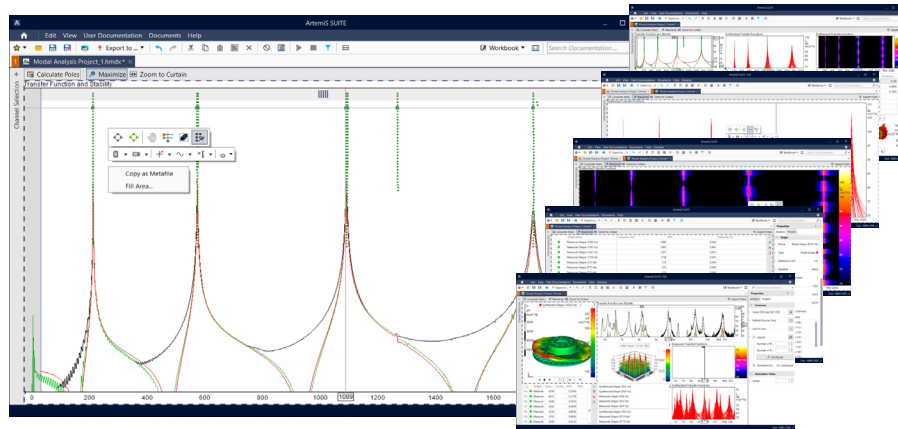


ArtemiS SUITE Modal Analysis (Code 5042)

Expansion module for analyzing the oscillation behavior of test objects



Overview

The Modal Analysis Project enables quick and interactive examinations of natural modes of test objects, e.g., on the basis of an Impact Measurement.

At the push of a button, the characteristic poles are determined from the measured transfer functions, the result is displayed in the stability diagram, and synthesized transfer functions are created using curve fitting.

The stability diagram displays the poles according to their stability in different colors, so that users can immediately detect whether further adjustments are necessary. Using different settings in the properties, the synthesized transfer functions can be optimized interactively in order to approximate the recorded transfer functions.

In addition, various diagrams and animations are available for examination and further investigation. In most cases, adjustments in one area directly affect all relevant representations without recalculation, so that users can perform their analyses intuitively and interactively by means of live feedback.

Shape Table

- Storing deflection shapes
- Displaying the shape names, the MAC and MPC values (Modal Phase Collinearity), as well as the modal dampings, frequencies, and physical quantities

Grouped Shape Table

- Combining the shapes with a MAC value above the set Group Threshold value
- Identifying similar or identical shapes

Features

Applications

- Examination of the oscillation behavior of test objects
- Validation of simulation results

Clearly arranged user interface

- Individual configuration of number and contents of the areas
- Areas can be maximized

Stability diagram / curve fitting

- Using the LSCF (Least Squares Complex Frequency) method for pole calculation
- Using multiple references when operating with more than one shaker, for example
- Automatic selection of the model size using a neural network
- The calculated poles are displayed as points in the stability diagram
- Evaluation of pole stability using color coding (red, yellow, green)
- The selection of the poles can be changed, if needed
- Calculation of the synthesized transfer functions using curve fitting
- The envelope of all selected transfer functions can optionally be displayed
- Various options for interactive optimization
 - Activating and deactivating individual poles
 - Free adding new poles (frequency and damping selectable)

- Adjusting the maximal model size and the stability criteria for evaluating the stability diagram

3D or 2D animation

- Animating all model points or individual measurement groups
- Selecting different display modes
- Export of results: AVI (video), PowerPoint, PDF, image (PNG, JPEG, TIFF, GIF)

Diagrams for displaying transfer functions

- Displaying the measured and the calculated (synthesized) transfer functions
- Detecting patterns of relevant deflection shapes
- Detailed monitoring of the signal
- Using the Value Cursor for identification of interesting frequencies directly in the diagram

Tabular Channel Selection

- Filtering, sorting, activating, and deactivating channels, etc.

