

SHManager™ User-Interface & Web-User-Interface for Permanent Monitoring Systems

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Permanent measurement systems (also called monitoring systems) continuously produce measurement data on a large scale in the best case. Apart from data recording, storage and management, data analysis and visualization play a decisive role for the further utilization of these data.

These aspects represent a challenge for permanent monitoring systems, in particular if:

- a large number of sensors is used (up to 1000 sensors and even more)
- high sample rates are applied for dynamic monitoring (500 to more than 1000 Hz)
- the monitoring systems are installed in remote locations (e.g. offshore structures)
- the monitoring systems are no longer accessible after installation (e.g. offshore wind parks, power stations, etc.)
- real-time data transmission and evaluation with alarm function is required.

For this purpose airwerk/VCE developed a so-called “web-user-interface“ applied in more than 50 monitoring systems up to now and also made available to partner enterprises.

This interface offers an individual, safe and reliable access to the monitoring systems and the measurement data. It has tools for semi- and fully automatic data analysis as well as for reporting. The full functionality is described in the following chapters.

1. Requirements for Permanent Monitoring Systems

Permanent monitoring systems have various basic technical requirements which are summarized below and whose knowledge is significant for the technical understanding and the use of the user interface.

1.1 Requirements for a Permanent Measurement System

The function of permanent monitoring systems is to collect measurement data on a building or structure by means of various sensors. For this purpose the measurement system must collect and store the data.

Apart from safe data storage the most important criterion is reliable, continuous and permanent operation of the system.

1.2 Requirements for Data Storage and Data Management

All raw measurement data of all sensors are recorded on site, mostly redundantly to avoid data loss, for a pre-defined period (typically 1 to 20 years). These data are mostly saved as temporary measurement files (e.g. for one hour) in a pre-defined filing structure. All measurement channels are collected in a file with chronological synchronism and provided with a time stamp (UTC). Files from video surveillance or weigh-in-motion systems are recorded in parallel.

At the same time the data are evaluated to generate further useful information from the raw measurement data and to reduce the data volume for further processing. Such evaluations are e.g. statistical analyses and pre-defined algorithms like FFT. These evaluations run fully automatically parallel to the generation of raw measurement data files. The results of this evaluation are recorded in a database structure and linked to the raw measurement data.

1.3 Requirements for Data Transmission

The following distinction shall be considered in data transmission:

- (1) Data transmission from the monitoring system to a local control room
- (2) Data transmission into the web-user-interface.

Data transmission to the control room is usually realized via optical fibres and has a big bandwidth. Thus, not only the preliminarily evaluated measurement data but also the raw measurement data and, if applicable, also video data can be easily transmitted and visualized in real time.

Data transmission to the airwerk/VCE server is often realized via mobile communications and internet. This results in a limitation of the transferrable data volume. In most cases only the preliminarily evaluated measurement data are transmitted. The real-time transmission of individual measurement channels is only possible with time limitations (called live-view). Raw measurement data can be transmitted on demand to a restricted extent.

1.4 Requirements for Evaluation

As already described above, a major part of data evaluation is performed fully automatically by the measurement system on site. The necessary routines are programmed according to the installed sensors and the respective requirements. The results are transmitted to the airwerk/VCE server and are further analysed there.

The measurement data can be transmitted with the raw measurement data for a detailed, manual evaluation.

1.5 Requirements for Data Accessibility and Data Visualization

Data visualization and data accessibility must be possible for every user according to his individual rights of use and access any time. This can be most easily ensured via a website with the corresponding functionality. The latter shall be informative and manageable in a user-friendly, easy and intuitive way. Appropriate speed and accessibility with mobile terminals (tablet, smartphone) must be respected.

2. Typical Setup of a SHManager™ Monitoringsystem

A monitoring system usually consists of the following parts:

Measurement chain:

- sensors and accessories
- analogue signal cables
- signal conditioning
- data acquisition (A/D conversion)

Measurement data processing – hardware:

- monitoring computer (redundant)
- network components
- video

Measurement data processing – software:

- operating system
- database system
- remote control software
- configuration software
- evaluation software

Supporting equipment:

- electrical power supply
- buffer batteries
- data transmission units (modem, wireless modem)
- cabinets, air conditioning, masts, mounting equipment

3. Data Management in SHManager™ Monitoring Systems

Most of the applied sensors deliver analogue voltage or current signals that are digitized by A/D-converters and can be consequently electronically further processed by the computer system.

