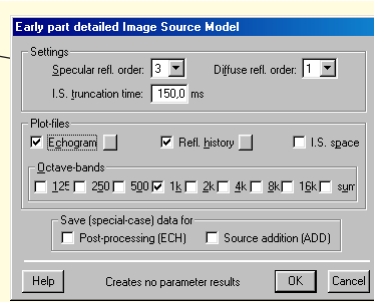
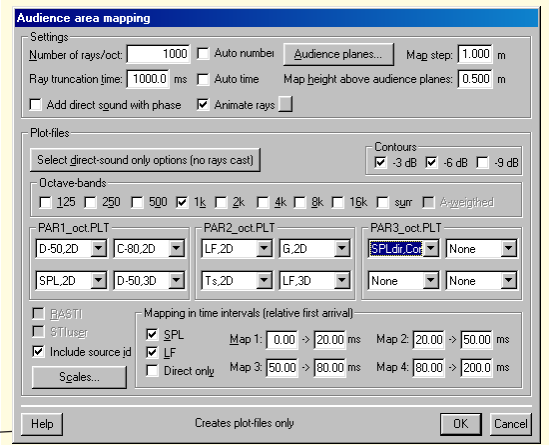
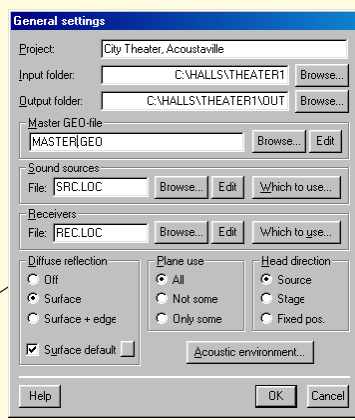
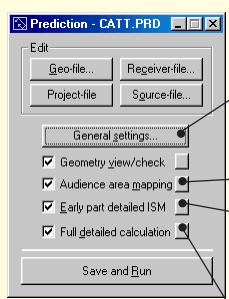


CATT-Acoustic™ v8 is a seven-module integrated application for 32-bit *Windows®*. It combines numerical prediction, multiple source addition, convolution, auralization, sequence (batch) processing, source directivity and surface property library handling. In addition, the stand-alone *OpenGL*-based *CATT 3D-viewer* can be used for enhanced 3D-viewing and customer presentations.

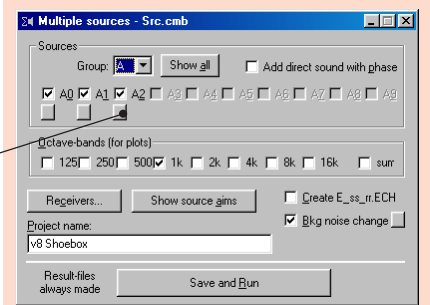
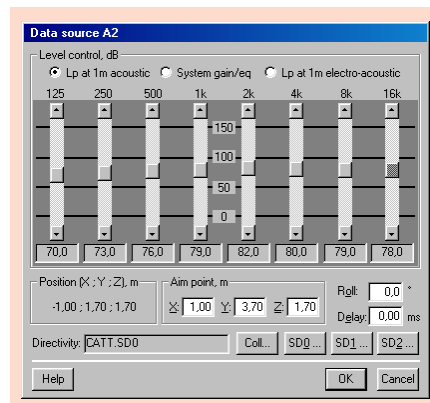
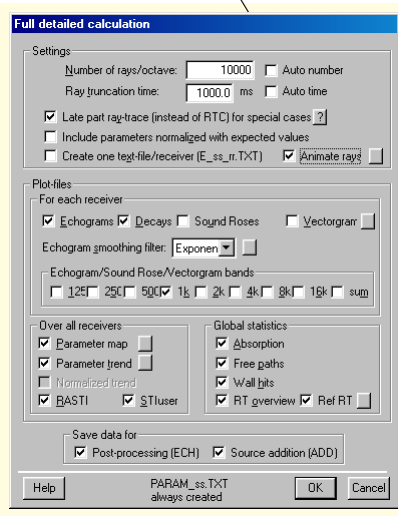
catt



The Prediction module utilizes the unique Randomized Tail-corrected Cone-tracing (RTC-II), the Image Source Model (ISM) as well as Ray-tracing. The module predicts room acoustical numerical measures, and creates data files for multiple source addition and for further post-processing for auralization.

