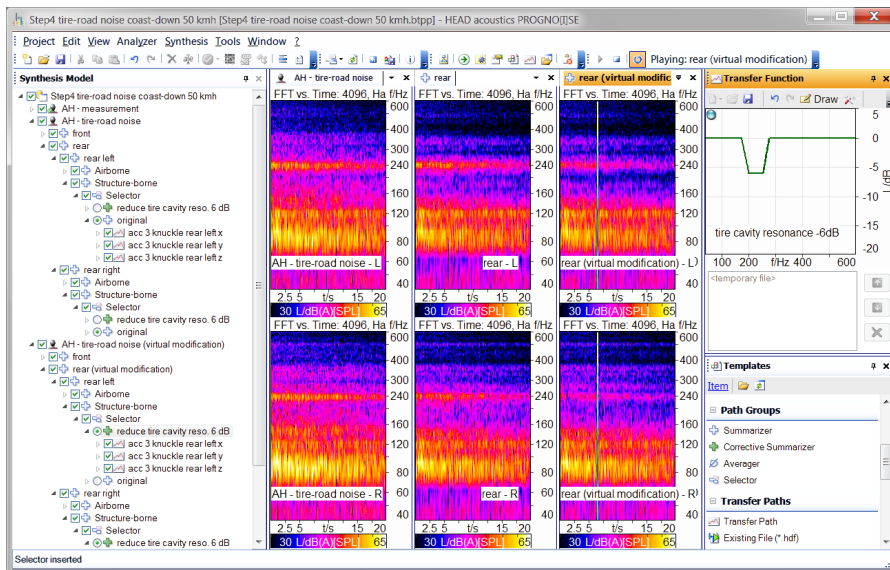## DATA SHEET

## PROGNO[I]SE (Code 4914)

Binaural Transfer Path Synthesis (BTPS) software



## Overview

PROGNO[I]SE is a software for performing BTPS (Binaural Transfer Path Synthesis).

Synthesis in PROGNO[I]SE is based on excitation signals measured during a transfer path analysis (time-domain data measured in the operating state) and transfer functions. The individual transfer functions (e.g., mounting transmission, apparent mass, or acoustic transfer function) are combined and assigned to the respective input signal. For each node on the transfer path, the corresponding time-domain signal can be determined, analyzed and auralized.

The model structure can be custom-defined in PROGNO[I]SE, so it is not only possible to calculate an engine compartment / passenger compartment BTPS, but also to define, for example, a model for calculating windshield wiper noise or suspension excitations, or even a model for the noise transmission of refrigerators. Furthermore, multiple receivers can be defined, which allows, for example, seat and steering wheel vibrations to be synthesized and optimized.

For calculating transfer functions using only operating data without additional measurements, the software also supports Operational Transfer Path Analysis (OTPA). The OTPA Wizard guides the user, step by step, to a PROGNO[I]SE model, which can then be used in the familiar way.

Using the TPA Project of ArtemiS SUITE, the required input data can be created. The TPA Project allows the creation of the transfer path analysis for airborne or structure-borne paths according to the Matrix Inversion Method. Step by step, the software guides the user from the model setup to the measurements and the calculation of the transfer functions up to a completed PROGNO[I]SE project.

## Features

- Synthesis of binaural or monaural sounds for one or several recipients (airborne and structure-borne sound), based on transfer functions and stimulus signals
- Flexible component-based modeling allowing any combination and synthesis of individual transfer paths, path groups or the entire soundscape
- Operational Transfer Path Analysis (OTPA); requires PROGNO[I]SE Tool Pack 01
  - User-friendly OTPA Wizard for calculating the transfer functions
- Easy editing of the model structure
- Addition or removal of paths or partial models
- Automatic creation of transfer functions for the correction of coherent airborne sound signals
- Manual editing of transfer functions in the PROGNO[I]SE editor
- Playback of individual or all calculated results at any node of the model
- Contribution Viewer for the phase-accurate determination of sound components

- Insertion of synthesized orders, e.g. from simulation results, and accurate synchronization between existing and imposed orders
- Quadripole Wizard with Kelvin-Voigt model for the virtual exchange of engine mountings
- Audio signal analysis and export at any point within the model, export of complete models to ArtemiS Classic
- PROGNO[I]SE-Tool-Pack 02
  - Synchronization of non-synchronous input data
- PROGNO[I]SE-Tool-Pack 03
  - Indirect Force Determination with Matrix Inversion and determination of Effective Mount Transfer Functions
  - Matrix Inversion Method for airborne transfer paths
- Advanced processing possibilities and interactive playback of the synthesis with the ArtemiS Classic analysis software, in the SoundCar or during a real test drive with the H3S software
- Data import in HDF and UFF58 format
- Intelligent and powerful signal processing

