CATT-Acoustic v9.1 with *TUCT* v2.0
Information on improved prediction methods, changes and added functionality

Introduction

This document is only a bare-bones outline of the news, during development extensive previews and beta testing has been available. Released February 12 2016.

Overall changes

The DLL Directivity Interface (DDI) (SD2-files) for array modeling, in use since 1998, will no longer be developed but is replaced by a new and fundamentally improved source and array handling using a flexible open array text-file format (**C**ATT-Acoustic **T**ext **A**rray, CTA) that after pre-processing is saved in a binary format (**C**ATT-Acoustic **B**inary **A**rray, CBA) used at actual prediction in *TUCT* v2. The CTA-format allows using symbolic numerical and string constants and expressions, element filters (several formats including encrypted), delays, polarity reversals, weights and more. A unique and simple way of modeling line-arrays with high-frequency line wave-guides, or other line elements, via modular **L**ine **EL**ements (LELs). The CTA-format can also be used to create incoherent arrays such as for noise line or array sources. CTA/CBA-files can have dedicated help (Directivity module Help button) via a file with the same name but with an extension `.PDF`, `.HTM`, `.CHM` or `.TXT`.

A new source-file format using `SOURCE` data blocks to support the new source and array modeling.

To support old projects, that used the DDI, the v9.1 installation will also include the last version of *TUCT* v1 (v1.1b) adapted to work with v9.1. Which *TUCT* version that will run depends on the source-file syntax used (`SOURCEDEFS` → v1, `SOURCE` data blocks → v2).

When using natural sources, such as an ideal omni for basic room acoustics, it only requires adapting to the new source format syntax that for natural sources is straightforward and all the added functionality and improvements with *TUCT* v2 will be available.

When using electro-acoustic sources and arrays the new syntax is more involved since it also means a paradigm shift especially regarding arrays but will give many benefits for sound-system predictions in addition to also be able to use the many *TUCT* v2 additions.

CATT-Edit templates and basic conversions from the old format is available.

The *DEBUG* and *ERROR* windows keep their positions when moved and closed.

v9.1 comes with new printed manuals, *CATT-A* and *TUCT* now due to size in separate binders.

New functions with *CATT-A* v9.1

General

· Long directivity file names (including long SD sub-folder names), extended from 15 characters + extension to 50 + extension (also for *TUCT* v1.1b as included with v9.1 at release). For some displays long names have to be shortened. SD2-files for the DDI interface can also have long filenames but since the DDI-interface is no longer developed any directivity-files *used* by the CATT_Generic ARRAY0, and some other DDI models, must still only use short filenames.

· Saves the project (input) folder path in the CAG-file, can be viewed via *TUCT* v2 **Utilities | CAG-file Room Info**.

- *Preferences* options to select dialog font and size as well as PL9-file and screen graphics font size. Selecting a large size will create larger dialogs and is mainly intended for presentations or to adapt to hi-res screens.

- An option to shut down *TUCT* after completed calculation (**Predict SxR** and **Map measures**) . Can be used to shut down the PC after a certain time.

Directivity module

- Editing of the CTA array format and additional array-related displays. Array data list item number (and file line number) readout for finding an error line in a CTA-file. CTA syntax reminder button and syntax shortcuts on main window. The plot-file created by **Utilities | Show Array Elements** has animation frames where details of each element are show.

- The CTA format is described in a dedicated manual/help appendix including examples of passive column arrays, DSP-steered column arrays, curved line arrays with hf line elements (using LELs), ribbon element column arrays, incoherent arrays.

- The array modeling itself is fully functioning also in the demo version to allow manufactures to develop export to the CTA format from their direct sound software, or to supply CBA-files. Actually using the arrays in *TUCT* requires a license.

- A dialog (**Show IR/FR**) showing the impulse and frequency responses of an array at selected distance and angles, with or without air absorption. IR zoom and display auto-scaled or fixed scales. IR export to WAV or MATLAB format.

- A *Slice rendering* dialog where a combination of the vertical, the horizontal and the frontal plane of an array can be rendered (frontal and horizontal plane can be moved). Optional long aim-lines. Video export.

- In **Show IR/FR** and **Slice rendering** dialogs the input voltage can be selected.

