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Technical Specifications
for ARTeMIS Modal 8.1

System requirements

ARTeMIS Modal is a software platform designed for Microsoft Windows 64-bit operating systems. To increase speed, it makes use of mathematical libraries from Intel.

- Intel® 64-bit processor architecture
- Microsoft® 64-bit Windows 10 and Windows 11
- Internet browser: Microsoft Edge, Google Chrome or Firefox
- 32GB of RAM (64GB or more recommended)
- 50GB of available hard-disk space is recommended. Since the space requirement is heavily dependent on the ARTeMIS Modal projects stored, 100GB or more is recommended in case of large external storage projects. Storage speed can be increased using a Solid- State Disk (SSD)
- 1,024x768 screen resolution or higher (recommended)
- Internet connection required for downloading of the installation program, receiving update notifications, and sending alerts
- Activation requires a license file that will be sent by email or downloaded from portal.svibs.com
- Web based help system (requires internet connection)
- Offline help included with the installer
- The software supports the following license models: Node-locked to a specific computer, locked to a specific USB dongle, locked to a specific license server located on the Local Area Network. In case a license server is used, the licenses can be checked out for a period of up to 30 days for a specific computer that needs to work disconnected from the network

Geometry Generator

- Universal File Format (UFF or UNV extension) Loads from UFF data sets 15 (nodes), 2411 (nodes), 82 (trace lines), 2431 (trace lines) and 2412 (triangular plate elements). For cylindrical and spherical coordinates additional UFF data sets 18 and 2420 are supported
- SVS Configuration File Format (CFG extension)
- Stereolithography file format (STL extension)
- Limited support for AutoCad file formats (DXF and DWG extensions)
- Object orientated drawing enabling drawing of complex structures using more basic sub-elements each with its own grid plane and coordinate system
- Drawing options are points, lines and triangular surfaces. Elements can be drawn using the mouse or by entering information into tables using the keyboard or copy/paste operations
- Drawing of high-level objects both in cartesian and cylindrical coordinate systems
- Operated through the Prepare Geometry Task
- ***Available in all versions of ARTeMIS Modal***

Data Input

- Import through either the user interface, SVS Configuration File format, or Universal File Format
- Universal File Format (UFF, UNV) ASCII as well as binary import of measured time series
- SVS Configuration File format and data files: Text (TXT and ASC), SVS binary format (BIN), Header File Formats (TEAC HDR, GeoSIG GHF, Diadem, Kyowa), Kinemetrics Altus (EVT), MS Wave file format (WAV), Weir Jones format (TAD), VDAS input format (VIF), National Instruments formats (LVM, TDM, TDMS), Matlab Format (MAT), Catman format, HDF5 format, SoMAT format (SIE), SAC and MiniSEED seismic formats, imc FAMOS file format (raw), LORD G-Link 100 (LORD), BRI Strong Motion Data Format (AC), Dewesoft file format (DXD), ASAM MDF file format, Comma Separated Values (CSV) formats with and

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without sample time stamps and header information, MS Excel formats (XLS, XLSX). In text file formats, data is stored as a matrix with measurement channels stored column by column
- Unlimited number of channels (tested with 300 simultaneously measured channels)
- Unlimited number of data points in each record
- Unlimited number of test setups
- Assign DOF information (measurement nodes and directions) for imported measurement channels using drag-and-drop on the test geometry or using the keyboard
- Automatic identification of reference channels when using multiple test setups
- Automatic updating of test geometry and DOF information when modifying geometry in the Geometry Generator
- For Operational Modal Analysis imported data is always time series response data. In the case of Experimental Modal Analysis data can be either time series input and response data, or Frequency Response Functions (FRF) stored in Universal File Format or in Dewesoft DXD file format
- Import Preview dialog allowing insertion of missing channel and FRF information. Warnings are provided if information is missing or faulty
- ***Available in all versions of ARTeMIS Modal***