## Operational Transfer Path Analysis (OTPA)

In conventional TPA, the required transfer functions are determined by means of additional, sometimes laborious measurements. OTPA calculates the transfer functions from operating data alone, without additional measurements. Using the OTPA Wizard, an OTPA model is developed, and after configuring the parameters, the transfer functions are calculated. With the resulting PROGNO[I]SE model, users can then work in the familiar way. The settings of the Wizard can be saved and restored in order to replace measurement data or to quickly change parameters. With 64-bit operating systems, the OTPA Wizard can process larger amounts of input data when calculating transfer functions.

OTPA is particularly suited for the analysis of tire noise. For examining engine noise, it is recommended to use measured transfer functions instead, as the strongly correlated signals from the engine would lead to errors in the calculation of the OTPA transfer functions.

In order to use the OTPA Wizards, the Tool Pack 01 (code 4915) is required.

## Configuration of the transfer path model

Even in the case of extensive projects with numerous transfer paths, the model of the corresponding PROGNO[I]SE is still easy to manage thanks to the graphical interface.

Each model is composed of individual binaural (or monaural) transfer paths and can easily be customized in a few steps using familiar commands, such as drag & drop and copy & paste. Furthermore, PROGNO[I]SE offers the possibility to create custom templates, which allow, for example, typical transfer paths to be inserted with a single mouse click.
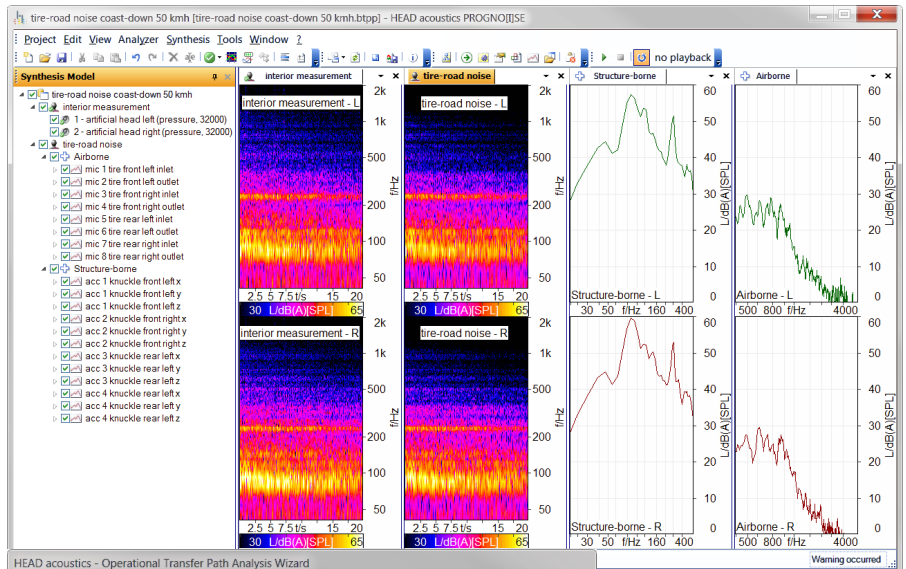


The OTPA Wizard creates a PROGNO[I]SE model that allows, for example, tire noise of a vehicle to synthesized.



In the OTPA Wizard, the model can quickly be configured from the channels of a measurement.
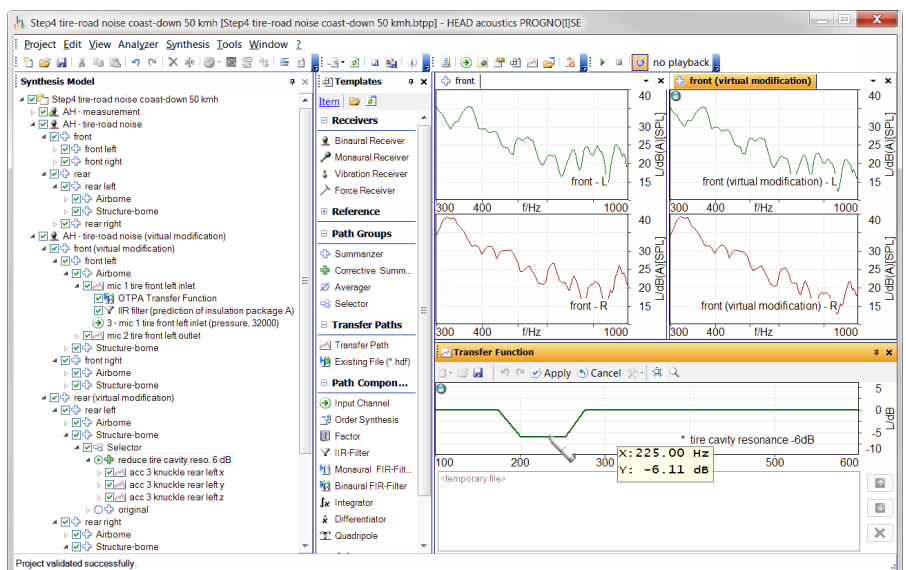


