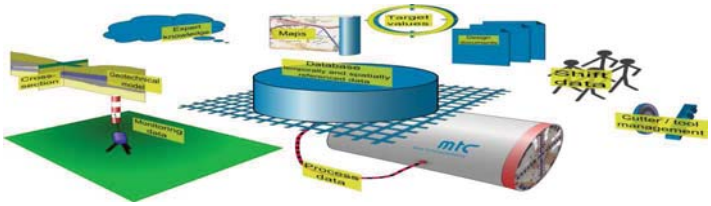
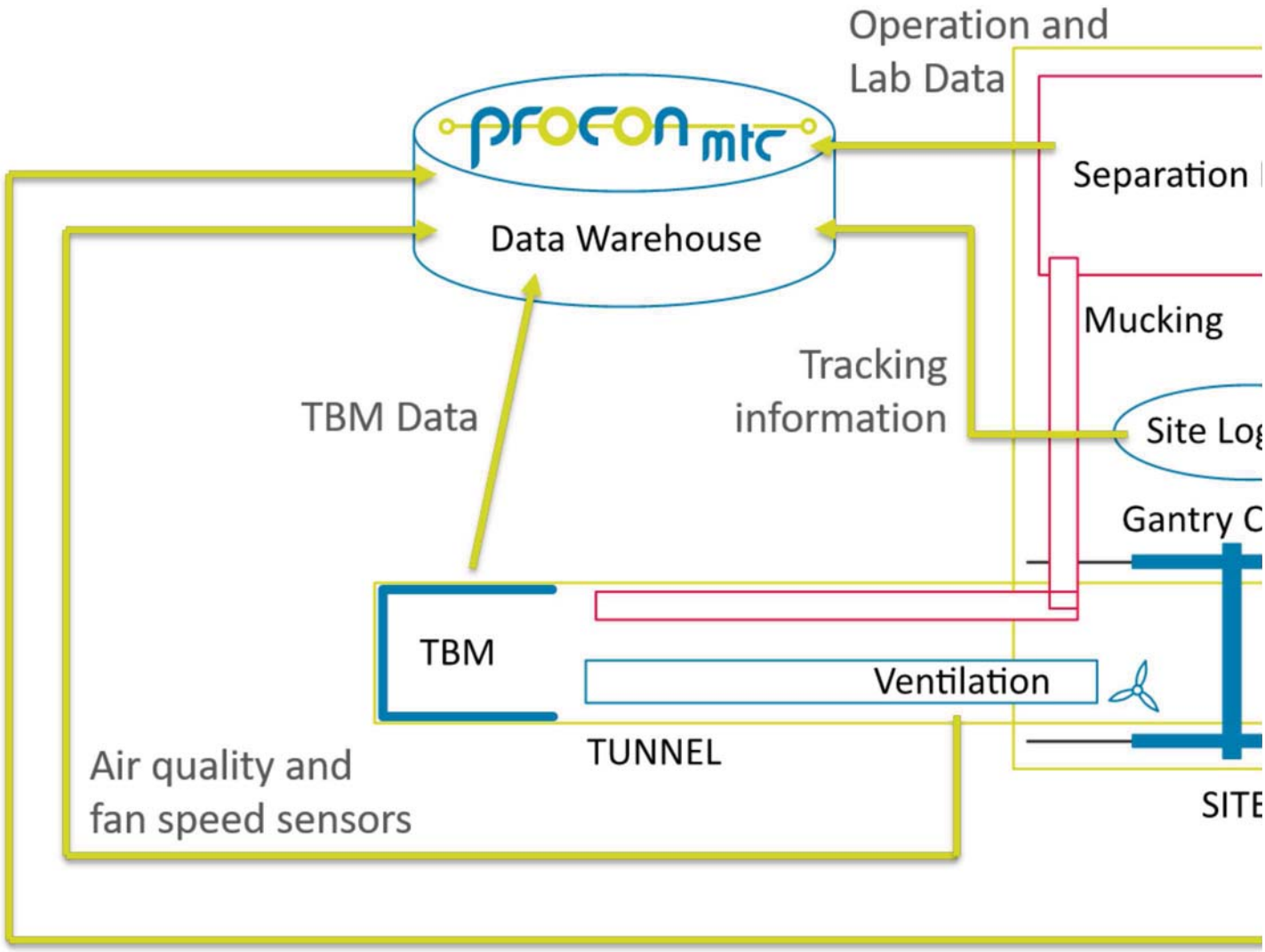
Procon Guide

PROCON II is a software for the technical controlling of mechanized tunnel drives. A professional management system for the efficient recording, analysis and visualization of data. The foundation for your knowledge management in mechanized tunneling projects. It aims to visualize time-dependent, location-dependent and object-dependent data in an intuitive and meaningful way. The figure below shows the various sources of data and information that can be integrated, visualized and analyzed in PROCON II.



PROCON II is based on the latest software technology. Thus, your vast process data are transformed into visual information. Take advantage of the affordable possibilities of geographical information systems (GIS) and link them to your interactive charts. With the generic chart and dashboard configurator, you can visualize all of the relevant information tailored to your specific needs and follow your project live with your web browser.

PROCON II is a web application that is hosted on a secure and highly availabile cloud system. On the client side, access to PROCON II is managed by means of SSL encrypted communication via the HTTPS protocol and an additional access control layer using personal logins per user. Beside the installation of a client certificate for the encrypted communication, no further installation efforts are required on the client's computer. A special version with an optimized visualization for mobile devices is optionally available.
The modular design of the software allows to freely configure the system according to the specific requirements of each project. Beside the visualization of both real-time and historical machine data, further information and data can be integrated to PROCON II. Target values from the design process can be directly compared to actual measurements. The manifold of different visualization options can be conveniently arranged on dashboards and can also be used to create printed reports.
Limit and alarm values are also stored in the system and can be configured for an automatic alarm messaging in case of breaking their thresholds.
In addition to sensor values, also calculated and aggregated values (minima, maxima, averages, cumulated values, etc.) can be defined used for further analyses and visualizations. Thus, for example, interactions between different parameters can be identified and investigated. Furthermore, it is possible to adapt the database to changes in the data acquisition that occurs in a later stage of the project using these customized calculation values without corrupting the original data.
In addition to the various fields of application of TBM data, PROCON can also integrate data from various other data sources related to the tunneling project. This can include data from the geo monitoring, the separation plant or the ventilation system. All of this external data can be assembled on PROCON dashboards along with critical TBM data to get a holistic overview of the tunneling project.