Data Output

- Copy/Paste and Print functions for all graphics and tables
- Modal results: Universal File Format (ASCII) including geometry, one or more modes in each file
- Modal results: SVS output files, one or more modes in each file (ASCII)
- Modal results: SVSX output files, one or more modes in each file (ASCII). File format exports expanded (all DOF's) and collapsed (measured DOF's only) mode shapes with uncertainty information if available
- Modal results: Interface to FEMtools updating software through UFF and SVSX
- Function values export through the Prepare Data Task
- Animations: Export of AVI movie files and GIF files to e.g. Windows Media Player or Microsoft Power Point
- Report generator for easy creation of Microsoft Office documents (Word & Power Point). Requires the installation of Microsoft Office
- SVS Configuration File Format (CFG extension): Geometry and DOF information is written directly in this file along with references to the required measurement files. Measurement files can be saved in text file format (ASC extension), SVS binary format (BIN extension), Matlab MAT file (MAT extension), VDAS file format (VIF extension), Universal File Format (UFF extension), MiniSEED file format (MSD extension). This is limited to Operational Modal Analysis projects, and Experimental Modal Analysis projects obtained using internal data acquisition or created from time series force and response data files.
- For Operational Modal Analysis projects data files in the above formats can also be saved from the Data Sets window located in the Manage Measurements Task
- Universal File Format (UFF extension) Geometry saved in UFF data sets 15 (nodes), 82 (trace lines) and 2412 (triangular plate elements). In case of odd sensors directions UFF data set 18 is also saved with coordinate system definitions
- DOF information and measurements are saved in UFF data sets 58 (ASCII) or 58b (binary) time series format
- Export in SVS Configuration File format of signal processing and modal estimation settings
- ***Available in all versions of ARTeMIS Modal***

Signal Processing

- Decimation, 1-1000 times, digital anti-aliasing filter, cut-off at 0.8 times Nyquist frequency of decimated signals
- Filtering: low-pass, high-pass, band-pass, band- stop Butterworth, filter order 1-50 poles, arbitrary cut-off frequencies, test for filter stability
- Projection Channels. Specify if all cross information of the measurement channels should be used or only between fewer number of channels
- Automatic detection of the required number of Projection Channels as well as what channels to pick. Specific channels can as an option be selected explicitly
- Spectral estimation using FFT and Welch's averaged periodogram method. Data segment length: radix-2 only limited by the amount of data, overlap: 0%, 50%, 66.7%, window: Hanning and Rectangular for Operational Modal Analysis, and Hanning, Exponential and Rectangular for Experimental Modal Analysis. Estimates the full spectral matrix if the Projection Channel option is disabled

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- In the case of Experimental Modal Analysis H1, H2 and Hv FRF estimators are available
- Common SSI input matrix estimation is used in all stochastic subspace identification algorithms. The maximum state space dimension is 300. Noise mode suppression using the Projection Channel option
- Option for reloading original uploaded data
- Data Presentation of Test Setups: Spectral magnitude and phase, singular value decomposition of spectral matrix, average of full spectral matrix, average of diagonal elements of spectral matrix, coherence of spectral matrix, time / frequency contour diagram. Cursor read out and annotation support on all curves
- For spectral densities post processing is available; Display displacement, velocity and acceleration with user- selectable choice of units. Additional for auto-spectral densities. Frequency domain presentation and cursor read-out of Peak, Peak-to-Peak, RMS and Power are available
- Data Presentation of Reference Data: Spectral magnitude and phase, average of full spectral matrix, average of diagonal elements of spectral matrix, coherence of spectral matrix. Cursor read out on all curves
- Manual peak selection tool
- Outlier testing and removal tool
- In the case of Experimental Modal Analysis data presentation includes Frequency Response Functions (Real, Imaginary, Magnitude, Phase) and Coherence
- Operated through the Prepare Data Task
- ***Available in all versions of ARTeMIS Modal, but appearance is version and project dependent***

Operating Deflection Shapes

- Frequency domain operating deflection shapes estimation using phased assigned spectra, i.e. the auto- spectra of a channel multiplied with the normalized cross-spectra between the channel and a reference channel
- Preview and shape estimation modes. Preview mode only presents the animated shape. Shape estimation mode allows the storage of the shapes in a Deflection Shapes list. This allows comparison with e.g. mode shapes through the Validation Task
- Estimated shapes can be viewed in Peak, Peak-to-Peak, RMS and Power with user selectable units
- Time domain animation of individual test setups
- Output signal type (displacement, velocity, acceleration) specified by the user
- AVI and GIF movie creation of animations
- Operated through the Estimation Task as Frequency- ODS or Time-ODS
- ***Available in all versions of ARTeMIS Modal for Operational Modal Analysis projects***