Even large models can be be managed easily with PROGNO[I]SE. Various tools are available for editing, e.g., for smoothing and inverting of transfer functions.

## Editing the transfer path model

Each transfer path is represented by a number of signal processing components, such as FIR or IIR filters and factors, which can be combined in unlimited ways.

The transfer paths can be combined into groups, in which the signals are either added or averaged. Such groups can in turn contain other groups, so many applications can be represented by multi-level hierarchies. With a tool called the Selector, alternative transfer paths (e.g., different exhaust tailpipes) can be interchanged with a mouse click and the resulting total soundscape can be calculated. In that way, the sounds of several subsystems can easily be compared.

## Calculation and playback of audio signals

A calculation run can be started from any node of the model, involving the respective subnodes. In that way, either the entire soundscape or partial sounds of individual transfer paths can be simulated. After a click on the calculate button, PROGNO[I]SE generates the audio signal of the selected node and saves it to disk.

PROGNO[I]SE generates the audio playback of a calculated node or all calculated results, as well as a time-synchronized cross-fading, during playback.

## Signal analysis

Integrated into the user interface is a signal analyzer that shows FFT spectrograms of the audio signals at various nodes of the model.

Furthermore, the transfer functions can be displayed in another section of the window.

By comparing the audio signals of results to those of intermediate nodes deeper in the model hierarchy, noise phenomena can be traced back to their actual origin.

For further examinations, for example, psychoacoustic analysis, and for interactive playback, the stored audio signals can be loaded into a suitable software (HEAD analysis software ArtemiS Classic, HEAD 3D Simulation System).
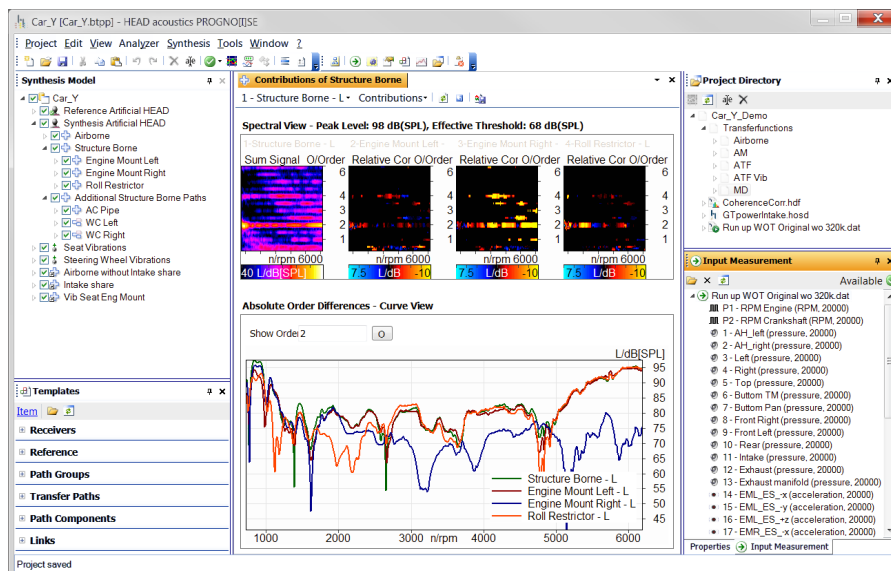