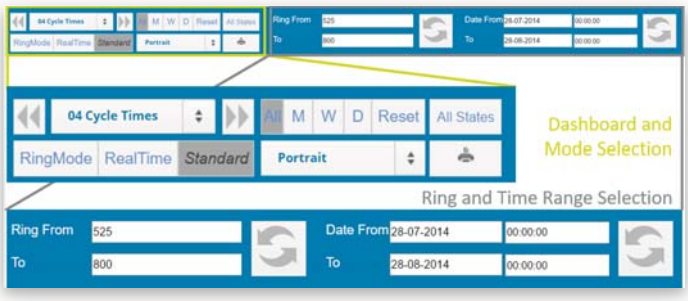


The secured data hosting in a cloud service computing centre ensures sustainable and secure archiving of both automatically acquired and manually entered data. The installation of special hardware on site is not required. For full usability it is sufficient to set up a reliable internet connection for the transfer of machine and monitoring data from site to the PROCON II host.

In the following we invite you to an interactive introduction tour to PROCON. In this process, the individual features of PROCON are generally described and assigned to a link to the software where you directly can test the introduced features on your own.

Dashboards

All data from the PROCON II data warehouse can be visualized by means of interactive and customizable charts. These charts can be directly zoomed, adjusted and arranged on specially developed dashboards in the browser. These dashboards gather information of specific topics and are used to display several sources of data in a common reference system for immediate comparability. In this context, your data is linked on dashboards with maps of a geographic information system as well as a digital ground models in a location or time reference system.
Each chart is capable of displaying an arbitrary selection of machine data, target values, additional information and calculated values in a customizable visual appearance. For this purpose, line charts, column charts and area charts are available. For suitable data sources, also pie charts can be employed.



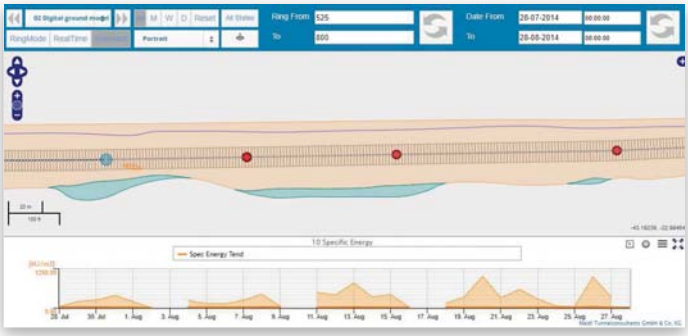
Dashboard navigation

The range of the data to be shown in the dashboard can be easily and intuitively selected by either scrolling or zooming in the charts or by picking a time or ring range in the top menu. Additionally, the last day, week or month can be selected by clicking the respective button.
After the selection of the respective range you can easily change the current dashboard using the drop down menu or the navigation arrows in the top left corner of the dasboard menu. This significantly simplifies the data analysis.
A unique feature of Procon is that the all data of all types is accessible. With am incredible high performance you can zoom, for example, average values from days to 10 seconds raw data.

Interactive GIS

All relevant project documents as CAD drawings, reports on existing infrastructure or buildings in the vicinity of the tunnel, geotechnical reports, ground parameters or images can be stored in the data warehouse and attached to the project-wide

geometrical and temporal reference system. Using a geodetic information system (GIS) the relation of these metadata with the automatically acquired machine data and all further available project information is displayed on an interactive map of the tunnel and its environment. Project relevant documents and drawings can be visualized on different layers. To see the individual layers, click the "+" Button at the top right corner of the map to open the drop-down menu. For better orientation, the alignment and the current position of the tunnel boring machine are marked in the map as well. It is also possible to display multiple alignments and TBM position on the same map. Thus, all potential hazards, alert conditions, data and performance analyses and further visualizations can be directly referred to the respective location of the machine and the event.



Ground model

An optional geo-referred ground model can be stored in the PROCON II data warehouse as well. This model comprises not only the geometrical definition of geotechnical layers in the longitudinal section along the tunnel alignment but also the respective ground parameters like strength or abrasivity. Thus, the ground model serves as a reference for wear, consumption and performance analyses.
The interactions of the TBM with the ground are continuously tracked by means of machine data analysis. The current ring is highlighted by a blue circle. Comparing target and actual values of the ground support, also settlements and the stability of the tunnel face can be monitored in real time. In an interactive visualization of the longitudinal section, the ground model can be further displayed along with arbitrary data visualization charts on a dashboard.

Excavation KPI Ranges

All machine parameters and other time- and location-dependent data can be visualized in single charts that can be positioned on the dashboard at will. Thus, you will always have the overview of the current status and developement of the project.

Cycle times

Of course, also production data of different processes can be arranged in individual dashboards.

Interactive Dashboard

In PROCON II, users can generate individual, interactive dashboards for their specific needs. They can combine maps, geological models, charts of different types and individually designed reports. For all elements of the configured dashboard, data with the same time range are injected such that they can be compared comprehensively.

TBM production

The performance of the TBM for each calendar day or week can be combined with maps or charts of machine parameters.

TBM Data Benchmarking

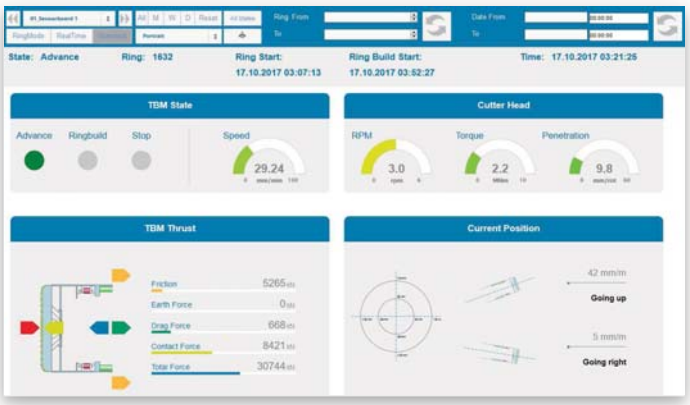
For each advance parameter, target values or desired ranges can be defined. Additionally, analytical computations can be performed using the formula editor. This enables a target/actual comparison on all levels.
In the presented example, the earth pressure developement is shown in comparison to the target values of the support pressure calculation.
In the bottom of the dashboard, the fluctuation of excavation volume in relation to the thrust jack extension is presented.