If necessary, sensors with digital data interfaces (RS232, RS485, Ethernet) can be integrated into the monitoring system.

The acquired measurement data are saved on the monitoring computer at the structure to be monitored. In order to guarantee high safety of data, measurement data are stored on two mirrored hard disks for permanent operation or SSDs. This measure prevents data loss caused by failure of one hard disk or SSD. The monitoring computer and its components are secured in a steel locker against unauthorized access.

The monitoring computer evaluates the recorded values and writes the results into the centrally administrated monitoring database via a secured VPN-link. The monitoring webserver and the database server are located in a safe environment at the VCE headquarters in Vienna, Austria.

All measurement data are stored on two separate servers located in two separate buildings in order to prevent data losses. Via the web address www.shmanager.org the monitoring internet service can be accessed from every computer or mobile device with active internet connection.

The monitoring computer is fully remotely maintainable via a secure VPN connection. This connection may be established via an existing dedicated line or via a mobile UMTS-based internet connection. The bandwidth of the UMTS-network is perfectly suitable for monitoring tasks. All measurement results can be transferred from the monitoring computer to the server.

At the same time remote control tasks (software updates, evaluation algorithms) can be performed without any limitations. Usually the data volume does not exceed 2GB/month.

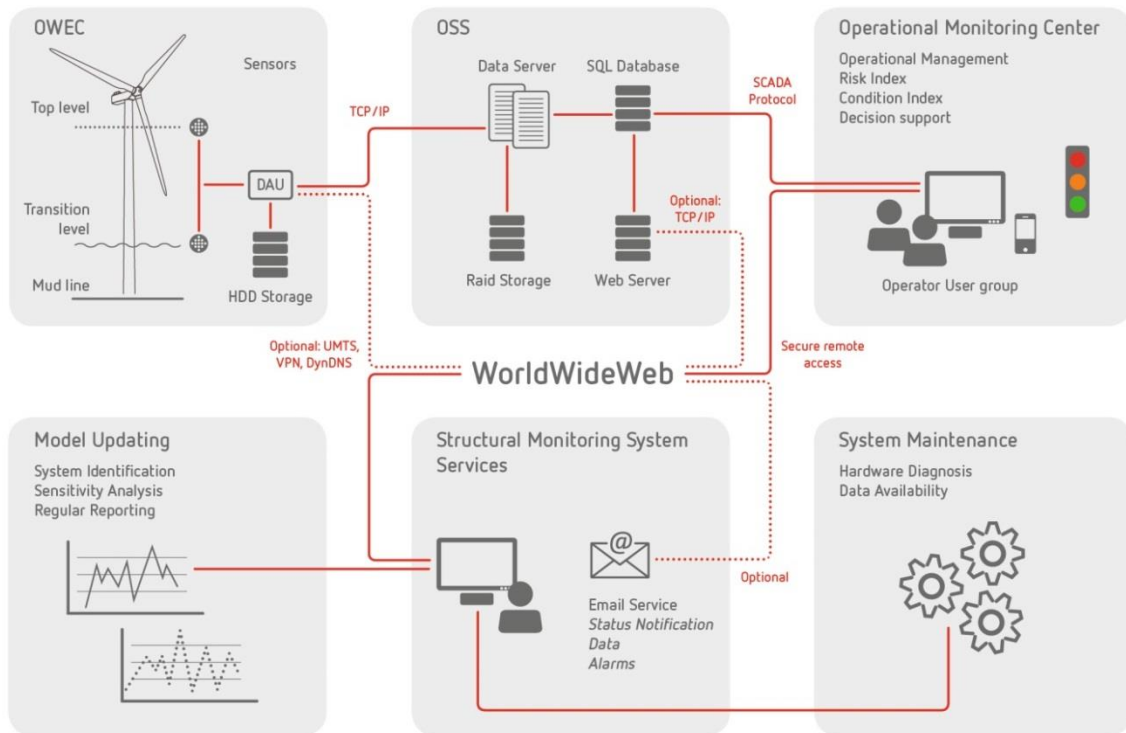


Figure 1: Data management scheme of the Web-User-Interface.