MAC Matrix

- Displaying the MAC (Modal Assurance Criterion) values of all possible comparisons between all shapes contained in the Shape Table in a 3D diagram or as a 2D diagram
- Grouping of shapes based on the MAC value depending on the Group Threshold (partially transparent layer)

Modal Analysis Project

Intuitive operation

The module combines a clear, intuitive user interface with a high level of functionality. All necessary sections are embedded in the interface, so that users can keep an eye on their analyses at any time. The number and content of the areas can be configured individually.

Stability diagram / curve fitting

The core of the Modal Analysis Project is the stability diagram, based on the LSCF (Least Squares Complex Frequency) algorithm. With a push of a button, the transfer functions are approximated in a multi-stage iteration procedure from different numbers of poles (natural frequency and the associated modal damping). Based on stable poles which present the smallest deviations from the frequencies averaged over all iterations in each case, the algorithm synthesizes the transfer functions using curve fitting.

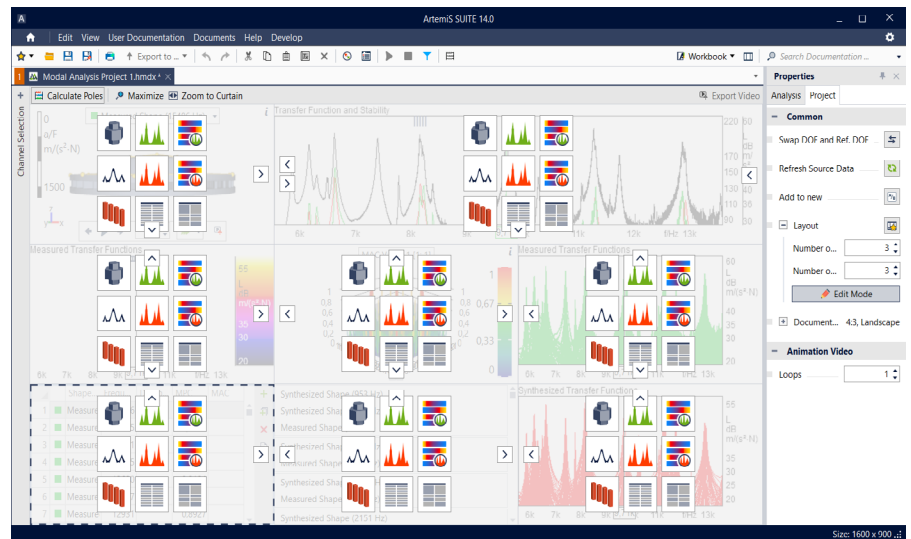
Users can decide, whether the selection of the model size should be done manually or automatically using a neuronal network.

After curve fitting, manual adjustments are quickly performed in the stability diagram. For visual convenience, each pole is displayed as a color-coded point, and the colors symbolize the level of pole stability (red, yellow, green).