TBM Data Regression Charts

By means of regression charts, correlations between parameters can be detected. Thus, changes of ground conditions or effects of steering decisions can be easily tracked and evaluated.

Pie Chart

Procon II comes with an integrated shift reporting module. To evaluate the downtimes, the shift reporting module offers different chart types like, for example, pie charts. Here, individual downtime reasons can be evaluated as well as complete downtime groups.
On the dashboard, these downtime evaluation charts can be arranged along with other elements like the geological model or machine data charts to analyze the reason for delays.



Sensorboard

For an efficient and consistent process, mechanized tunneling requires constant surveillance. Therefore, PROCON II provides one or multiple so called Sensorboards which display the current values of a selected sample of sensors in graphical and intuitive manner. MTC provides a basic layout of the Sensorboards but it can be customized for each individual project. Our Sensorboards are optimized for mobile devices so that they can be used for monitoring the project on the go.
In addition to the "advance mode" which always presents the current data, a Sensorboard can also show historical data. In the "history mode" you can jump to a defined point in time, ring, or tunnelmeter to analyse the situation at the chosen moment. For an easy navigation in the time line Quick-Select buttons have been added.

Advanced Analysis

The advanced analysis is a category for more sophisticated dashboards that are accessible for selected users of the system. It is reserved for complex topics, or deeper analyses of certain processes.

Key Excavation Parameters

One key process of the advance is the excavation process. Specifically designed dashboards can visualize all key parameters to this topic for a deep investigation and evaluation of the excavation.

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Foam Grout Face Pressure

Another important process of the advance is soil conditioning at the tunnel face. Many different aspects and parameters have to be considered, which can be visualized on one dashboard to make informed decisions.

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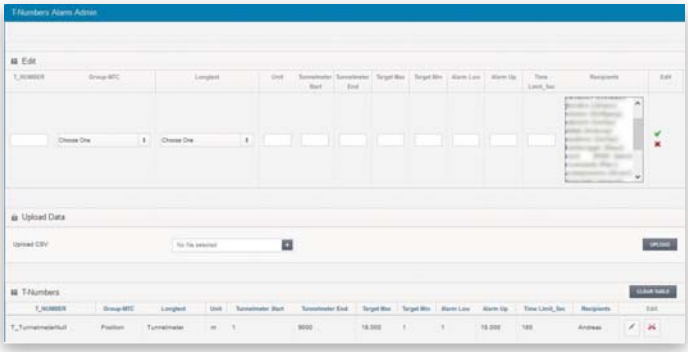
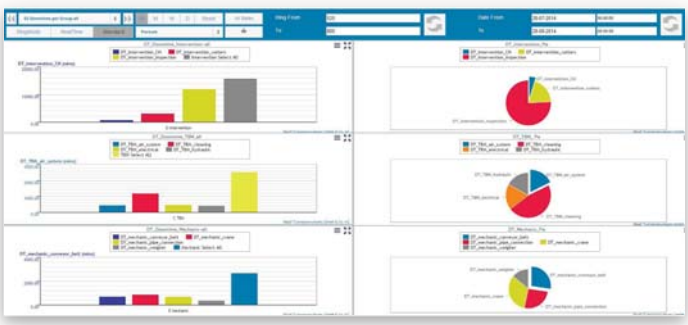


Alarming and Messaging

The simultaneous storage and common referencing of target and actual values allows for automated alarming that is seamlessly integrated in PROCON II. Using the common location-and-time reference system, any violation of user-defined thresholds can be set to trigger an e-mail alarm to selected users. An e-mail alarm can be further configured by defining how long a threshold has to be violated before sending an alarm. Additionally, a period can be provided which has to pass before sending another message.
Furthermore, hazards can be displayed in the built-in map feature to assist with a quick location of potential problems.
Using the alarming and messaging system, potential hazards can be communicated to the responsible persons in real time such that required counter measures can be initiated without delays. Many hazardous situations can be prevented or diminished by quick reactions.

Shift Reporting

An interactive module for shift protocols extends the list of optional features of PROCON. Extracting periods of advance, ring building and standstill automatically from the machine data, these time intervals are displayed using a Gantt chart visualization for each shift.
Shift reporting represents an essential element of the documentation of a tunneling project. All actions are documented and can be evaluated as well as exported. In Procon II, multiple types of shifts per day can be generated like a morning, day and late shift. The key processes like advance and ring build are automatically retrieved from the machine data and assigned to each shift. The reason for each downtime slot needs to be specified by the user. Here, the catalog of downtimes is specified according to each project's requirements. Based on the documented downtime reasons, evaluations can be performed based on which the process can be optimized.
For detail evaluations, additional filters on specific shifts or staff members can be used, hence allowing for an assessment of reasons for performance differences among the shifts or to identify specific parameters that correlate with the performance. The integrative nature of the data warehouse and the unified temporal and spatial reference system helps identifying previously unknown interactions and hidden mechanisms in the process.



Evaluation of all Groups

Evaluate the downtime distribution and analyze the reasons for performance issues using different visualizations like pie charts or bar charts. In those charts, either specific codes can be captured or a whole group code. In this example, groups of codes are selected.
The x-axis of the downtime bar charts can be selected as required. For example, the downtimes can be evaluated by ring, by day or by week.
Combining this information, all processes in excavation can be analyzed regarding their time and cost structure. Here, all information stored in PROCON can be employed, like, e.g. geological information or machine data.

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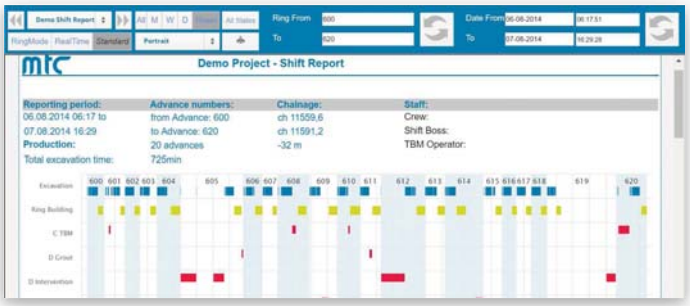
Evaluation per Code

The downtime evalauation can also be performed code-based. In this example the downtimes of an individual downtime group are investigated based on different chart types. On the x-axis of the bar chart a downtime group is shown.