The Contribution Viewer shows the summed signal and all direct sub-elements by means of particularly prepared order spectra (upper diagrams). Also the representation of the order cuts (lower diagram) allows the quick identification of prominent noise components.
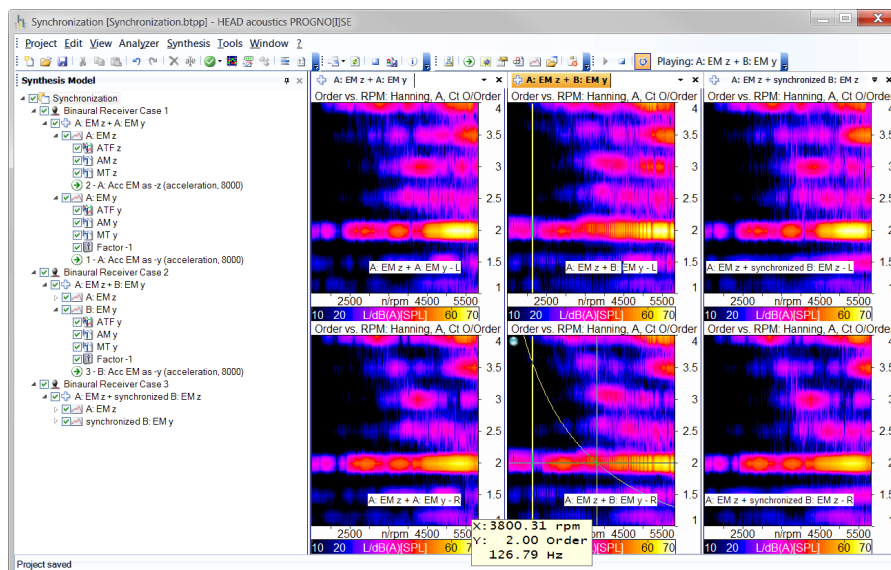


Reinforcements and cancellations (in the 2nd motor order), caused by a superposition of non-synchronous input data, can be prevented by synchronizing via order synthesis.

## Contribution Analyzer

The Contribution Analyzer allows a quick identification and visualization of prominent noise components. Specially-conditioned order spectra show the contribution of each sub-element to the entire soundscape. An intelligent threshold algorithm examines the represented paths and automatically determines the dynamic range.

Furthermore, the Contribution Analyzer shows phase-accurate sectional order views through all sub-elements. This shows which paths aggravate the entire noise situation and which do not change it. All results can be exported.

## Order synthesis

In order to synthesize authentic target sounds the sound synthesis must be as realistic as possible. With the Order Synthesis Wizard, calculated order curves can be applied to existing input measurements and processed further.

This can save the user a lot of time, as the order synthesis allows sound components from other measurements, simulation data, etc., to be integrated realistically into an existing PROGNO[I]SE model without additional, time-consuming measurements.

For the exact synchronization between the base signal and new sound components, customer-specific plug-ins can be used.

## Synchronization of input measurement data

Tool Pack 02 allows non-synchronous input data for a BTPA/BTPS model to be synchronized retroactively.

For example, if recordings for the development of a new engine type are made on different test benches, partial measurements of modified components are performed later, or the number of sensors or measurement channels is not sufficient, the recorded data of the separate recordings are not synchronized to each other. In particular, the revolution speed curves measured are not exactly identical, so a superposition of the filtered excitation signals can result in audible artifacts, such as beat frequencies, cancellations and increases.

To avoid such effects, a retroactive synchronization using Tool Pack 02 is required. Working with this Tool Pack is easy and intuitive. An Event Viewer verifies the correct configuration and indicates errors, so they can be easily located and fixed.

The synchronization of input data is not the only possibility to apply this method. It also allows engine run-ups to be slowed or accelerated retroactively. It is even possible to reverse the revolution speed curve.

Several similar measurements, such as different gears of the same gearbox, can be synchronized with corresponding recordings without creating new projects (Multiple Calculation).