The web-service and database servers are supervised by monitoring experts and IT-staff at the VCE headquarters. Both servers are redundantly designed so that high availability may be expected. Both, database schemata and web-service architecture have been completely developed by VCE and are continuously expanded. Therefore exceptional demands of monitoring projects can be easily considered and required additional features can be implemented on short notice. Extensions may be also applied on running monitoring systems without suffering any data loss.

All measurement results that have already been transferred to the database-server are backed up regularly at short intervals and archived at a separate position. Additionally these results are also stored on the monitoring computer on site.

All measurement raw data that are stored on the monitoring computer but cannot be transferred automatically (e.g. raw data of high-frequency acceleration measurements) may be copied onto an external USB-drive, USB-pen or notebook and afterwards inserted into the monitoring database. This archive is organized according to structures and time stamps.

This (database-supported) method allows explicit assignment and retrieval of monitoring data to the corresponding structure/project and works as basis for later evaluation or more profound investigations.

If required raw measurement data can be downloaded from the monitoring computer via the web-user-interface any time.

4. The SHManager™ Web-User-Interface – Funtionality

The user part of the monitoring systems is fully designed as internet service so that no additional software programs have to be installed at the terminal of the user. The application is performed via common web browsers (Internet Explorer, Mozilla, ...).

The application by means of mobile terminals is intended (smartphones, tablets). Appropriate apps for these devices are available.

The web-user interface offers the following functions in its current version:

- (1) Password secured user authentication for any number of users. Every user gets his own user name and password. Access is via www.shmanager.org
- (2) The access rights of single users for individual projects and measurement data are individually assigned. The same applies to the functionality of the system (logbook function, acknowledgement of alarms, preparation of reports, download of data, etc.). So for example within one company individual users might receive full and others only restricted access. Every user has strictly only access to his own projects
- (3) After login and the selection of the project there is a general view of the monitoring project including a summary of all the relevant information ("monitoring dashboard"). The general view contains information on the project and the monitoring system. This includes a project description, the presentation in a map, photos and a link to the measurement system description and the individual components / data specifications. The dashboard also allows rapid access to selected measurement data and evaluation results. The dashboard also shows an interactive 3D-sketch of the object with all sensor positions.
- (4) The Web-UI allows the representation of time history charts for any number of measurement channels. In addition to a complete view of all channels views for groups of channels may be arranged. Free time domain selection for display is available. The download of time history charts for the selected time segment is possible as CSV-file.
- (5) Different types of charts can be selected: line and bar charts, scatter plots, special types for meteorological measurements.
- (6) Furthermore there are alarm functions via e-mail or SMS, e.g. in case of exceedance or shortfall of static or dynamic threshold values, missing data input or malfunctions like interruption of power supply. The notifications are internally provided with a priority ranking in order to be able to separate "warnings" from "alarms".
- (7) Logbook function: The user has the possibility to journalize events relating to the structure as logbook entry to oppose the monitored data to impacts e.g. from building site activities, extraordinary traffic events etc.

- (8) Real-time display of selected measurement channels allows the presentation of continuous data flows of dynamic, high-frequency acceleration signals or other rapidly changing parameters.
- (9) Integration of webcams at the object is possible. The pictures are allocated to the measurement data with the correct time.
- (10) Data export of all data from the time history charts in common comma-separated ASCII-format.
- (11) Import of external data via different interfaces (web forms, e-mail attachments, ftp-upload and download, database replication mechanisms, etc.).
- (12) The establishment of a so-called “monitoring cockpit” is possible specifically for each project. This cockpit shows the current measurement data for all sensors at the object.
- (13) Automatic implementation of mathematical operations and analyses: calculation of measurement channels, correlation analyses, trend analyses, threshold criteria, classification, cycle counting, evaluations, etc.
- (14) Preparation and transmission of automatically generated periodic measurement reports is possible. For this purpose project-specific templates are prepared and imported into the system. The reports can be downloaded or automatically sent by e-mail.