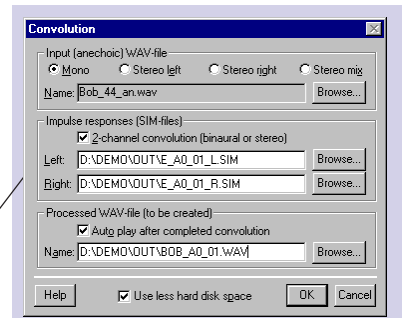
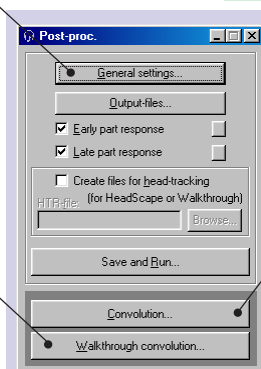
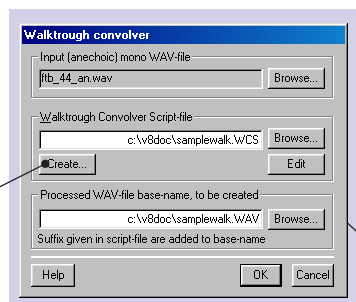
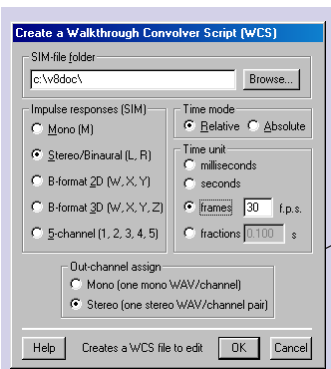
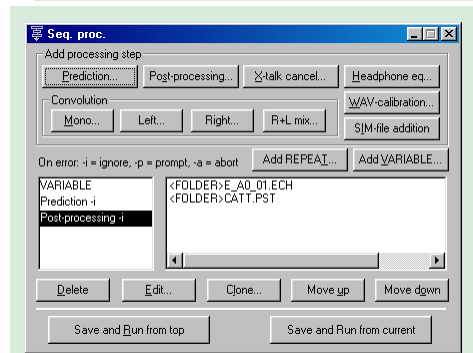
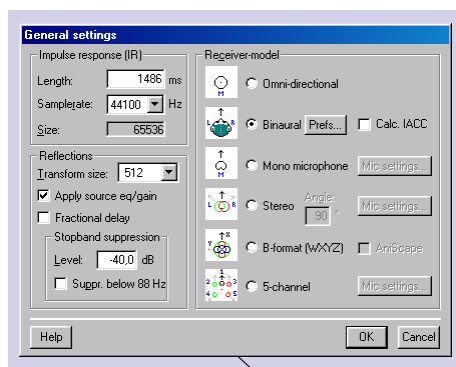


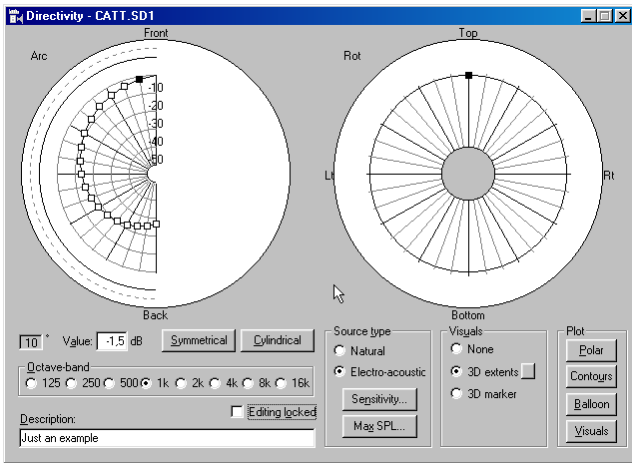
Based on results from the Prediction module, the Multiple source addition module creates sum echograms by addition of individual source echograms where source directivity, aim, eq, background noise and delay can be varied without need for a full recalculation. Source changes can also be applied to individual source echograms. The module optionally creates new data for multiple source auralization.