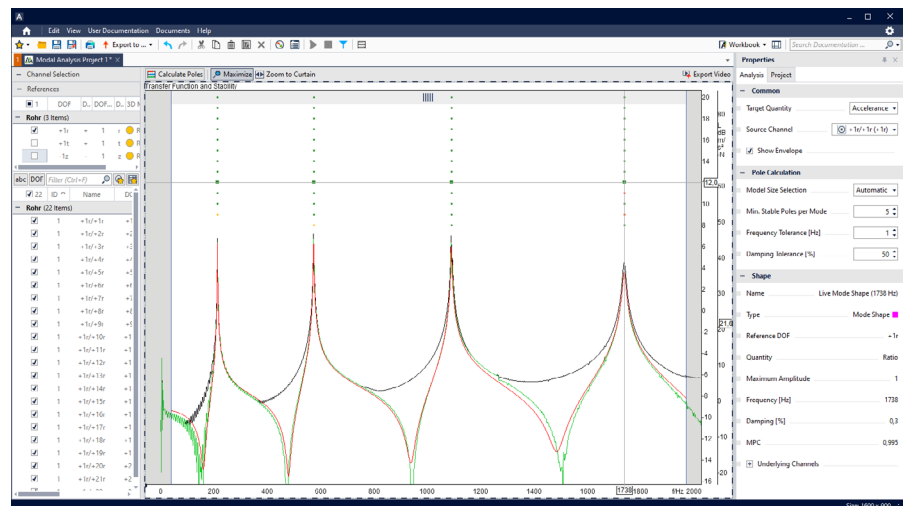
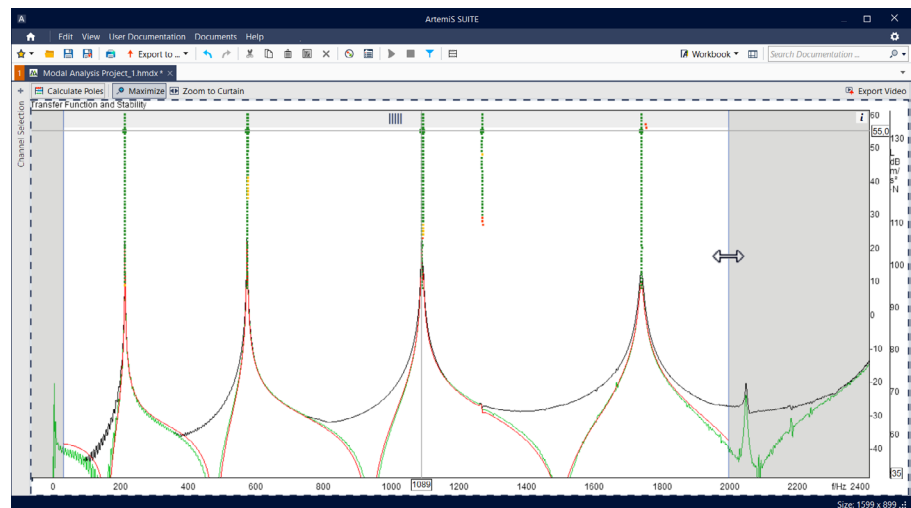
If necessary, the selection of poles can be changed, whereby the combination of poles from different iterations is possible, too. With a click, poles can be deactivated or activated, in order to optimize synthesized transfer functions interactively as well.

Furthermore, the maximum number of iterations, the minimum number of stable poles per mode, and the frequency and damping tolerance can be set individually. In addition, the envelope of the transfer functions can be switched on or off.

After calculating the poles, most adjustments are implemented live without the need to recalculate the fit.



In the Edit Mode, users individually select the number, the size, and the position of the elements visible during the analysis as well as the corresponding contents.



The stability diagram allows to adjust the cut-off frequencies with the mouse, which determines the data range to be considered for curve fitting (upper diagram). Various display and processing options are available to assist an interactive customization (lower diagram).

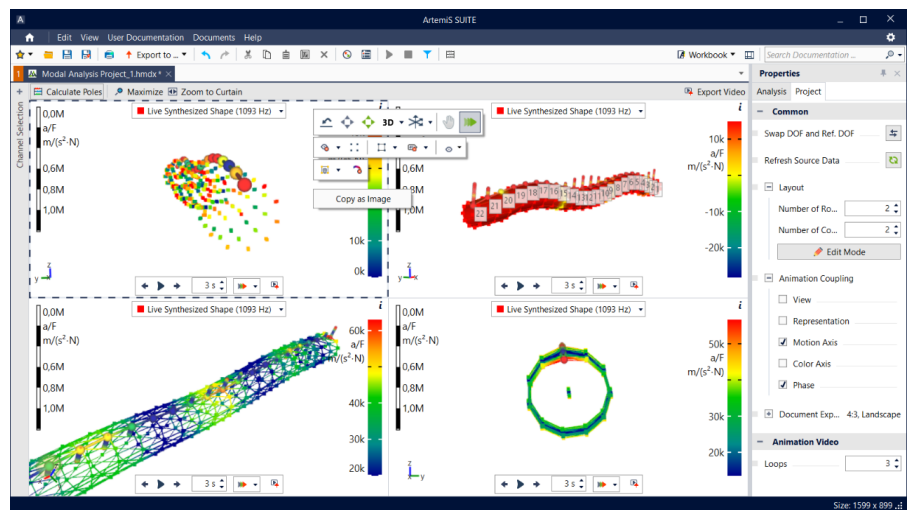
The Animation area serves for the representation of the measurement points contained in the selected Measurement Point Library and of an optionally existing model, whereby multiple references may also be considered and animated simultaneously. Users have various options for animating the data.