5. Use of the Web-User-Interface

5.1 Login

The internet service “Measurement Data Management” is very user-friendly. The login is carried out via www.shmanager.org :

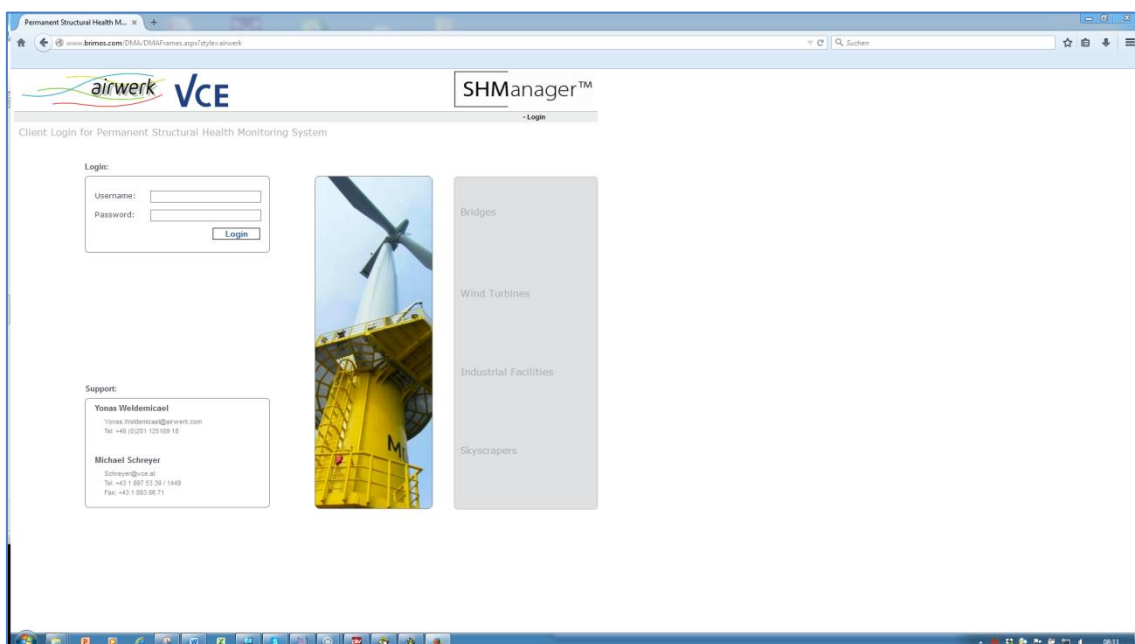


Figure 2: Login area

5.2 Monitoring Dashboard

After selecting the project you reach the monitoring dashboard for this project (Figure 3).



Figure 3: Dashboard

The project dashboard provides an overview of the structure, the monitoring task and also possibly existing notifications. Additionally pictures from webcams or contents from other webpages in relation to the monitored structures may be embedded:

- At the top left there is a short description of the structure, the project and the measurement task.
- At the top in the centre there is a collection of pictures of the project, which are enlarged after clicking on them.
- At the top right you can find interactive maps and aerial images.
- At the bottom left lists of curve progressions of the parameters observed are shown for rapid access. The respective charts are displayed by clicking on them.
- At the bottom right you can see a sketchy 3D display of the respective structure where the sensor positions can be found. This display is also interactive and allows rotation and zooming of the model. You get information on the respective sensor by clicking the sensor points.

5.3 Monitoring Cockpit

You reach the so-called monitoring cockpit (Figure 4) by clicking the button "Cockpit". The „Cockpit-display“ shows an overview on the windpark. The individual sensor-layout of each WTG and the monitoring-data (Monitoring Data – Timelines) can be reached by clicking on the selected WTG.