Frequency Domain Decomposition – Operational Modal Analysis

- User choices: Peak picking
- Frequency resolution: Defined by number of frequency lines in spectral density function
- Mode shape estimation: Immediate animation
- Damping: None
- Operated through the Estimation Task as FDD
- ***Available in all versions of ARTeMIS Modal for Operational Modal Analysis projects***

Enhanced Frequency Domain Decomposition - Operational Modal Analysis

- User choices: Peak picking, MAC level for identification of spectral peak, time interval for identification of frequency and damping
- Mode shape estimation: Immediate animation, mode shape estimate improved by frequency domain averaging
- Frequency and damping estimation: Estimated from free decays corresponding to identified spectral peak
- Detection of harmonics and removal of their influence from estimated modal parameters
- Operated through the Estimation Task as EFDD
- ***Available in Standard and Pro versions of ARTeMIS Modal for Operational Modal Analysis projects***

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Curve-fit Frequency Domain Decomposition - Operational Modal Analysis

- User choices: Peak picking, MAC level for identification of spectral peak, frequency interval for identification of frequency and damping
- Mode shape estimation: Immediate animation, mode shape estimate improved by frequency domain averaging
- Frequency and damping estimation: Estimated directly from identified spectral peak
- Detection of harmonics and removal of their influence from estimated modal parameters
- Operated through the Estimation Task as CFDD
- ***Available in Standard and Pro versions of ARTeMIS Modal for Operational Modal Analysis projects***

Stochastic Subspace Identification - Operational Modal Analysis

- Basic Method: Data driven Stochastic Subspace Identification
- User choices: Implementation: Extended Unweighted Principal components, Unweighted Principal components, Principal Components and Canonical Variate Analysis. Estimation: Standard Least Squares or Crystal-Clear SSI
- Model orders: from one mode to the size defined by the common SSI input matrix
- Stabilization criteria: Natural frequency deviation, damping ratio deviation, mode shape MAC deviation, all limits user defined. For Extended Unweighted Principal components also maximum coefficient of variations for natural frequency and damping ratio
- Physical mode separation: Damping ratio limits are user defined. Mode shape complexity limit is user defined
- Select and link: Modes from the models chosen from each test setup are selected and linked using snap functions and editing facilities
- Uncertainty estimation: In the case of Extended Unweighted Principal Components uncertainties are estimated for natural frequencies, damping ratios and mode shapes
- Uncertainty estimation of mode shapes can be visualized in the animation of the mode shapes, in the Modal Assurance Criterion 3D diagram, and in the Complexity diagram
- Can estimate negative damping if necessary
- Can estimate uncertainties of modal parameters
- Comparison: Estimated model vs. FFT based auto and cross-spectra of measurements
- Spectral density functions of response and prediction errors between estimated model and measurements
- Operated through the Estimation Task as SSI- UPCX, SSI-UPC, SSI-PC, SSI-CVA, SSI-UPC-Merged. Automatic analysis can be configured through the Prepare Data Task
- ***Available in the Pro version of ARTeMIS Modal for Operational Modal Analysis projects***

Rational Fraction Polynomial in Z domain – Experimental Modal Analysis

- Basic Method: Rational Polynomial fitting of MIMO Frequency Response Functions in Z-domain
- Polynomial orders: from 1 to the order defined by the user
- User-defined frequency band selection
- Stabilization criteria: Natural frequency deviation, damping ratio deviation, mode shape MAC deviation, all limits user defined
- Physical mode separation: Damping ratio limits are user defined. Mode shape complexity limit is user defined
- Select and link: Stable modes are automatically extracted, and global mode estimates are returned
- Comparison: Estimated model vs. FFT based Frequency Response Functions of measurements
- If used with Impact Testing plugin with Exponential windowing enabled, then optionally a damping correction is available
- Mode shapes are returned in displacement units and scaled as; Unscaled, Max Component, Unity Vector Length, Unity Modal Mass. For each mode, the mode shape scaling factor that will result in a unity modal mass scaled shape is also returned
- Operated through the Estimation Task as RFP-Z
- ***Available in all versions of ARTeMIS Modal for Experimental Modal Analysis projects and with the EMA plugin license present***