In order to highlight interesting areas, the Trace Tool is available. During the animation, the Trace Tool visualizes the movement of each measuring point selected in the Channel Selection in the form of a fading trace. This makes it easier to follow the movement course of individual measuring points.

Shape Table

For each shape, the MPC value, the corresponding frequency, and, if modes are included, the corresponding damping values are displayed. By means of the MPC value, users get a meaningful evaluation of the collinearity of the modal phases of all contained channels.

For the examination of the recorded signal, users can switch between the shapes, allowing direct views of the corresponding animations.



The screenshot displays the ANSYS Workbench interface for a Modal Analysis Project 1. The main area shows a list of 34 Mode Shapes, categorized into Measured Shapes and Model Shapes. The right sidebar shows the Properties panel for the selected Mode Shape (1487 Hz), including Target Quantity, Source Channel, and various tolerance settings.

Mode Shape	Frequency	Damping	BOC
1 Measured Shape (5688 Hz)	5688		0.7490
2 Measured Shape (5324 Hz)	5324		0.0001
3 Measured Shape (5118 Hz)	5118		0.0066
4 Measured Shape (4687 Hz)	4687		0.0714
5 Measured Shape (4735 Hz)	4735		0.7707
6 Measured Shape (4205 Hz)	4205		0.1814
7 Measured Shape (4200 Hz)	4200		0.3215
8 Measured Shape (3644 Hz)	3644		0.3436
9 Measured Shape (3643 Hz)	3643		0.2718
10 Measured Shape (3138 Hz)	3138		0.0713
11 Measured Shape (3131 Hz)	3131		0.7221
12 Measured Shape (2448 Hz)	2448		0.6745
13 Measured Shape (2213 Hz)	2213		0.0809
14 Measured Shape (2151 Hz)	2151		0.8488
15 Measured Shape (1760 Hz)	1760		0.5879
16 Measured Shape (914 Hz)	914		0.0604
17 Model Shape (7406 Hz)	7406	0.2077	0.6048
18 Model Shape (6837 Hz)	6837	0.1834	0.5705
19 Model Shape (6176 Hz)	6176	0.2480	0.8153
20 Model Shape (5968 Hz)	5968	0.1903	0.9031
21 Model Shape (5354 Hz)	5354	0.1091	0.9741
22 Model Shape (5118 Hz)	5118	0.1263	0.9603
23 Model Shape (4887 Hz)	4887	0.1343	0.2639
24 Model Shape (4735 Hz)	4735	0.1691	0.5610
25 Model Shape (4205 Hz)	4205	0.0834	0.2020
26 Model Shape (4200 Hz)	4200	0.2307	0.8771
27 Model Shape (3644 Hz)	3644	0.0086	0.7823
28 Model Shape (3643 Hz)	3643	0.2205	0.2828
29 Model Shape (3138 Hz)	3138	0.1187	0.9379
30 Model Shape (3131 Hz)	3131	0.0571	0.5819
31 Model Shape (2448 Hz)	2448	0.0603	0.9790

The right sidebar shows the Properties panel for the selected Mode Shape (1487 Hz). The Target Quantity is set to Accelerance. The Source Channel is set to +26/-12/-12d. The Group Threshold is set to 0.37. The Min. Stable Poles per ML is set to 3. The Frequency Tolerance [%] is set to 1. The Damping Tolerance [%] is set to 50. The Shape is set to Mode Shape (1487 Hz). The Type is set to Mode Shape. The Reference eDOF is set to +26. The Quantity is set to Ratio. The Maximum Amplitude is set to 1. The Frequency [Hz] is set to 4807. The Damping [1/s] is set to 0.134.