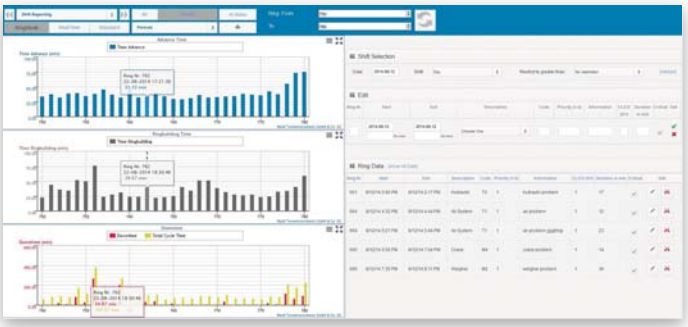
Shift Report



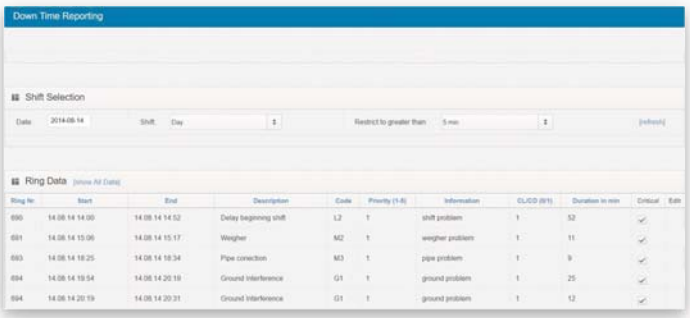
The presented shift report is a customized report. It can be adapted specifically for your needs.
In the report the individual downtimes are visualized in a Gantt chart and listed in a table underneath. Additionally, the main downtime reasons are provided.

Downtime Report

The planned processes and downtime durations can also be visualized in usual charts. Additionally, other pages, e.g. of Procon, can be integrated into a dashboard for operation. Here, the page for data input is integrated into the dasboard so that you can easily enter the specific downtime reasons in context of the overall advance progress.



Downtime Configuration



The individual downtimes for each shift can be entered in a simple mask. A gantt chart on the top of the page shows the main processes advance, ring build and downtime along with already configured downtimes. The share of each main process is shown in an adjacent pie chart. Each process is assigned to a ring number that serves as location reference and helps analyzing the downtimes for each ring separately.
The entered downtimes can either be critical or non-critical. Non-critical downtimes can overlap other critical tasks whereas critical process and downtimes are not allowed to overlap.
If required, those downtimes which have not been assigned to a downtime category (e.g. because they are too small), can be automatically be assigned to an uncategorized downtime category to ensure that all downtimes are captured. Additionally, many smaller downtimes can be merged to one bigger one, if this is required to document the shift.
Important: To see entered downtime on the demo page, please select either a ring (range: 525 - 800) or a date in the "Shift Selection" (range: 27.07.2014 - 27.08.2014), a shift type and, optionally, a time restriction. Next, click on the "refresh" link on the right.

Cutter Tool Management

The management of cutter tools is very important especially when excavating in hard rock. The wear of the individual cutter tools must be documented to prevent the tunneling machine from being damaged due to worn-out tools. In Procon II, the individual tools can be registered and maintained. Data can be entered based on interventions which represents an event when the cutter tools are checked for their current wear and changed, if required. Types of cutting tools like disks, scrapers and buckets are distinguished in the system and can be managed in respective user interfaces.
The entered intervention data can be displayed using Procon's chart and dashboard configurators. Here, the tool consumption can be correlated with machine data and geology information. Thus, evaluations can be performed of the required tools in context of the excavated ground. Following the identification of those wear mechanisms, the prediction of the tool service life can be improved and maintenance intervals can be optimized, reducing the risk of unplanned standstills.

Intervention Overview

Correlating maintenance logs with the digital ground model, data mining and data analysis tools can be further employed to detect the influence of certain ground properties, types of tools and driving parameters on the tool wear. In this context, the number of changed tools of different cutter types can be combined in one chart, represented in different compressions like per ring, per day or per week. This data can be arranged on a dashboard along with data which influences the tool abrasion like the geology or the thrust force. Based on this assembling of data the advance can be evaluated and informed decisions can be made to improve the excavation process.

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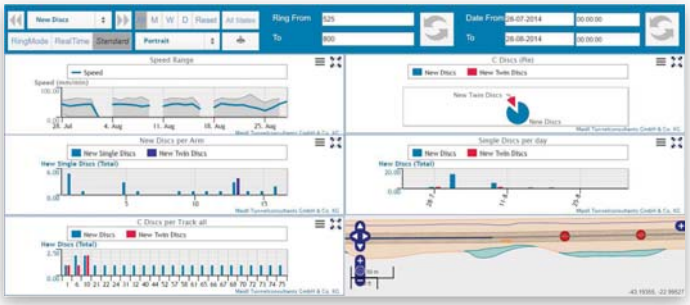

New Disks

Evaluations can also only be performed for a specifically selected tool type like disk cutters or scapers.

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Scraper left and right

Cutter tools can not only be evaluated based on the time but also based on their track. For each track the performed operations like tool changes can be visualized in a chart. Of course, all in the context of influencing parameters like ground conditions or penetration rate.

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Track overview

The condition of the installed cutter tools is visually provided. The current wear of the installed tools is represented by different colors. Additionally, those tracks are highlighted on which a tool has been exchanged, refurnished or switched. When displaying the tracks of the discs an overview of the number of already changed tools is shown on the right of the cutter image.
The status of the tool condition can be presented for each intervention. Furthermore, by selecting a specific track the history of this track is provided in a table beneath the cutter image.

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Intervention list

All documented interventions are shown in a list with shortcuts to their containing data. The interventions can be filtered by several criteria to easily identify the required intervention. An intervention can be exported to a customized PDF report for a holistic documentation of the intervention.
This list can also easily be added to a dashboard to generate a custom software structure.