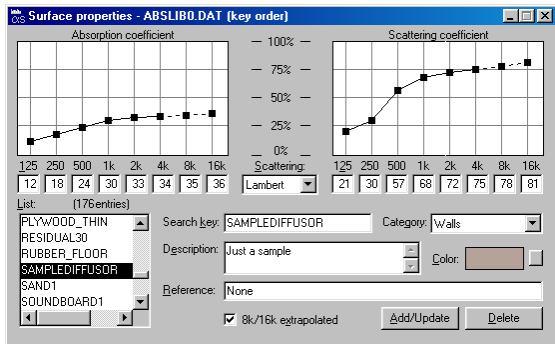
All steps from prediction over binaural post-processing, filtering to convolution and WAV-file calibration can be performed in "batch" using the Sequence processing module. Sequence merge, re-arrange, loops and string variables give flexibility and power.

Octave-band echogram reductions, created by the prediction module, are via DSP procedures and HRTFs transformed to binaural reflections creating a binaural impulse response to be convolved with anechoically recorded material - auralization. The Post-processing module offers many other post-processing options (mono, stereo, B-format, 5-channel), multiple source auralization, fast convolution, walkthrough convolution, crosstalk cancellation, headphone equalization, and an assortment of file format conversions, scaling, filtering, samplerate conversion and calibration utilities as well as a WAV-file player with A/B and a playlist.

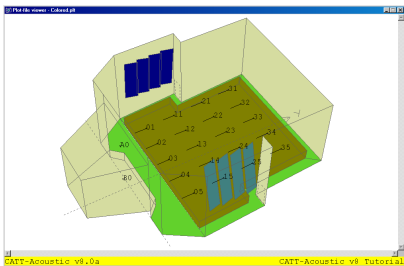




Source directivity is either imported from measured 10° full-space data-files, run-time simulated via a DLL-interface (DDI, with array modeling including handling of the near-field) or interpolated from simple 15° polar data.

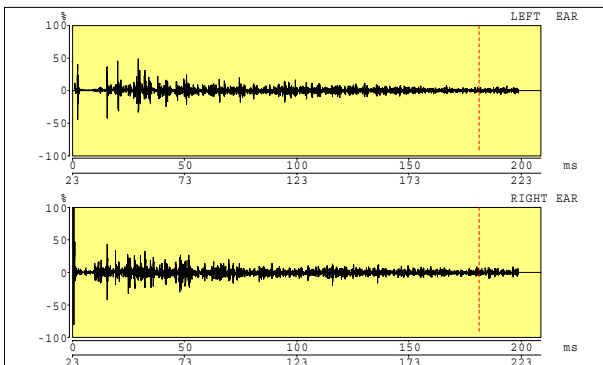
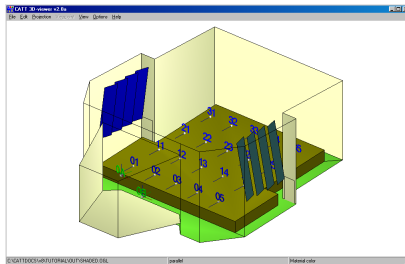


Named surface properties are either managed by the **Surface properties module** or entered directly into geometry-files. Each user can have his own private library selected in Prefs.