The Shape Table lists all defined shapes in tabular form. The MPC index evaluates the collinearity of the modal phases of all channels. Small phase differences between the channels or a rotation by 180° result in good values of up to 1. The greater the phase differences, the more this value tends to 0.

Diagrams for displaying transfer functions

The measured and the synthesized transfer functions can each be displayed in 2D diagrams as well as in Color Band diagrams. This enables a more detailed view of the signal and the pattern detection related to relevant modes.

In the case of synthesized transfer functions, the synthesis is performed on the basis of the poles selected in the stabilizability diagram.

Users can select the desired frequency for the animation with the Value Cursor or via an input field.

- 2D diagrams

The 2D diagrams display the measured and the synthesized transfer functions of all channels activated in the Channel Selection. This simplifies the detection of patterns of relevant modes which are characterized by the fact that the curves of many channels overlap and have a similar course overall.

- Color Band diagrams

The Color Band diagrams display the transfer functions of all channels activated in the Channel Selection as individual color bands over a common abscissa.

MAC Matrix

In a 3D diagram or as a 2D diagram the MAC Matrix displays the MAC values of all possible comparisons between all shapes contained in the Shape Table. Thereby the MAC values are represented via the height of the bars and via their color.

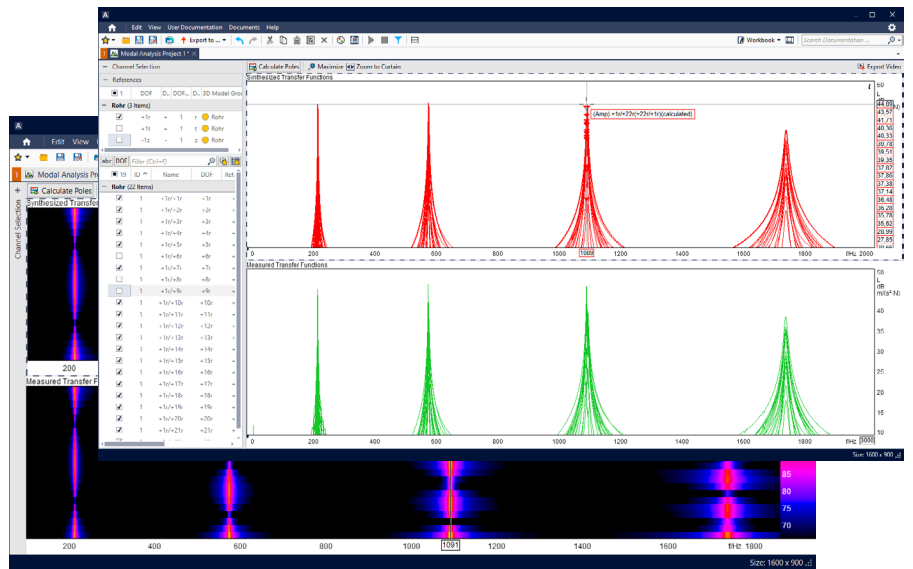
By means of the Group Threshold, which is displayed as a partially transparent layer, users get an optical grouping of relevant MAC values.