- An option to encrypt a CTA-file. The resulting CTA-file can be viewed but not edited. The corresponding option will be available via a small DLL that array manufacturers of DSP-steered arrays can call from their direct sound software to create an encrypted version from a created temporary plain CTA-file.

- The **File | Open Directivity and Save As** dialogs use a new two-pane dialog (SD-folder/subfolder vs filename) for simpler navigation and browsing of content. The *Save As* dialog also allows for creation of SD sub-folders.

- A *Polar options* dialog has a direct options for drawing with heavy polars or transparent background. CTA and CF2 horizontal and vertical polars can be displayed alone (useful for comparison to measured array directivites in CF2 format). CF2 files are displayed as 1/3-oct: 5º, CTA polars can be displayed at 1/1-oct, 1/3-oct or both. 1/3-oct polars (CF2 and CTA) creates an anim PL9 where the first frame is as showing all 1/3-octaves but to better see details the next three frames show only lower, center or upper 1/3-octaves in each 1/1-octave. Enables clear direct overlay comparisons between an array measured as CF2 and the same array modeled as CTA at the measurement distance. Extensive use of overlays during development to compare to measured arrays.

- CTA array simulation balloons are displayed as 1/3-octave.

- CF2 balloons are displayed (and used) at its inherent 1/3-octave resolution.

- Mouseover values (when pressing SHIFT) on directivity balloons.

- All types of directivities calculates and displays DI for all bands (not just the current selected one as v9.0) and the numbers can be copied.

- Sensitivity display with graph and data export. For CTA Sensitivity can be evaluated at a selected distance or start of farfield and referred to 1 m. Sensitivity for arrays of some size is not so meaningful (Sensitivity assumes a point source) but is useful for comparing to the same array measured.

- *Balloons* and *Slice Rendering* color palettes based on the default *TUCT* palette.

- Indicates the Mechanical Reference (MR) position of a CLF2 v2 directivity to the source/array visuals, as well as the source point (which the 3D balloon is measured around) in array source/array visuals, useful if MR positioning is used.

- Limited export of CATT_Generic DDI arrays to CTA (the source and aim positions mainly)

Modeling module

- More responsive when checking the geometry and creating geometry plot-files for complex models.

- Mouse-over readout on the *Interactive RT estimation* RT graph and general graphics copy.

- A more stringent division of sources as being coherent (typically loudspeakers that can interfere with each other) or incoherent (typically noise sources or other natural sources that can not interfere)

- **Utilities | Creating a New Project** uses `SOURCE` blocks for the *TUCT* v2 source-file but also includes, at the end, the `SOURCEDEFS` way for projects that may use the old *TUCT* v1

- A previously defined corner in the `CORNERS` section of a GEO-file may optionally be overridden to get a different coordinate:
    ```
    11  2.0 3.2 1  OVERRIDE
    ```
  Typical use would be if in a `loop()` where, due to numerical issues, an x-value that ought to have been exactly zero turned out to become say 0.0000001 and makes a plane be mirrored (if using `MIRROR`) when it should not.

- If a `GLOBAL` string variable called `CAGCASE` is defined it will be appended to the *General settings Project name* used for the CAG-file name. This can be used to better track and document variations of the same basic room such as material changes. An example: if the *Project name* is `"School"` and `CAGCASE = "absorbing ceiling"` the CAG-file name will be `School (absorbing ceiling)_n.CAG`. If each case has many variations instead us e.g. `CAGCASE = "case 1"` and document in the GEO-file what case 1 is comprised of.

- `SRCINFO3D.PL9` displays long aim lines (intersecting the closest surface). If an aim line hits a plane the hit point is indicated by a circle in the plane (similar to *TUCT Image Source Model* reflection point circles). It also colors audience planes grey.

- `VIEW4.PL9` is now a file with anim frames, the first frame is the same as in v9.0, the three subsequent frames show the side, top and end views full window, i.e. at twice the size.

- Source-file data for an electro-acoustic source or array has two options, one for line-in specifying `LvIn` in dBV, and one for acoustic input such as a voice where `Lp1m_a` (like a natural source) where also `MICSENSITIVITY` has to be given. Shortcuts for `LvIn` use `Lv_`... (e.g. `Lv_pink 9`) while shortcuts for `Lp1m_a` use `Lp_`... Also `LvIn` can use the STI IEC speech shortcuts but starting with `Lv_`.