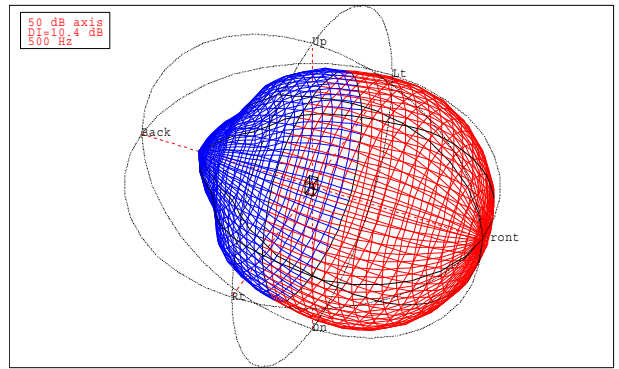


Graphical output can be transferred over the clipboard (Meta and Bitmap) or be exported in EMF, BMP and EPSF formats. Plot-files can be viewed in sequence interactive or automatic and with auto-

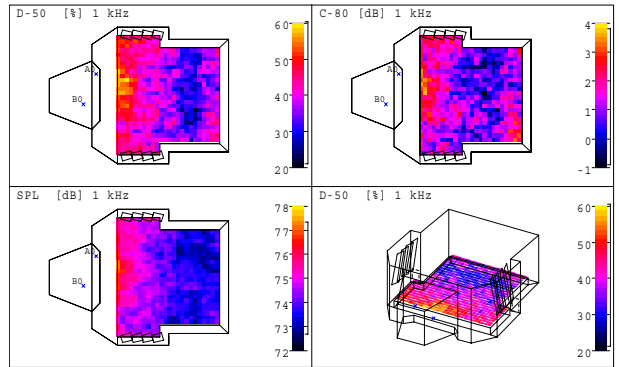
playing WAV-files attached to plots. A stand-alone plot-file viewer can be used for customer presentations. The stand-alone *OpenGL*-based 3D-viewer offers enhanced viewing with variable lighting and many options such as surface color coding.



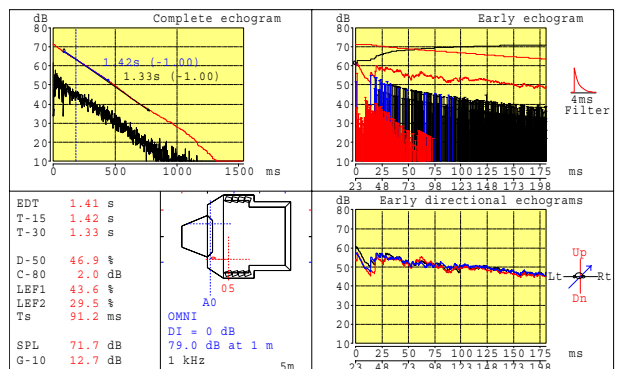
Synthesized binaural room impulse response



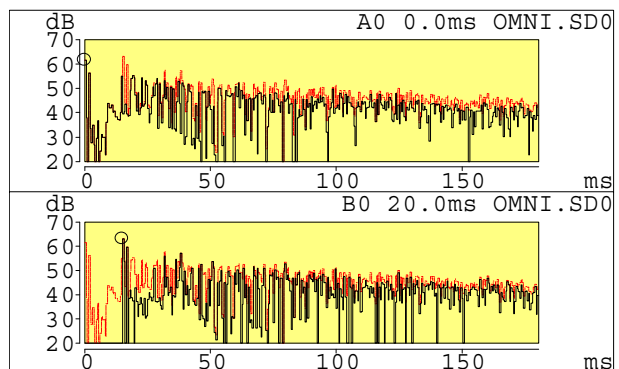
Directivity balloon, 10°-format (sampled every 5°)