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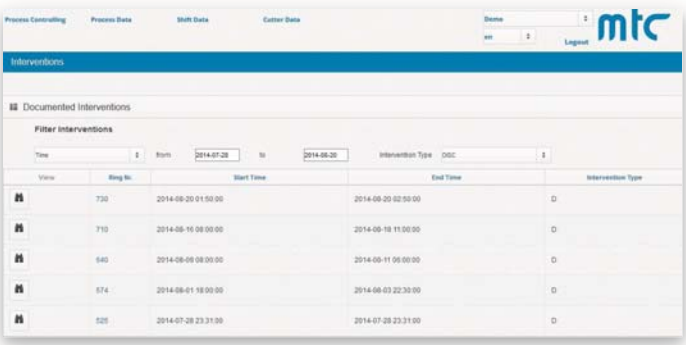
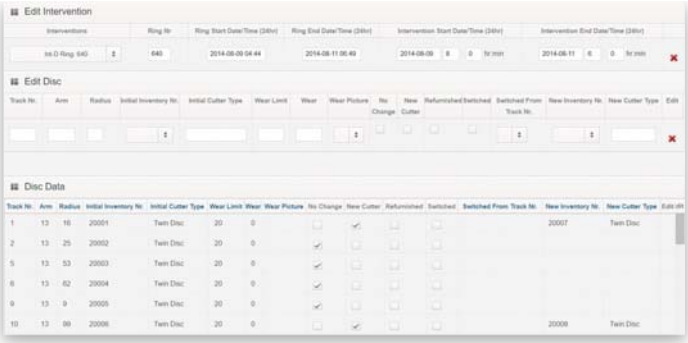


Intervention configuration

For entering a new tool change, an intervention either has to be created or an existing one edited. Each intervention is assigned to a ring during which it was performed.
When a tool change or another action on a tool shall be documented, the tool has to



be selected and the information can be assigned. In addition to usual information like the current wear of the tool also the reason for a tool change the so called wear picture can be specified.
When you open the page in the demo project, please select an intervention (under the headline of "Edit Intervention") to see some data.

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Cutter refurbishment

For the documentation of the repair of the disassembeled tools, PROCON provides a page to enter the data gathered during the repair in the workshop. Based on this data, a PDF report can be generated fow a holistic documentation.
In a pop-up a listed overview is provided over the available refurbishment parts.

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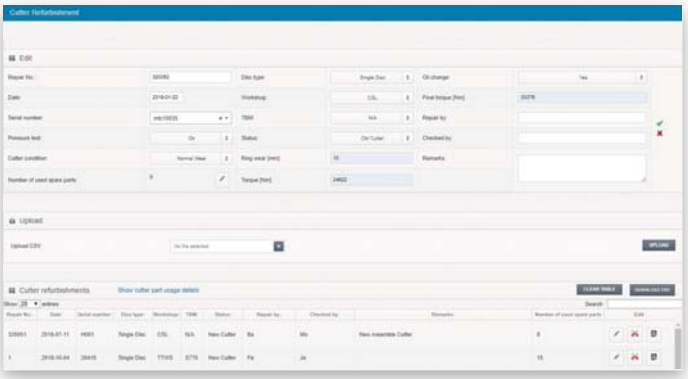

Monitoring

In an integrated additional database, monitoring data is stored that is retrieved from arbitrary instruments registered in the PROCON II data warehouse. Here, an instrument consists of a number of data series which contain the individual data. For each instrument the position and its assignment to a specific class of instrument (e.g. extensometers or leveling points) is captured. The data series contain additional information regarding their assignment to a monitoring section and their warning and alarm levels which can then be applied to determine the status of the instrument. Using this information, the location and the time of measurement of each data entry is connected with the project reference system.
This allows specific visualization options for monitoring data. The development of settlement troughs, for example, can by shown by visualizing monitoring cross-sections.

Settlements

The monitoring data module provides several features for displaying settlement data and other monitoring data in an interactive environment. Some of these features are listed below:

- Visualization of monitoring points in the interactive map
- Visualization of the timeline of a specific instrument by clicking its icon in the map
- Display of settlements along the tunnel alignment in a combined chart
- Display of settlements in cross-section charts along the alignment.
- Comparison of settlements with machine data in customized dashboards.

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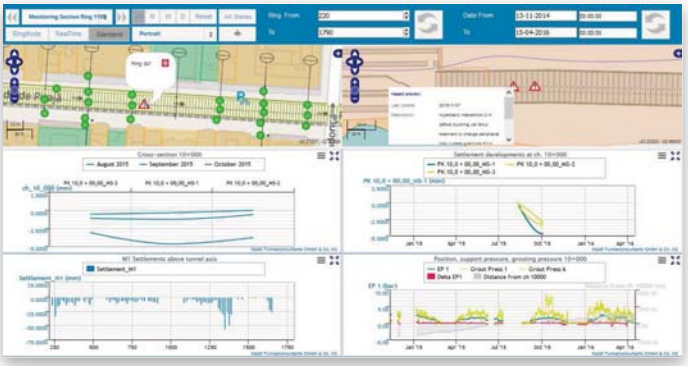

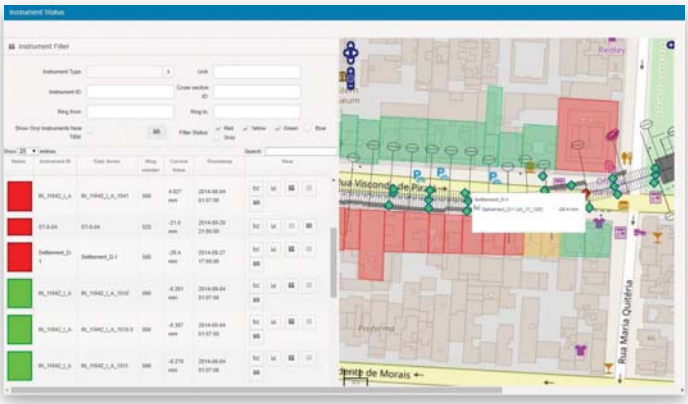

Instrument monitoring

To monitor the status of the individual instruments, PROCON provides a page where instruments are listed in a table as well as shown on map. The table and map are linked so that only those instruments listed in the table are visible on the map. The content of the table can be individually defined applying several filters like the instrument type or the status of the instrument. Another filter shows only those instrument in the table which are located near the current position of the TBM in order to rapidly list and access those instruments in the area of influence of the tunnel excavation works. By default, the instruments in the table are sorted by their status so that the most critical instruments are always shown first.
For monitoring an instrument more closely, several chart options are provided for openening a standard chart, shield passing chart or cross section chart. Additionally, data of the corresponding instrument can be checked in a data table popup.