- Plane id set selections (e.g. Audience planes), sets can be saved and loaded.

- Entered values for `GETLOCAL` and `GETGLOBAL` are shown in the *DEBUG* window to better keep track of what values have been given (the contents of the debug window can be copied if the selections need to be further documented)

- Speech level shortcuts for use with Articulation Index (AI) and Privacy Index (PI) based on ASTM 1130-08 normal and raised peak voice levels (`Lp_voice_AI_normal`, `Lp_voice_AI_raised` and `Lv_` ditto). AI and PI are implemented in *TUCT* v2

- **File | Export Source-file for TUCT2 Use** exports a current source-file using the `SOURCEDEFS` syntax for *TUCT* v1 to on using the `SOURCE` data blocks for *TUCT* v2 (electro-acoustic sources need to be edited and completed)

- Mouseover basic plane info (when pressing SHIFT) for the `Colored.PL9` file. For more plane details use `Plinfo.PL9` as before.

PL9-viewer module

· 3D windows can select background color, useful in some cases for better contrast. Not used for printing, copy as Meta or copy as PL9. Hidden feature: hold down Ctrl and click *[R]*

New functions with *TUCT* v2

In addition to using the new source- and array-handling, which in *TUCT* is mainly "under the hood", a number of additions have been made.

General

· **File | Save Modified CAG As** gives options to save a new case with 100% specular surfaces (all scattering coefficients set to zero) or 100% diffusing surfaces (all scattering coefficients set to 100%). These two options are useful to check how mixing the geometry is. If T-30 comes close to Sabine with 100% scattering there are no overlapping surfaces. The Sabine values are a good reference for the shortest possible late RT. These options have previously been internal only to help checking the behavior of models received from users.

· **File | Save Modified CAG As** allows for changing the audience mapping planes, an alternative to creating a new CAG-file via CATT-A

· Air absorption uses a distance-dependent filter for direct sound and 1st order specular instead of only octave-band values.

· Air absorption on/off in all prediction functions. Air absorption is normally always on but if for some test it has been switched off as a reminder it is indicated by ~~aa~~ (i.e. ~~air absorption~~) in the upper right corner of result windows.

· *Max/Range* +/-/? scale buttons are now used in most functions.

· An audience area mapping result display option to view a subset of audience plane map results and where Statistics is calculated, and exports are made, only for the subset selected. This option works independently of the selection of layers (if z-overlapping audiences such as balconies exist). Subsets can be saved and recalled.

· **File | Import Prediction Settings** imports prediction settings from another project (from a *Projectname*_predictionsettings.DAT file). These settings are associated with the Project name (in CATT-A General settings) so if a project is the same in principle but a variation is created, using a new Project name, the previous prediction settings can be imported to be the same as the previous project. **Notes:** 1) the new settings are not saved with the new project until a prediction is actually made, 2) settings will not be imported if old results for the prediction type (e.g. Predict SxR) already are loaded.

· When background noise dBA and NCB is shown with a measure based on a limited frequency range (STI:125|250..8k and AI, PI: 250..4k) it is based only on the frequency range used.

· Support of long directivity file names, v1.1b as well.

· 3D windows can select individual background colors (sometime useful e.g. when many sources are displayed in the ISM module to increase contrast). Hidden feature: click the [...] button while holding Ctrl. Not used for printing, copy as Meta or copy as PL9.

· More stringent when it comes to mixing incoherent natural sources and coherent natural sources and electro-acoustic sources (typically assumed coherent) regarding IR summation *(*xR)* and interference. Some cases are blocked and some give warnings.

· Prediction is blocked if a used directivity file has been changed after a CAG-file was loaded (the CAG-file then has to be reloaded and saved).

· Warning if old results are loaded and a directivity file that was used has been changed after the calculation was made (the shown result may then not match what the current directivity files imply).

- Prediction is blocked if a used loudspeaker directivity file has no Sensitivity (can happen with powered CLF speakers) and it has to be specified (CTA element SENSITIVITY, for a single source it can be made a single element CTA).

- Changes and additions due to ISO 3382-1:2009: L_j implemented (in *TUCT* v2 called L-J, Late lateral sound level, but a better name would have been Late lateral strength) and for ST source and receiver can now both be either at 1 m height (as v1) *or* both be at 1.5 m height. Lateral efficiency is now (for some reason) renamed to J_{LF} (in *TUCT* v2 called J-LF)

- Implementation of Articulation Index (AI) and Privacy Index (PI) based on ASTM E1130-08. These measures have some fundamental issues unless rooms are very dry, and also for a useful implementation such as mapping, that are discussed in the documentation.