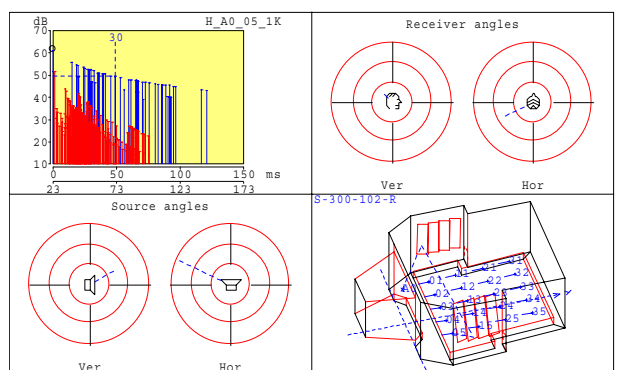
Audience area color mapping (palette can be selected)



Full calculation echograms (RTC-II)



Source addition: individual + total echograms



Interactive specular reflection path analysis (ISM)

General Prediction Methods

*CATT-Acoustic*TM v8 employs a unique and general prediction method introduced with v7 and baptized Randomized Tail-corrected Cone-tracing (RTC-II), that combines the best features of the Image Source Model (ISM), Cone-tracing and Ray-tracing. All

methods take into account frequency dependent diffusion (the ISM for first order reflections): walls, or parts of walls, can be assigned frequency dependent absorption, surface and edge scattering, and transparency coefficients. Due to the frequency dependence of diffuse reflection, separate ray/cone-tracing is performed for each octave. With RTC-II, direct sound and 1st+2nd order specular reflections are handled deterministically using the ISM while 1st order diffuse reflection is handled by direct reflection from diffusing surfaces. Higher order diffuse reflections are handled by randomly distributing rays that hit diffusing surfaces. Dedicated ISM can be used for qualitative early reflection analysis while standard Ray-tracing is used for audience area color mapping. Predictions are made for up to 260 sources, 100 receivers and 8 octave-bands (125 Hz - 16 kHz, the 8 kHz and 16 kHz bands are extrapolated if no data is available). In a round-robin test on computer modelling software, only three out of sixteen software were judged to give reliable and useful results¹. Of these three *CATT-Acoustic*TM (v5) had the best results for five of the eight measures calculated, methods employed by v7 and v8 are of a more general nature and give overall even better results.

Efficient Multiple Source Handling

After echograms have been predicted for a number of sources, new results for an arbitrary combination of these sources can be created very rapidly which changed source directivity, aim, level, eq, delay or background noise. The results of an optionally coherent source addition can be carried over to the binaural post-processing stage allowing for multiple source auralization e.g. for sound reinforcement systems. After binaural post-processing individual source delay and gain can still be varied when adding sources together.

Advanced Geometry Description

Free-format hierarchic geometry files with comments - makes it possible to structure the model. Symbolic constants, arithmetic expressions and mathematical functions can be used to specify coordinates - makes hall dimension adjustments

easy, safe and accurate. Several tools to create a consistent model are provided: Conditional statements · Automatic locking of corners to surfaces · Definition of corners as the intersection between a line and a surface · Scaling · Copying · Mirroring · Rotation · Loops. The geometry format enables a very high degree of control and flexibility. In addition, non-acoustical marker elements can be used for details such as 3D text, actual shape of diffusers etc. Alternatively, *AutoCAD*TM drawings can be exported to *CATT* format by specially designed *AutoLISP*TM procedures enabling the complete model to be input directly in *AutoCAD*TM (a DXF import is also available). Models in *CATT* format can be exported to *AutoCAD*TM and to the Virtual Reality Modeling Language (VRML 2.0) for interactive 3D presentations (on local or internet homepages) optionally including auralized sound.

Source Directivity

Source directivity is handled via the common measured full-space 10° format, a 15° polar format or via a DLL Directivity Interface (DDI), enabling array modeling including near-fields and beam steering of e.g. *Duran Audio Intellivox*TM, *L-Acoustics dV-DOSC/V-DOSC* and *NEXO GEO*. Polar patterns · 3D balloons · -3/-6/-9 dB contours · DI calculation · Source and array visuals · Graphical editing · Text import/export.