Grouped Shape Table

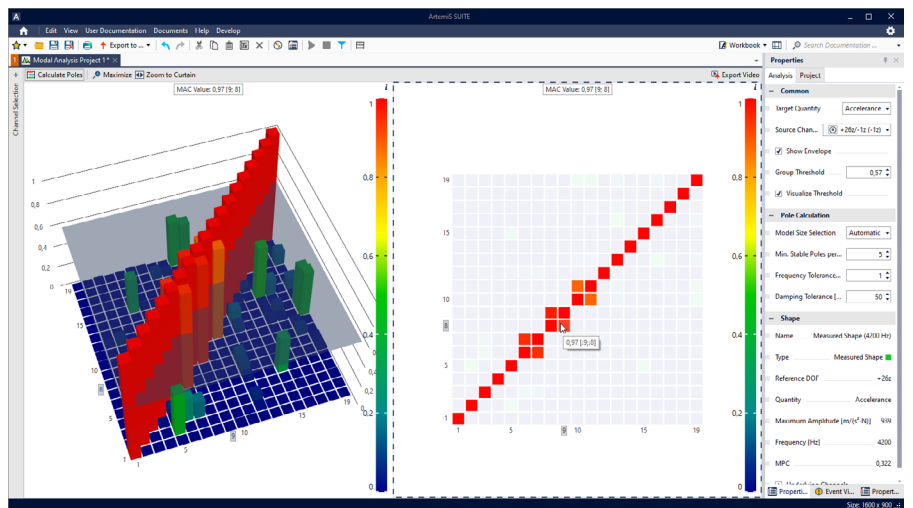
This table combines all shapes of the shape table that have a MAC value above the set Group Threshold.

Channel Selection

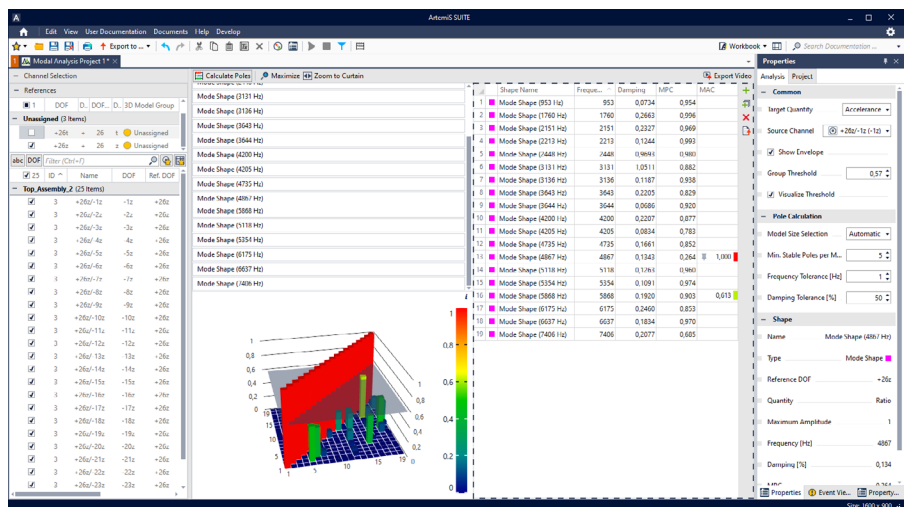
The Channel Selection provides the channels to be used. The tabular arrangement of the channels as well as additional information, such as the measurement point number, channel name, and DOF facilitate filtering, sorting, selection, etc.



2D and Color Band Diagrams are available for displaying the measured and the synthesized transfer functions. Via the mouse wheel, users zoom on the x- and the z-axis and adapt the displayed area while holding down the left mouse button.



In the MAC Matrix, tooltips display the MAC values and the numbers of the involved modal shapes. Switching from 3D to the 2D representation, a possible occlusion of bars further back is avoided.



The Channel Selection allows a filtered channel selection via the input field. Channels can be activated or deactivated by means of multiple selection. The Grouped Shape Table makes it easier to identify similar or identical shapes.