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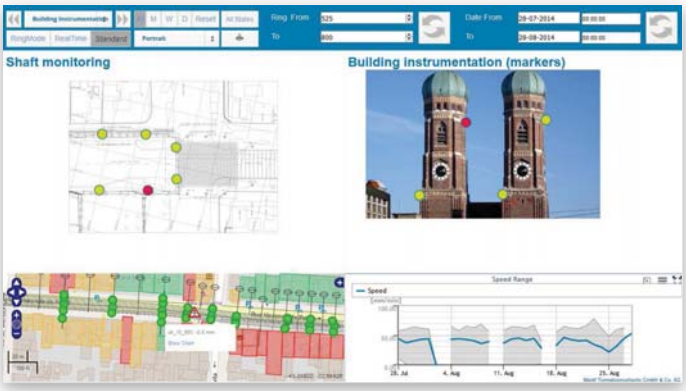
Site monitoring

During a tunneling project some buildings are highly sensitive and have to be monitored very closely. In PROCON for these building individual dashboards can be created which contain structural images where installed monitoring sensors have been marked. By clicking on the marker, a chart pops up and displays the data of the sensor. Thus, the user can very fast and easily inform himself about the status of corresponding building.



Horizontal timber wall

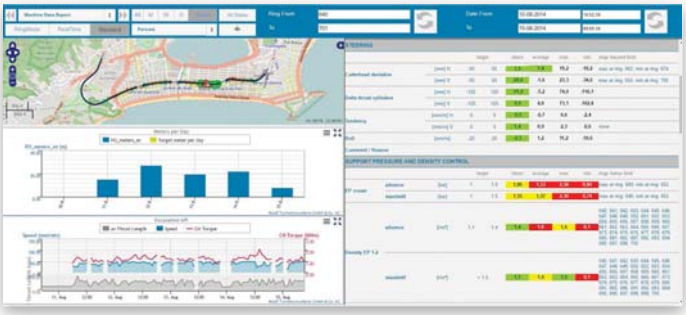
All aspects of a tunneling project can be captured with PROCON as well as the monitoring of the construction pit. The arrangement of the individual sensors can be shown on a specific plot where each captured sensor can be clicked to show its sensor values in a chart. Some corresponding charts of the monitored area can be arranged on the same dashboard to get a quick overview.

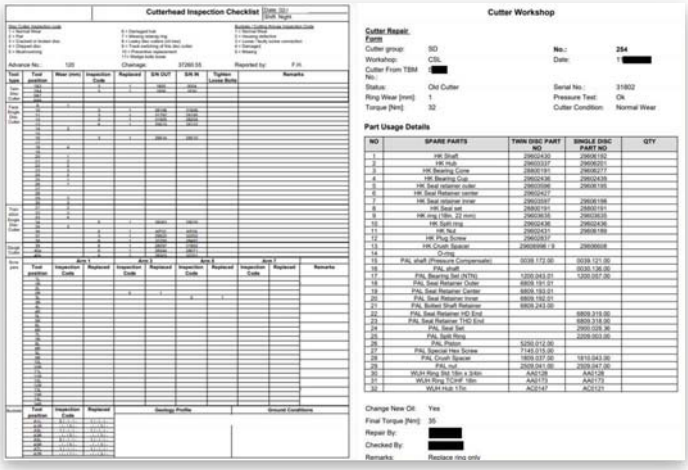
Reporting

The documentation of the tunneling process is essential due to many aspects. Therefore, Procon II offers custom-designed machine data reports, intervention reports and shift protocols as printable reports to document the progress. Upon setup of the project, MTC considers the project-specific requirements and prepares automatically updating report templates via the web interface. Reporting periods and various filter functions can be arbitrarily selected.
The reports can be arranged in dashboards to allow for adjustments of reporting periods and to add manual annotations before downloadind and printing them.

Machine Data Report

Special customized reports containing different, selected machine parameters are provided by MTC. They are filled with data for the selected range in the dashboard and offer a download functionality such that they can be printed and signed.
As usual, these reports can be displayed on dashboards in the context of additional data visualisations, thus allowing for further in-place evaluations.



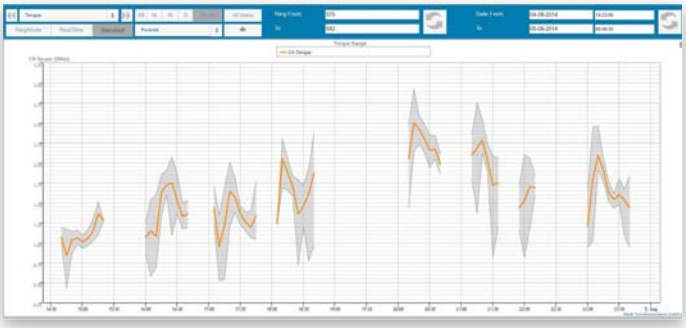


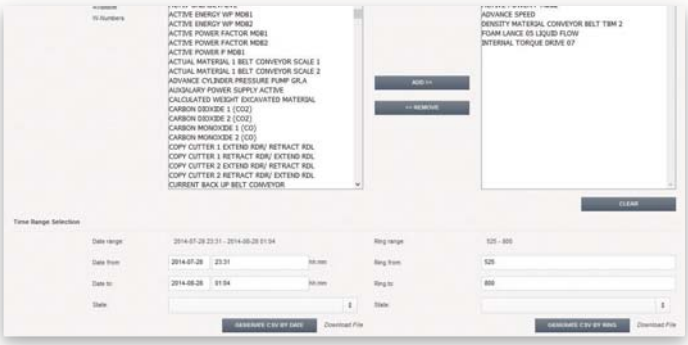
Tool Management Reports

With PROCON II you are well equipped for the documentation of the tool management process. Individual, customized reports are provided for managing and documenting the performed interventions and exchanged tools. Additionally, reports are provided for the documentation of the tool repair process in the cutter workshops.

Example: torque chart

Single charts can be generated for the reporting so that they can be exported as PDF or image and attached to your documentation report.





CSV export

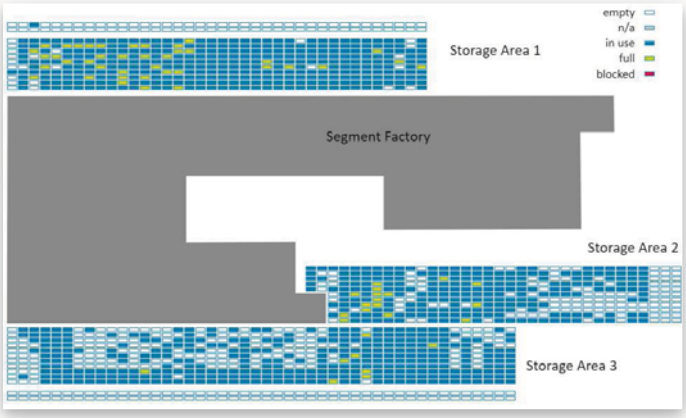
For further specialized processing of the recorded data, selected data can be exported in CSV format. This can be either TBM data, entered downtimes or monitoring data. The required data series or downtimes can be easily selected and stored in a template for a quick reuse, so that for each download only the time range has to be specified.