## Quadripole Wizard with Kelvin-Voigt model

With the Quadripole Wizard, users can determine the dynamic stiffness of, for example, engine mountings. The required Z parameters can be taken from a measurement or calculated with the Quadripole Wizard based on a Kelvin-Voigt model with adjustable parameters. In that way, a virtual engine mounting can be included in an existing engine model. The Quadripole Wizard supports the virtual replacement and calculates the dynamic stiffness values, which are included in the engine model as filters.
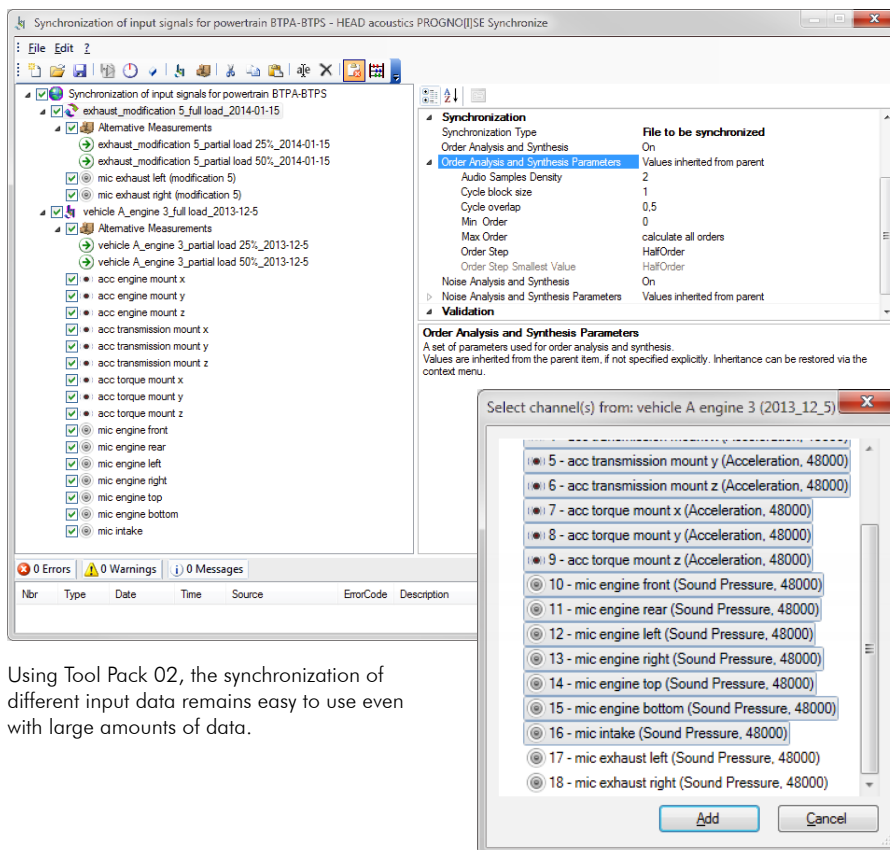


Using Tool Pack 02, the synchronization of different input data remains easy to use even with large amounts of data.

## Export and further processing with ArtemiS Classic

Partial signals as well as the complete synthesized soundscape can be further processed with the ArtemiS Classic analysis software from HEAD acoustics. For this purpose, the PROGNO[I]SE export function automatically creates ArtemiS Classic projects from the synthesis results and recreates the model structure of the synthesis in the Source Pool of ArtemiS Classic.

## Export and playback with the HEAD 3D Sound Simulation System H3S

The HEAD 3D Sound Simulation System (H3S) has a PROGNO[I]SE interface allowing the synthesized sounds of the PROGNO[I]SE to be transferred into the H3S software, where they can be played back and evaluated interactively. Playback via the H3S software is possible, for example, at a desktop PC, in the HEAD SoundCar or in a mobile variant of H3S, i.e., in a roadgoing vehicle.

For the playback with H3S, PROGNO[I]SE allows creation of link groups, which allow individual paths or path groups to be switched off, filtered, amplified or attenuated.

## Transfer Path Analysis
## (TPA Project of ArtemiS SUITE)

With the TPA Project of ArtemiS SUITE, Tool Pack 03 (Matrix Inversion) allows creating input measurement data for PROGNO[I]SE.

The TPA Project supports the two methods „Indirect Force Determination with Matrix Inversion" and „Effective Mount Transfer Functions". Using the Matrix Inversion Method for airborne transfer paths, the volume source of the sound source is determined indirectly from sound pressure measurements.

Step by step, the TPA Project guides the user through the model setup. First, the TPA model is configured in a clear tree structere in order to determine the receivers, the force introduction points, and the positions of the acceleration sensors. For determining the airborne transfer paths, the microphones and volume source locations are specified. The channel names to be used for the impact measurements are automatically generated from the TPA model so that a clear assignment from the measurement channels to the measuring positions is possible.

The remote control of the HEAD Recorder (ArtemiS SUITE Data Acquisition Module - ASM 04) supports the execution of the transfer function measurements: impact measurements for structure-born paths and measurements using a volume velocity source for airborne paths. Each successful transfer function measurement is automatically visualized in the tree structure. In addition, the transfer functions and coherences can be presented to verify the measurement.