Requirements: Module

- ArtemiS SUITE Basic Framework (Code 5000)

Requirements: Files

- Measurement Point Library (*.hmlp) including measurement points
- A measurement file with transfer functions (*.hdf) matching the Measurement Point Library, which was ideally recorded with the Impact Measurement or the Recorder of ArtemiS SUITE

Compatibility criteria:

- Each combination of measured degree of freedom and reference degree of freedom must only exist once
- In the channels,
 - the acceleration (acceleration/force, also called inertance),
 - the mobility (velocity/force, also called admittance),
 - or the compliance (displacement/force) has to be stored
- Sampling rate and block size must be the same in all channels

The Modal Analysis Project checks the requirements and the compatibility of the files. After this, the analysis can be started immediately

When monitoring an Impact Measurement (Roving Hammer or Roving Accelerometer) with the Impact Measurement (ASM 43), users specify

- the path to the Impact Measurement to be monitored or
- the folder with a measured Impact Measurement

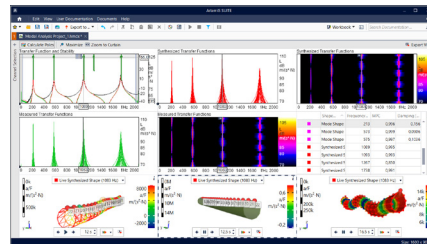
ArtemiS SUITE Structural Analysis Package

In combination with the Measurement Point Library (ASM 00), the modules Modal Analysis (ASM 42), Shape Comparison (ASM 41), Operating Deflection Shape Analysis (ASM 40), and Impact Measurement (ASM 43) form the Structural Analysis Package of ArtemiS SUITE.

Modal Analysis

(Modal Analysis – ASM 42)

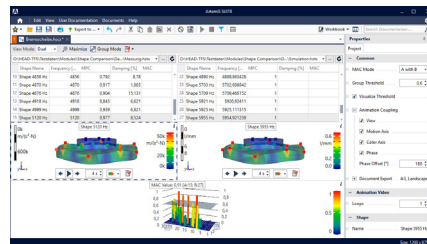
The easy-to-use Modal Analysis Project enables quick and interactive analyzes of natural modes of test objects, e.g., on the basis of an Impact Measurement.



Comparing shapes

(Shape Comparison – ASM 41)

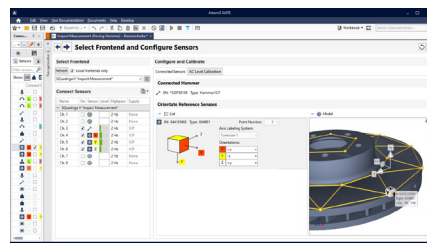
The Shape Comparison Project is used for analyzing and comparing deflection shapes.



Impact Measurement

(Impact Measurement – ASM 43)

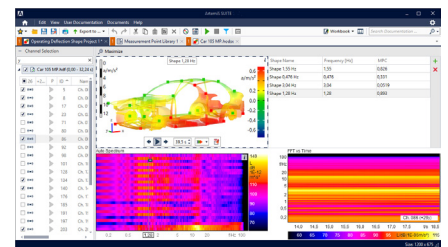
The Impact Measurement allows structural analysis examinations using the methods Roving Hammer and Roving Accelerometer.



Analyzing shapes

(Operating Deflection Shape Analysis – ASM 40)

The module includes the Operating Deflection Shape Project (ODS) and the Time Domain Animation Project (TDA). The projects can be used to animate and analyze structures in a defined stationary operating status as well as time-variant motions.

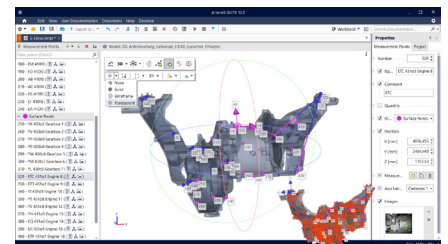


Measurement Point Library

(Basic Framework – ASM 00)

A Measurement Point Library can be created very easily to simplify planning and execution of real measurements considerably.

A corresponding CAD model can be imported and merged with the grid model of the Measurement Point Library.



Channel Editor

(Basic Framework – ASM 00)

Using the Channel Editor, the rotation of the measurement coordinate system can be corrected according to a Measurement Point Library.