- Preferences options to select dialog font and size as well as PL9-file graphics font size. Selecting a large size will create larger dialogs and is mainly intended for presentations or to adapt to hi-res screens.

- All direct sound map/rendering functions and all measure and rendering color maps show white dots on top of the saturated scale colors if values are outside of the selected scale min/max.

- To make it easier to adjust the receiver heights when Predict SxR is run, and any receiver is < 0.3 m from a surface or edge, all receiver distances are listed (using receives close to surface require using more rays that what otherwise is necessary) . Note that within GEO lock() can be used to place receivers at a desired height also over slanted surfaces. Also added to v1.1.

- In all EDT, T-15, T-20 and T-30 predictions it is ensured that the length of the echogram corresponds to at least 10 dB below the end of the range (e.g. for T-30 -5..-35 dB the length has to correspond to at least -45 dB). A reason for this is that since a simulated decay has no background noise it can estimate e.g. T-30 even if the decay is too short (the Schröder integration starts from zero instead of at a background noise level giving a very fast decay drop at the end). Also added to v1.1b.

Predict SxR

- Stage support (ST) also calculated for the IR (h). Indicates ST's problem regarding interference with the 1st order floor reflection.

- **Utilities | ?x? Measures | Show Graphs**: displays selected measures as function of receiver id, distance from source (r or $\log_2(r)$) for any combination of sources and receivers, octave-bands, A-weighted and linear, E and h.

- Both E and h include direct sound, 1st order specular and diffraction (if on) interference

- E-based Lateral Fraction, J-LF, now also includes diffraction (if on)

Map direct

- With *SPLdir* using **Edit | Copy 3D | To PL9-file** gives options to save all bands, where each band map becomes an anim frame, optionally either using the current color scale or auto-scaling each band. This serves as way of saving results in cases where the processing has taken some time (such as several curved line arrays where each box uses a LEL or when a small map step is used). An alternative is to use Map measures special case with direct sound only (number of rays = 1) where old results can be recalled.

- Mouse-over direct sound *Spectrum* á la Map measures *Spectra*

Map measures

- C-7 implemented also for audience mapping

- C-7 display option for audience mapping mouse-over *Echogram*

- *DLf*, *DL2* and *DL lines* indicates a 4 m radius circle around the source (black/white alternating color) that can be used as a mouse-over guideline for the $L_{p,A,S,4m}$ measure.

·   DL lines draws the line in the 3D model marking the d1 and d2 region limits. This addition makes it possible to copy the 3D window with the line shown and the 2D window with the regression along that line.

·   A new option *SPL(t1..t2)* where the direct and pseudo-direct sound (such as a stage floor reflection) can be excluded and only up to a selected upper time can be included, e.g. 1..50 ms or 5..80 ms. This is similar to the old v8 mapping in time intervals but more flexible and works afterwards with an ordinary saved map.

·   Using a noisemap normally requires using **File | Save Modified CAG-file As** to create separate compatible _signal and _noise CAG-files that have the same internal date/time stamp on both to ensure they represent exactly the same room/map case. Unfortunately it requires recalculating the noise map also if only a new or changed sound "signal" system is used. Therefore the date/time checking is now relaxed so that if a difference between the "signal" CAG-file and the noise map-file is detected a confirmation is required that the user knows it is the same room/map case. If a Sequence is used confirmation of a date/time stamp mismatch is not requested (since it will block the sequence) but if the map points do not match then the noise map will not be used when looking at the results.

·   *EDT* min regression coefficient lowered from 0.95 to 0.70 (the 0..-10 dB decay is seldom linear especially not close to a source or on axis of a directive source, a fundamental problem with the EDT measure, a linear regression on a curve that is often not very linear)

·   *T-15* and *T-20* also implemented for mapping

·   Includes direct sound, 1st order specular and diffraction (if on) interference

·   *Direct only* option removed, instead use the special test options with number of rays set as 1, 2 or 3 for direct, 1st order, or direct + 1st order. Special tests are now also saved but separately from full mapping calculations.