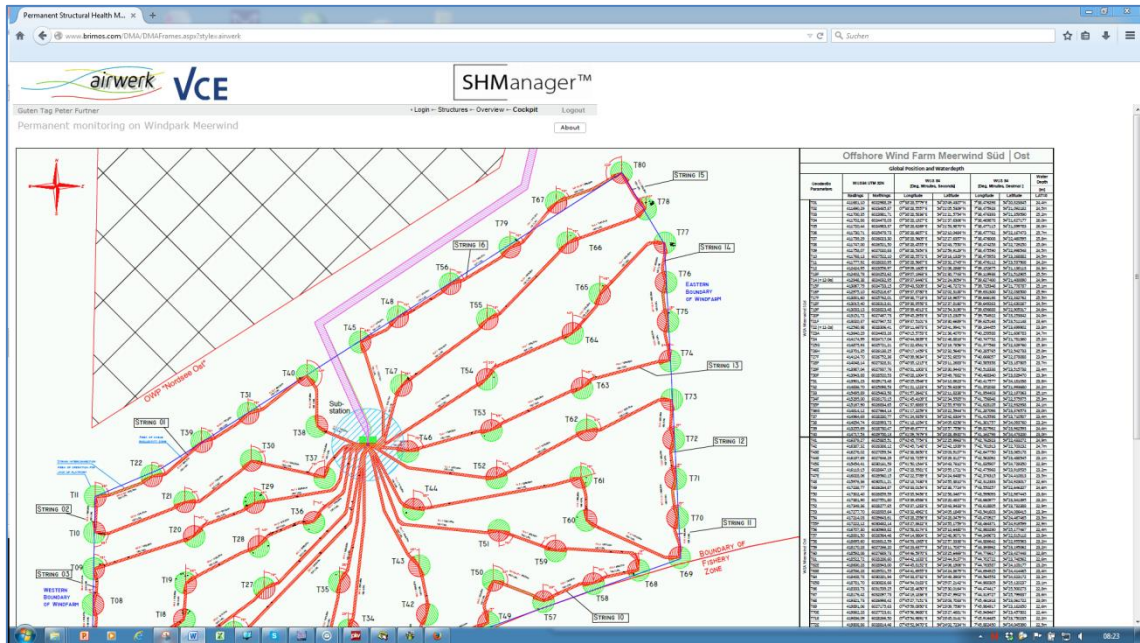


Figure 4: Monitoring Cockpit

5.4 Alarms

The alarm function (access by clicking of “Alarms” in the dashboard) for notification is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.** in list format. On the right is the category of the notification (orange = “warning”: red = “alarm”).

All events triggering alarms are listed. Every alarm is provided with a time stamp and alarm value. The alarms are sent to a pre-defined list of addressees by e-mail or SMS. The alarms can be sorted and filtered according to different categories.

The alarms can be also found on the timeline in the time history chart (see Figure 5) in form of red and orange warning triangles. Alarms that have already been actively noticed by the user are displayed as grey triangles.

5.5 Monitoring Data – Data Time Histories

Figure 5 and **Fehler! Verweisquelle konnte nicht gefunden werden.** show the time history charts of different measurement values with charts for various variables. Certain time histories can also be displayed as colour charts, like for example trend cards, which show the frequency trend over time.

In the upper navigation area the time segment can be selected and events or logbook entries can be faded in and out. Logbook entries are illustrated with a sign of a clock in the timeline.