The indirect force determination or the volume source determination can be configured flexibly by selecting only a part of the paths and sensors if needed (separate calculation of subsystems). In addition, the crosstalk between paths can deliberately not be taken into account if, for example, the signal-to-noise ratio in the impact measurements is insufficient.
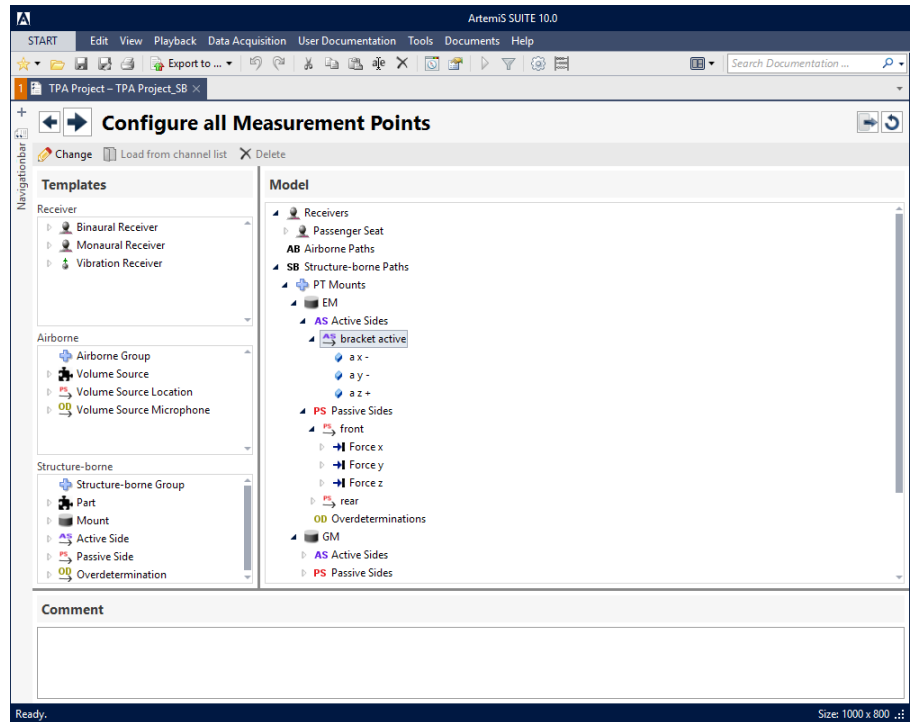


For creating a TPA project with ArtemiS SUITE, the convenient tree structure facilitates the procedure. Via drag and drop, the templates can be moved from the left side into the desired composition.
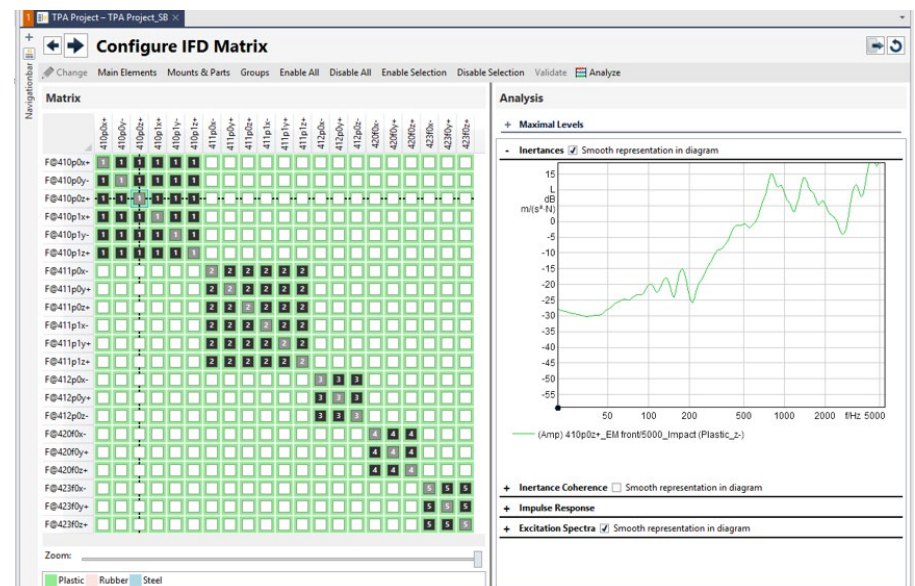


Immediately, the bar display and various diagrams allows the user to check the properties of the impact measurements visually. Subsystems can be independently considered. For that, the associated submatrices are calculated individually and configured independently from each other.

All necessary transfer functions (structure-borne: inertances, vibro-acoustic/acoustic transfer functions; airborne: acoustic impedance and acoustic transfer function) are calculated by the software. Subsequently, a matrix inversion of the inertances or of the acoustic impedances is calculated.

In order to avoid an overestimation of the source characteristics (operational forces or volume source), which can occur by the inversion of ill-conditioned matrices, a mathematical regularization is possible. For improving the accuracy of the results, an over-determination is possible, which has more reference signals than the source characteristics. The synthesis of the operating forces from the accelerations measured during operation and the inverted inertance matrices is performed in the time domain. The same applies to the volume source signals.

In submatrices, subsystems can be considered and calculated independently from each other. The mathematical method of regularization allows to counteract that small measurement errors lead to very large errors in the path contributions. The degree of regularization can be selected frequency-dependent. Due to that, more reliable results can be achieved with greater significance.