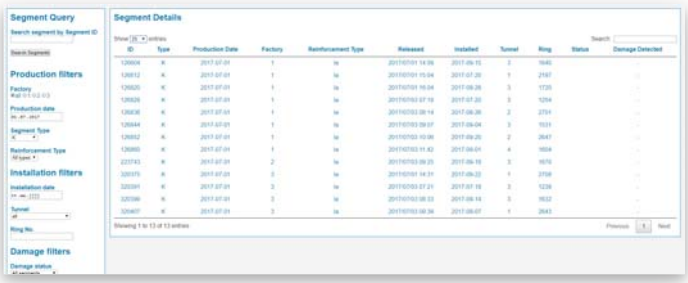
Segment Tracking

Segment Tracking describes the consistent tracking of produced segments throughout their life cycle. This process includes the production of the segments, their temporary storage on the construction site, their installation as part of a tunnel ring and their health status both during construction and operation of the tunnel. The segments are tracked by applying labels with codes on each segment.
Maidl Tunnelconsultants offer segment tracking services in cooperation with a well-experienced partner company, who provides the workflow implementation as well as all required hardware including handheld devices for entering the current information of the corresponding segments and a server which stores all the collected information and transfers it to the PROCON server. Thus, segment tracking information is available and accessible through PROCON at any time.

Segment Storage

To always be informed about the current condition of the segment storage area, PROCON provides a dashboard where all storage spaces are visualized including their current status. By highlighting the individual storage spaces in different colors, it can be easily identified which spaces are empty, in use or full. The arrangement of the storage spaces is customized for each project. By clicking on one storage space, the stored segments on this space are shown.





Segement Query

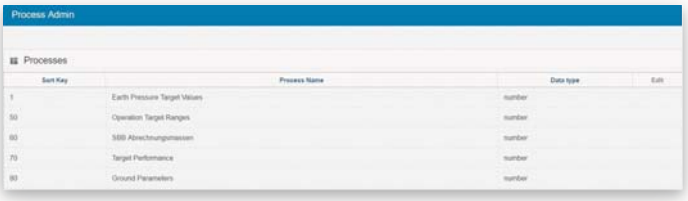
To get detailed information on the existing segments, PROCON provides a query service where the segment database can be searched. To easily identify the required segments, filters can be applied which filter the available segments, for example, by the production date, installation date, installed tunnel ring, segment type or reinforcement type. The identified segments are provided in a list. By clicking on the corresponding segment id, the PDF report to the corresponding segment can be downloaded.

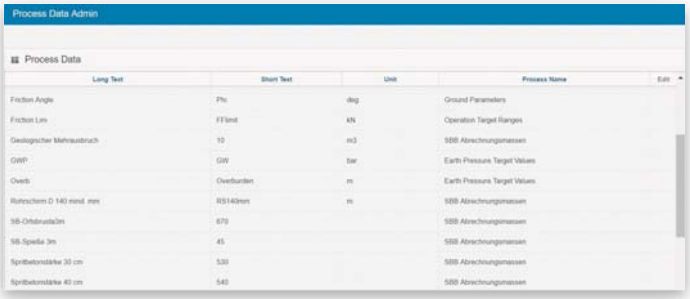
Ring-based information

In many cases, you may want to add location-based and process-related additional information. These can be (ranges of) target values for operational parameters such as the support pressures. But also external measurements and evaluations such as ground water levels, information on site logistics, or ground conditions can be easily acquired on a by-ring basis.
PROCON II enables you to add this data in an arbitrary structure by means of user-defined processes and definition of respective data types. These data can be arbitrarily visualized and combined with machine and monitoring data on Procon's dashboards.

Category

A category of processes is defined along with their type. This type can be a number, a date or a text. These categories capture individual processes which represent the same aspect, for example, earth pressure target values.



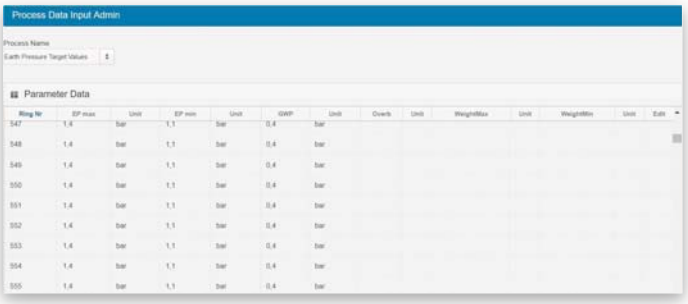


Process

Here, the individual processes are defined, for example, â€œUpper pressure limit of earth pressure sensor 1â€□. For defining a process, a name and a unit must be specified as well as the category to which the value is assigned.

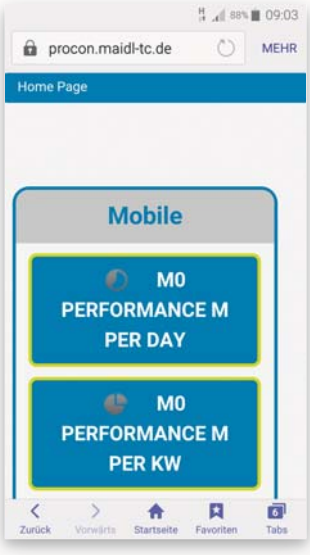
Data

In the "Process Data" the values for the configured target values and ranges are entered. These values habe to be provided for each ring. To reduce the work, the data can be prepared in an excel sheet beforehand and imported into PROCON using CSV files.



Mobile View

Often you are on the move and you have no possibilities to monitor the current status of the project at a computer. Therefore, PROCON II offers a mobile version which can access customized dashboards via smartphone or tablet to monitor different aspects of the project to quickly react in case of problems. You can easily reach the mobile version using the browser of your device and the known URL.



Mobile Navigation

After your PROCON II login you reach the start page. Here, all dashboards of the mobile version are listed and you can quickly navigate to the required data. However, the dashboards of the mobile version are only shown on the start page of the mobile version. In case of a tablet, dashboards of all categories are listed, mobile or not.

Performance View

For the mobile version you can create individual dashboards which contain all data you require while you are on the move. The example displayed in the figure shows the daily performance of the project. Of course, you can create dashboards which show the current thrust forces or grout injection quantity to be always informed of the current status.