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Complex Mode Indicator Function - Experimental Modal Analysis

- Basic Method: Peak picking on the Complex Mode Indicator function (CMIF) extracted by Singular Value Decomposition of the Frequency Response Functions
- User choices: Automatic and manual peak picking, MAC level for identification of peaks, frequency interval for identification of frequency and damping
- Mode shape estimation: Immediate animation, mode shape estimate improved by frequency domain averaging
- Frequency and damping estimation: Estimated directly from identified Singular Values peak using an SDOF curve-fitting
- Operated through the Estimation Task as CMIF
- ***Available in all versions of ARTeMIS Modal for Experimental Modal Analysis projects and with the EMA plugin license present***

Validation

- Modal Assurance Criterion, MAC diagrams for comparison of mode shapes between same or different estimation techniques as well as between same or different projects
- Complexity plot and complexity values of mode shapes
- Simultaneous animation of different mode shapes, side-by-side and overlapped
- Animation of differences between mode shapes
- Frequency versus Damping diagrams present damping ratios as a function of natural frequencies. Optionally, also a confidence ellipsoid (SSI-UPCX)
- Mode import facility using Universal File Format for comparison with e.g. FE modes
- Operated through the Validation Task
- ***Available in Standard and Pro versions of ARTeMIS Modal***

Plugin to ARTeMIS Modal Pro - Data Manager Base Module

- Support for Multiple Analysis Sessions
- Licenses available for limited number of channels usage. Channel limits are 16, 32, 64, and unlimited
- External storage with saving and loading of measurements and results for each Analysis Session
- Global alert status indicating potential changes of indicators with a traffic light (green, yellow, red) for safe, critical and unsafe status
- Historical measurement statistics (Maximum, Minimum, RMS, Median, Mean, Variance, Skewness, Kurtosis)
- Master Session definition, allowing automatic processing across all Analysis Sessions using settings of the Master Session. Includes automatic SSI modal estimation
- Notification (Alert) services. Visual, sound, email, SMS
- Optionally, results can be stored in a Microsoft SQL Database in a user-defined location
- ***Available in the Pro version of ARTeMIS Modal for Operational Modal Analysis projects with the Data Manager Base module license***

Plugin to ARTeMIS Modal Pro - Automatic File Upload Module

- Automating the data file import by specifying a folder to be monitored for new files
- Automating the Signal Processing and Operational Modal Analysis of the new files
- Automatic mode tracking option if Modal Parameter History module is present
- Automatic Damage Detection option if Damage Detection module is present
- Automatic Interstorey Drift Analysis option if Drift Analysis module is present
- Data upload date/time can be configured as well as the duration of each analysis session. Two different file name definitions schemes are allowed to enable identification of UTC file start based on the filename
- Operated through the Automatic File Upload option in the status bar of ARTeMIS Modal Pro
- ***Available in the Pro version of ARTeMIS Modal for Operational Modal Analysis projects with the Data Manager Base module license and the Automatic File Upload module license***

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Plugin to ARTeMIS Modal Pro - Damage Detection Module

- Importing of multiple sessions i.e. historical data
- Historical export of damage indicators and control values
- Statistical Subspace-based Damage Detection using two different algorithms, Classic and Robust
- Detection process is divided in three: Reference State Model Estimation, Reference State Model Validation, and Damage Detection
- Hoteling Control Chart Prediction for unification of damage indicators
- Multiple instances of each damage indicator can be defined using e.g. different reference states and settings.
- Operated through the Analysis History Task
- ***Available in the Pro version of ARTeMIS Modal for Operational Modal Analysis projects with the Data Manager Base module license and the Damage Detection module license***