If mounts have been defined in the TPA model and acceleration on the active side has been measured in operation, effective mount transfer functions can be calculated. For this, the correlation between the indirectly determined forces and the accelerations on the active side are evaluated.

For the export, a PROGNO[I]SE project is created with all transfer functions and input data. This allows users to synthesize the structure-borne and/or the airborne sound components and the individual path contributions in the time domain in PROGNO[I]SE.
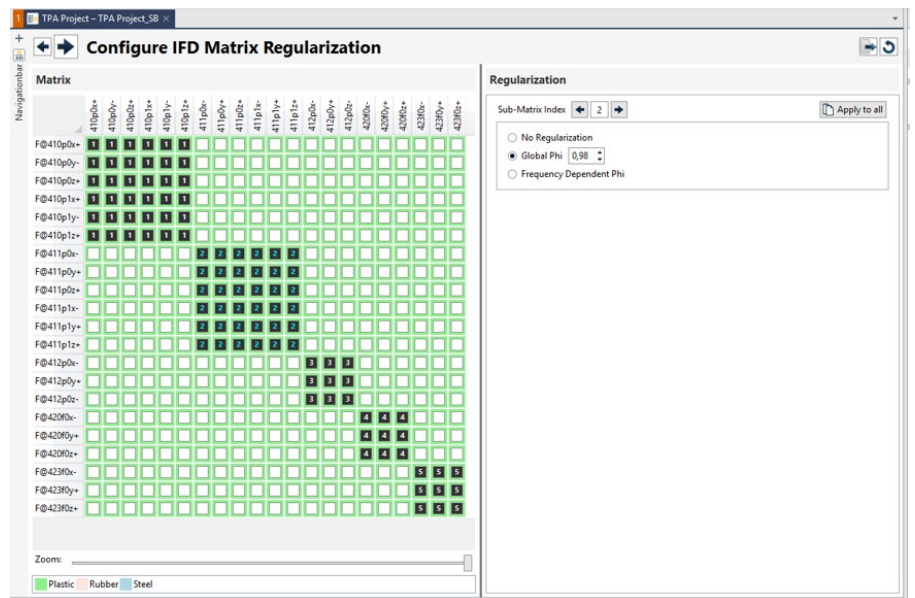


In order to prevent that small measurement errors in the input data lead to an overestimation of path contributions resulting in case of badly conditioned matrices, matrix inversion with frequency-dependent regularization are used.
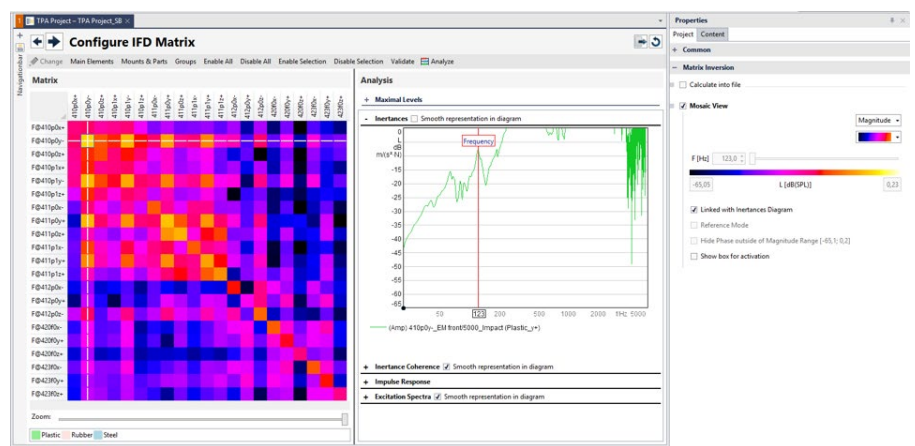