Room Acoustic Measures

Early Decay Time (EDT) · T-15 · T-30 · Eyring and Sabine (interactive) · SPL (also dBA) · Strength (G) · Speech Transmission Index (STI/RASTI) · Definition (D-50/C-50) · Clarity (C-80) · Lateral Energy Fraction (LF, LFC) · Center of Gravity (Ts) · Inter Aural Cross-correlation Coefficient (IACC, after binaural post-processing) · Mean absorption factor and mean free path · Measures can be normalized with expected values · Spreadsheet export.

Graphics

General: 3D models with selectable shading palettes (natural, parallel, and camera with variable lens) or actual surface colors · x-y, x-z, y-z views · Interactive source information including -3/-6/-9 dB contours · Reflector coverage contours · Animated calculation of rays and echogram. **ISM:** Interactive reflection tracing · Echograms (dB-scale backward and forward integrated, linear, “ear-integrated” with Sone scale) · Image source 3D space. **RTC-II:** Echograms (full-length, detailed, detailed directional, smoothed, backward and forward integrated) · Vectorgrams · Sound roses · Absorption statistics · Reflection path statistics · Interactive wall hit statistics · Reverberation decays · Room acoustic measures overview and trend · RASTI · STI · Octave-band Transmission Index · Animated rays and echograms. **Ray-tracing:** Direct sound, Early part SPL and LF mapping · Color mapping of most measures (T³, SPL, G, STI, RASTI, D-50/C-50, C-80, LF, Ts, source delay, closest source group) · 2D and/or 3D maps with selectable scales/palettes · Animated rays and maps. **CATT 3D viewer:** see front page and previous page.

Advanced General Auralization

Binaural post-processing with measured and analytical HRTFs · Headphone equalization and HRTF library selectable in Prefs · Loudspeaker replay via cross-talk cancellation · B-format processing (for *Ambisonic* replay) · Stereo processing (e.g. *Blumlein* pair) · Mono microphone processing (e.g. *Cardioid*) · 5-channel processing (arbitrary mic. configurations) · Binaural 5-channel replay simulation · File conversion utilities (use e.g. *MATLAB*[®] or *MLSSA*TM FIRs) · Samplerate conversion · Filtering utility · Real-time speed convolution with anechoic music/speech without need for specialized hardware · Walkthrough convolution enabling high-quality auralized soundtracks to be synchronized to a graphical walkthrough · Anechoic and processed material utilizes *Windows*[®] WAV format · 44.1 and 48 kHz operation (conversion to 88.2 and 96 kHz) · Optionally use *Lake Huron*TM or *CP4*TM convolution processors for real-time operation, head-tracking and VR applications² · Natural-sounding late reverberation is created based on the actual room model using principles similar to those in *PureVerb*TM (that with *MultiVolver*TM forms *The FIRverb Suite*TM made for studio/VR reverberation and is used e.g. by *Deutsche Grammophon* to enhance too dry recordings - see separate sheet).

Software Versions

*CATT-Acoustic*TM v8 versions: **A:** full prediction/demo auralization, **B:** full prediction/full auralization including *The FIRverb Suite*TM and a CD with anechoically recorded material, **C:** B with additional functionality for *Lake² Huron*TM/*CP4*TM users (5-channel binaural simulation, HRTF and headphone eq. compilation from measured data, *AniScape*TM and *HeadScape*TM support, analytical sphere HRTFs creation). For all versions research/education discounts are offered. A fully working demo, including auralization, is available for download.

References

¹M. Vorländer, “International round-robin on room acoustical computer simulations”, Proc 15th ICA pp. 689-692, Trondheim 1995, ²Lake Technology Ltd., Sydney, Australia, <http://www.laketechnology.com>

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