Plugin to ARTeMIS Modal Pro - Modal Parameter History Module

- Historical presentation of natural frequencies and damping ratios
- Historical export of modal parameters to SVS, SVSX and UFF file formats
- Automatic mode tracking based on the estimation of a set of reference modes obtained from a specified set of reference Analysis Sessions
- Historical presentation of the tracked modes (Drawn interconnected). Natural frequencies and damping ratios - absolute and relative to their reference mode. Modal Assurance Criterion of the mode shapes relative to the mode shape of their reference mode
- Historical export of tracked modes and individual analysis session modes to SVS, SVSX and UFF file formats
- Modal Damage Detection based on tracked SSI-UPCX modes. The detection is divided into two steps: First step is a Reference State Model estimation made from mean and standard deviations of natural frequency estimates of a user selectable set of reference analysis sessions. The second step is damage detection performed over all analysis sessions by a Chi Squares testing approach
- ***Available in the Pro version of ARTeMIS Modal for Operational Modal Analysis projects with the Data Manager Base module license and the Modal Parameter History module license***

Plugin to ARTeMIS Modal Pro – Interstorey Drift Analysis Module

- Multiple drift definitions. Each definition specifies two parallel measurement sensors and a critical relative drift threshold
- List displaying all drift definitions with a visual alert. Turns red if the critical relative drift threshold has been exceeded
- Automatic integration into displacements and calibration of units from raw time histories
- Automatic estimation of physical distance between measurement sensors for easy relative drift calculation. Based on the available test geometry
- Display of the raw sensor time histories or the processed displacements, and the relative drift time series of the selected drift definition
- Display of critical relative drift ratio (threshold) as well as the number of exceedances of the selected drift definition
- Display the sensors in the geometry window of the selected drift definition. If the critical relative drift threshold has been exceeded, the sensors will be highlighted in red
- Operated through the Drift Analysis Task
- In case of multiple Analysis Sessions projects, the drift definitions are presented in the Analysis History Task. Each drift definition is represented by a curve. This curve can be one of following values extracted from the relative drift time series: Absolute maximum, RMS, Maximum Positive, Minimum Negative, Number of occurrences of Absolute maximum, Maximum Positive, and Minimum Negative
- Historical export of relative drift values
- ***Available in the Pro version of ARTeMIS Modal for Operational Modal Analysis projects with the Data Manager Base module license and the Interstorey Drift Analysis module license***

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Plugin to ARTeMIS Modal Pro – SHM Automation Service

- Allow ARTeMIS Modal Pro external storage projects to be managed by an ARTeMIS 64-bit windows service
- The service can be configured to open/analyze/save/close multiple projects sequentially using a single ARTeMIS Modal instance (1-user license)
- Maintains a ring buffer of the imported files allowing the user to define how many files to keep in the past
- ***Available in the Pro version of ARTeMIS Modal for Operational Modal Analysis projects with the Data Manager Base module license and the SHM Automation Service module license***

Plugin to ARTeMIS Modal - Data Acquisition Module

- Direct control of National Instrument acquisition module that can be controlled using NI-DAQmx driver version 25-Q3
- Direct control of SINUS Messtechnik Apollo acquisition module
- Direct control of HGL Dragonfly acquisition module
- Direct control of HBM acquisition module
- Seamless integration with all other tasks in ARTeMIS Modal
- Direct streaming of measurements to ARTeMIS Modal test setups
- View acquired time series real-time of user selectable channels
- On-the-fly calculation of spectral densities and singular value decomposition (SVD) of spectral densities
- Support IEPE sensors with or without TEDS
- Multiple recording modes: Manual or triggered start/stop, predefined interval of time, continuous recording mode with optional definition of a ring buffer period in days
- In case of an Experimental Modal Analysis project with the input channel set to the Hammer setting, an Impact Testing module is replacing the above module. This allows SISO or SIMO impact testing. The module automatically calculates averaged Frequency Response Functions for direct use by CMIF and RFP-Z estimators
- ***Available in all versions of ARTeMIS Modal with a Data Acquisition module license***

Plugin to ARTeMIS Modal – Harmonic Detection & Reduction

- Fast or extended method for automatic detection of peaks of harmonics components in the measurements
- Reduce peaks tool for reduction of unwanted modes or harmonic components in the measurements
- Operated through the Prepare Data Task
- ***Available in all versions of ARTeMIS Modal with a Harmonic Detection & Reduction module license***

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