·   Mouse-over *Echogram* shows the full length (instead of the early part only) with Schröder integration and optional EDT, T-15, T-20 or T-30 values and line regression, graphics and data export.

Main:Show2D

·   *Echogram*s can be shown for E and h (default, as v1), only E (as v1), only h (added for v2)

·   *Echogram / Polar* has octave-band displays (previous versions were based on the full impulse response)

·   *Echogram / Directional* has octave-band displays (previous versions were based on the unfiltered impulse response)

·   *Echogram*s can optionally also show direct and 1st order specular as bars (if an array element has filters the bar time-position is adjusted by the filter group delay)

·   The *Plan/Section* display can optionally hide the receivers (not so useful to see if mainly mapping is used)

Main:Show3D

·   the *Src aim* option now displays long aim lines (intersecting the closest surface), with the option off the short aim lines are shown if *Src point* is checked (as in v1 with the *Src aim* option off). If an aim line hits a plane the hit point is indicate by a circle in the plane (similar to Image Source Model reflection point circles)

·   Mapping results *Fast (dots)* option removed (of little use)

·   Mapping results *sum(A)* option moved, it is now instead added to the *Band* menu

Pixel Rendering

·   Runs multi-threaded.

·   Shows mouseover SPL complete spectra of values (current map band marked)

- Calculates all 1/1-oct bands directly (changing band no longer requires a new calculation)

- Rescaling no longer requires a new calculation

- Also shows lin and A-weighted sum of all bands

- Locking of the display so a render is not accidentally lost (double-click display to unlock)

Surface Rendering

- Runs multi-threaded.

- Shows mouseover complete spectra of values (current map band marked)

- Using **Edit | Copy 3D | To PL9-file** gives options to save all bands, where each band map becomes an anim frame, optionally either using the current color scale or auto-scaling each band. This serves as way to save results in cases where the processing has taken some time.

- Calculates all 1/1-oct bands directly

- Also shows lin and A-weighted sum of all bands

Vertical Slice Rendering *(new module)*

Similar to Surface Rendering but here the vertical coverage of loudspeakers can be illustrated via rendering of the direct SPL over a moveable and rotatable transparent vertical surface.

- Runs multi-threaded**.**

- The slice can be selected to show the vertical radiation of a selected source.

- Shows mouseover complete spectra of values (current map band marked)

- Using **Edit | Copy 3D | To PL9-file** gives options to save all bands, where each band map becomes an anim frame, optionally either using the current color scale or auto-scaling each band. This serves as way to save results in cases where the processing has taken some time.

Time trace

- Rays can be limited to those that have a first order hit on defined set of planes allowing for studying reflector or special wall reflection coverage. Plane sets can be saved and loaded.

- Instead of only following all rays as a function of time, rays can also be shown one by one for its full length (similar to *CATT-A* v8 ray animation).

- The *Save AVI* option now uses a suitable compressed video format by default

- Traces shown from each sub-source (array-element), a way to see element delays

Image Source Model

- An option to exclude all IS contributions below a selected SPL. Holding down Ctrl while changing *IS limit* suppresses redrawing. Note: A potential danger with this option is that too much emphasis is put on the strong reflections since a major part of the acoustics of a room is also the smoothness of the echogram and it is the many weak reflections that "fill in" the gaps and create a more smooth echogram shape giving less coloration.

- Optionally shows *Early pressure sum* of array-elements (direct and 1st order specular).

- Shows an upside-down reflection histogram at the top of the graph, one y pixel per "hit" (useful for arrays mostly where arrivals from elements may overlap)

- Indicates currently used *Bar color*

New functions with other software parts

CATT-Edit v2.3

· Adds a new menu **Template | SOURCE block** (and data) for inserting source-file SOURCE blocks and shortcuts. The corresponding menu for *TUCT* v1 is now called **Template | Source (for old TUCT v1 projects)**

External PL9-viewer

· 3D windows can select background color, useful in some cases for better contrast. Not used for printing, copy as Meta or copy as PL9. Hidden feature: hold down Ctrl and click [R]

MulltiVolver WCP

· Logs settings used to a text-file *basename_wav_MV-WCP_info.txt* so that it can afterwards be checked what the resulting WAV-file was created from. The info given is: MVF-file used, overall gain, input WAVs (name, gain and WAV-channel used), and resulting margin.

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