

The complete vibration-based SHM solution

If you are looking for a software system that can help detect both fast and slow growing damage to a structure, then ARTeMIS-SHM is the solution for you. Our vibration-based Structural Health Monitoring (SHM) system can help plan inspections and maintenance of structures more efficiently, reducing unnecessary inspections, and you will be notified much earlier with ARTeMIS-SHM compared to other systems when a structure's dynamic behavior changes.

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ARTEMIS Modal Pro is the analysis engine in the ARTEMIS-SHM system. It is through the desktop version that the analysis is configured. The configuration includes the required signal processing, and which modal analysis and damage detection tools to use. The Automatic File Upload of measurements files is also configured at this state. Once everything is set up, the desktop version of ARTEMIS Modal Pro can be closed, and the continuous monitoring process is managed by the SHM Automation Service. This is a Windows service that runs the analysis automatically.

At any time, the SHM Automation Service can be paused, and the results can be inspected in ARTeMIS Modal Pro desktop version. In the picture, the tracking of modal parameters and damage detection is displayed. To the right the SHM Status Overview is showed for the latest analyzed measurement file. Here each of the analysis tools display their current health status for the structure. The status is either **Safe, Critical**, or **Unsafe**. The overall health status is also showed in a similar manner. This is based on a weighted average of the health status of all the analysis tools.



#### With our SHM solution there are several benefits:

- Get a notification with link to a status report the instant the systems detect a structural change that can be critical for the performance of the structure.
- Get a quick overview of all monitored structures with color indicators for safe, critical, and unsafe status. An overview dashboard displays the structures and their state either using Google Maps or in different types of list views.
- Get immediate access to analysis details for closer inspection of what has caused an alert.
- Share information across the organization using web browser access.
- Analysis can be configured to run many methods in parallel that joined together deliver highly sensitive results. This allows an early detection of damage and at the same time prevent too many false alarms.
- Multiple structures can be analyzed sequentially by the same license and same computer.

### Open framework - works with multiple hardware vendors

The input to the analysis made by ARTeMIS-SHM is the raw time series measurements, which makes the solution very open. We support a wide range of file formats used by major hardware vendors. Currently, more than 20 files formats are supported. Some specific formats are:

- MiniSEED files exported from Guralp Systems Ltd., and GeoSIG AG
- EVT files exported Kinemetrics Inc.

- VIF files exported from a variety of hardware suppliers.
- Text files where channels are stored column-wise, with or without header information.

Data acquisition systems designed for long term monitoring typically store measurement in fixed length recorder files (e.g., 5-10 minutes files). Files are read by ARTeMIS Modal Pro which is the data analysis engine of the system and possibly merged to longer recordings for improved analysis results. The data files can be read from any network accessible location like Network Attached Storage, FTP or from the cloud.

#### The Analysis Engine - ARTeMIS Modal Pro

The analysis engine of the system is ARTeMIS Modal Pro, and optionally with additional SHM plugins enabled. For setting up the projects the graphical user interface of ARTeMIS Modal Pro is used. Once the project and the various analysis methods are configured, then the project is managed by the SHM Automation Service that is a Windows Service. This service can analyze multiple structures sequentially using a single ARTeMIS Modal Pro license. What structures that should be analyzed is configured using the ARTeMIS Modal Pro desktop application. Through the application an XML file is created that contains all necessary instructions for the Windows Service to run. The analyses and the storage of results is made automatically and completely transparent without user interaction.





The analysis results are synchronized to an SQL database that allow multiple users to view them through a web browser at www.artemis-shm.com. The analysis results to display are based on user choices and includes 3D animation of mode shapes, mode lists, mode tracking, damage detection, and statistics of measurement channels. Generated reports can also be viewed, and their content and layout can be configured from the web-based administration module. This module also allows to manage users, structures, and notifications.



# **Database Storage for Open Data Access**

Analysis results are stored in a Microsoft SQL Database that can be located anywhere on the network. The database support storage of results of multiple structures. Results stored are:

- Geometry and channel information
- For each analysis session, i.e., the analysis of a specific measurement file, the following information is stored:

 Analysis session information, including references to the measurement files and notifications related to the specific analysis. This includes warnings and errors.

– Channels statistics: Maximum, Minimum, RMS, Median, Mean, Variance, Skewness.

Modal results of any of the Stochastic Subspace Identification methods available in ARTeMIS Modal Pro: SSI-UPC, SSI-UPC, SSI-UPCX (Used default).

Modal results stored for each method are: Mode shapes and mode shape complexity. Natural frequencies (mean + standard deviation). Damping ratios (mean + standard deviation).

 Damage indicator results of any of the damage detection methods available in ARTeMIS Modal Pro: Modal Damage Detection, Classic Damage Detection, Robust Damage Detection, Control Chart for joint damage indicator presentation.
SHM overview status values per mode tracked mode and per damage indicator.

– Overall health status value (Global Weight Ratio): 100% >= Safe > 90% >= Critical > 50% >= Unsafe >= 0%.

– Ground motion values for any channel registered as a ground channel: Peak Ground Displacement (PGD), Peak

Ground Velocity (PGV), Peak Ground Acceleration (PGA), Katayama Spectral Intensity (kSI), Arias Intensity (Total), Normalized Arias Intensity, Significant Duration of the shaking (D\_5\_95), The mean period extracted in the frequency range between 0.5 Hz and 20 Hz (Tmean), Modified Mercalli Intensity (MMI), Response Spectrum, Fourier Spectrum.

• For all analysis sessions the following information is stored:

Mode tracking of reference modes over all analysis sessions.
Thresholds for critical and unsafe levels of the following:
Channel statistics. Relative interstorey drift ratios. Tracked modes. Damage Indicators. Control Chart Values.

### Web presentation, reporting, and notification

The analysis results can be viewed at <u>www.artemis-shm.com</u> simultaneously by multiple users.

Users can also be notified either by SMS or e-mail or both. The notification is configured through an administration back-office per user and per structure in an organization, and the users can by notified when:

- A new measurement record has been analysis and new results are available.
- A structures overall health status changes from being safe to critical or unsafe.
- Errors or warning are detected during the analysis.

The notifications will link to reports with information related to the notification type. These reports can be configured through an administration back-office.

## ARTeMIS-SHM

More information about ARTeMIS-SHM is available on our website: <u>www.svibs.com/artemis-shm</u> NOVI Science Park Niels Jernes Vej 10 DK- 9220 Aalborg East Denmark PH: +45 9635 4422 F: +45 9635 4575 E: info@svibs.com www.svibs.com