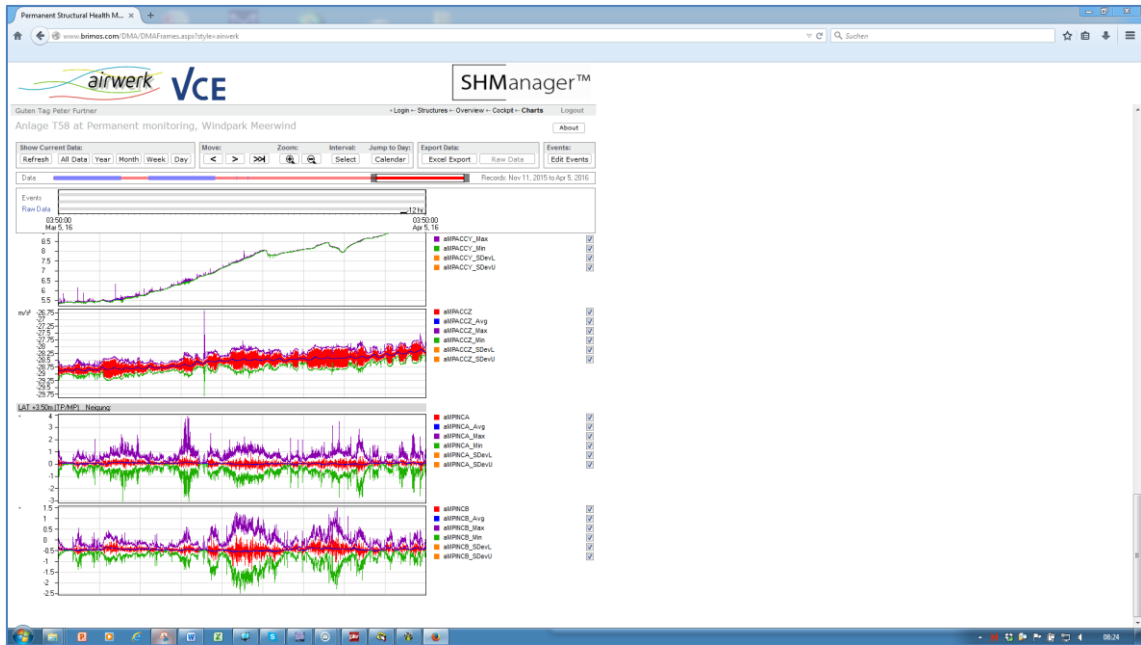


Figure 5: Time history charts

5.6 Data Analysis

Special forms of display serve for the analysis of the monitoring data.

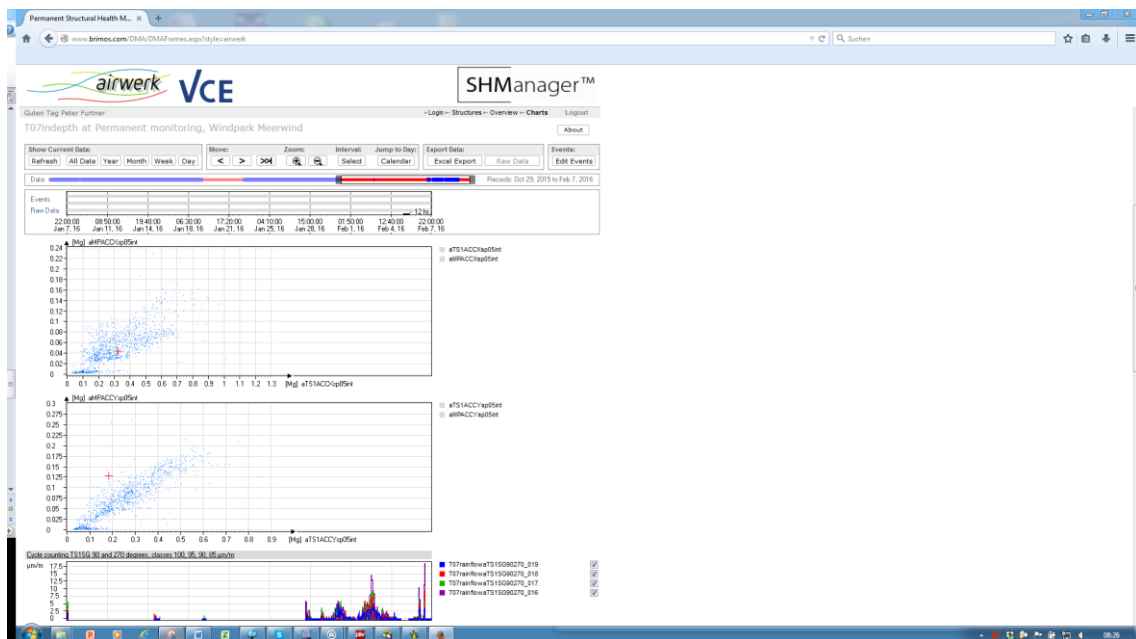


Figure 6: Correlation analysis

Figure 6 shows the correlation between two variables, in this case 2 acceleration sensors. Figure 7 presents an example for the counting of stress cycles.



Figure 7: Counting of stress cycles

5.7 Live-View Display

The web-user-interface is also equipped with a live-view-function. This allows real-time access to individual measurement channels in the form of passing time series.

5.8 Data-Download

All data can be downloaded in the web-user-interface and be further processed in other programs. A common comma-separated ASCII-format is used as data exchange format. All values are provided with a time stamp.

Individual or all measurement channels can be downloaded; they are selected by setting checkmarks. The downloaded tables contain the data of the time domain which was previously selected for display.

Furthermore it is possible to directly download raw data from the measurement system. As the available bandwidth for the access to the monitoring computer of the measurement system on site is limited, the measurement channels and periods for the download of the raw data have to be carefully selected.

We are pleased to integrate the demands and requests of the client!

6. References

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- [2] Wenzel H et al. IRIS - Industrial Safety and Life Cycle Engineering, VCE Vienna Consulting Engineers ZT GmbH: Vienna, Austria, 2013.
- [3] www.shmanager.org