The Mosaic View visualizes the magnitude or the phase of the transfer functions in form of a frequency-dependent, color-coded matrix. This makes it easier for users to gain a profound understanding of systems and provides an aid to decision-making, whether coupling between subsystems must be considered or can be neglected.
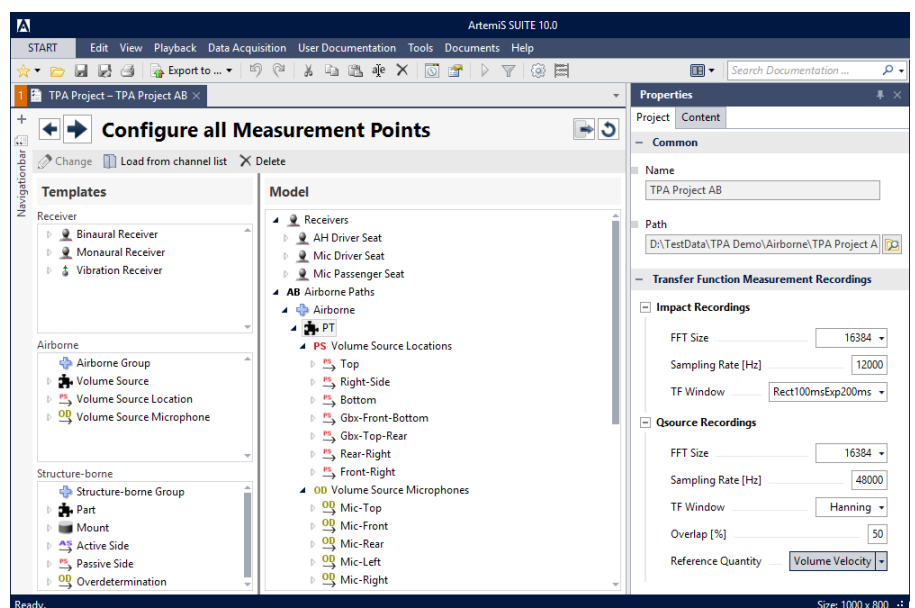


Executing airborne volume source measurements, the measurement points for the microphones, the volume source positions and the airborne receivers can be clearly arranged.

## Network licenses

PROGNO[I]SE can be purchased as a single user license as well as a network license. The single user solution stores the license on a dongle which can be used by simply plugging into multiple computers on which the PROGNO[I]SE software is installed. The the network solution stores the licenses on a network dongle. Via network and a computer with corresponding authorisation and installed PROGNO[I]SE software, users select one or more licenses and return them after use.

## Network Licenses (optional)

- PROGNO[I]SE-N
  (Code 4914N)
- PTP 01-N:
  PROGNO[I]SE Tool Pack 01-N
  (Code 4915N)
- PTP 02-N:
  PROGNO[I]SE Tool Pack 02-N
  (Code 4916N)
- PTP 03-N:
  PROGNO[I]SE Tool Pack 03-N
  (Code 4917N)

## Scope of supply

- PROGNO[I]SE (Code 4914)
  Binaural Transfer Path Synthesis
  (BTPS) software

## Options

- PTP 01:
  PROGNO[I]SE Tool Pack 01
  (Code 4915)
  Operational Transfer Path Analysis
- PTP 02:
  PROGNO[I]SE Tool Pack 02
  (Code 4916)
  Synchronization
- PTP 03:
  PROGNO[I]SE Tool Pack 03
  (Code 4917)
  Matrix Inversion

  For executing Tool Pack 03, the following additional ArtemiS SUITE modules are required:

  - ASM 00 (Code 5000)
    Basic Framework
  - ASM 04 (Code 5004)
    Data Acquisition Module
    (HEAD Recorder)

## System Requirements

- Windows 10 (x64): Pro, Enterprise, Education; languages: US/Western European

  or:

- Windows 8.1 (x64): Pro, Enterprise; languages: US/Western European
  Min: .NET Framework 3.5

  or:

- Windows 7 (x64): Professional, Enterprise, Ultimate; languages: US / Western European, Service Pack 1
- Min: Core2Duo Processor 2 GHz; recommended: Intel i7 Quad.
- Min: 4 GB RAM; recommended: 8 GB

For information on system requirements of ArtemiS SUITE, see the data sheet  ArtemiS SUITE Basic Framework (Code 5000)

In order to install software and drivers from HEAD acoustics, administrator rights are required. To operate the software, only standard user rights are needed.

## Hardware (optional)

For executing the transfer function measurements, various front ends are available:

- HEAD*lab* (Code 3700ff)
  Modular multi-channel 24 bit front-end system from HEAD acoustics for mobile data acquisition
- *lab*COMPACT12 (Code 3708)
  Compact HEAD*lab* module (single module system) for 12 analog/ICP sensors (expandable to 24 sensors)
- *lab*COMPACT24 (Code 3709)
  Compact HEADlab module (single module system) for 24 analog/ICP sensors (expandable to 36 sensors)
- SQuadriga II (Code 3709)
  Mobile recording and playback system - suitable as stand-alone system or USB front end
  (for maximal 6 sensors)
- DATaRec 4
  Modular multi-channel front-end system
  Required: ArtemiS SUITE Module: Data Acquisition Support for DATa-Rec 4 Module (Code 5028)
- For executing the Matrix Inversion Method for airborne transfer paths, a calibrated volume velocity source is required.