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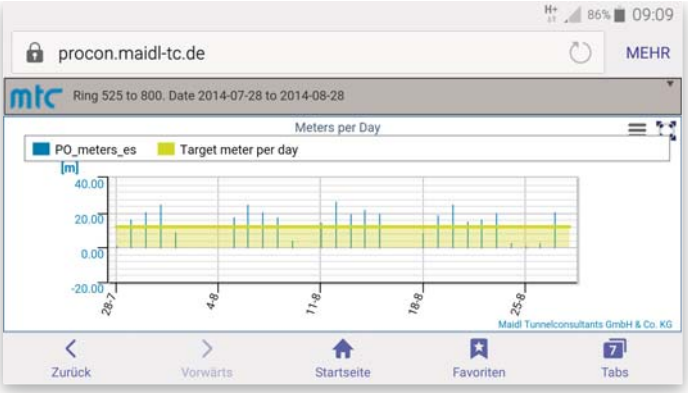

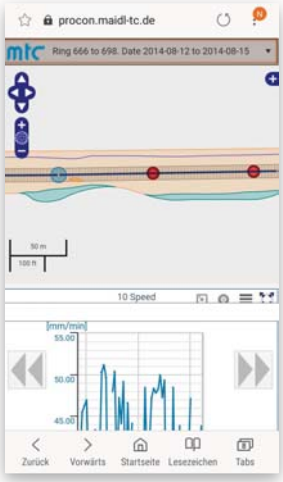

Map and Ground View

Follow the current position of the machine on your mobile device. In the mobile view as in the normal view you can monitor the machine in a GIS environment alongside with machine and monitoring data. The GIS environment can be represented by a map as well as a geological longitudinal section.

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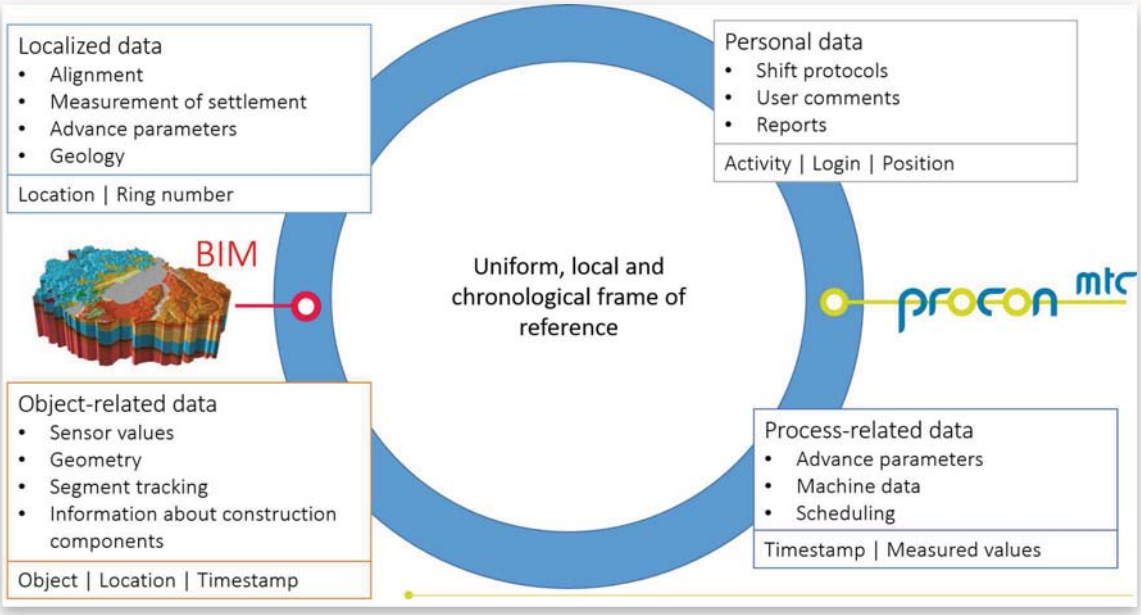
Integration with BIM

BIM can be employed at an early stage of the tunnel project and used already to advantage in the design and construction phases. The key components of these models can be linked to each other by means of a common location and time reference framework.

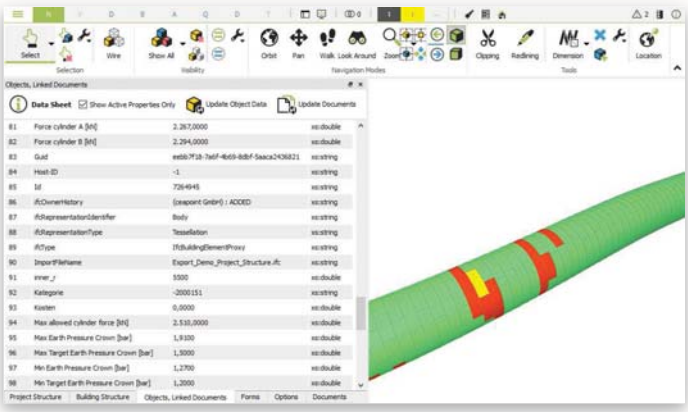


3D tunnel model

The tunnel model consists of the individual segmental linings representing the tunnel tubes. Each tunnel tube contains a number of rings consisting of a defined number of individual segments. Each digital segment has assigned various information from the start like its segment type or its ring number. During the tunnel advance, the information of the segments increases steadily by the incorporation of data from segment tracking and quality management, document linkage or highlighting of the TBM data history (e.g. thrust forces). An easily navigable visualization of the segmented lining allows a quick data identification, problem evaluation and overview of the projects progress.

3D ground model

The purpose of a digital ground model is to provide information from geotechnical investigation and geological expertise to all project stakeholders in a computer-readable form. Incorporating a 3D ground model into the day-to-day project assessment provides target-actual comparisons of ground conditions and disposal masses, the verification of operation parameters and consumption records as well as conservation of evidence.
The ground model consists of numerous closed shells representing the individual ground layers. Each layer has assigned its geological properties. The volume of the 3D tunnel model is cut out from the 3D ground model. Along its alignment, the tunnel volume is intersected with the digital ground model to create a digital 3D tunnel model with areas of similar geotechnical properties.



Integeration of TBM and monitoring data in PROCON

The integration of data from PROCON or other data sources into the BIM model is implemented by applying the DESITE MD software which contains an integrated JavaScript API. DESITE MD is a very powerful BIM Viewer software which can be used for BIM model evaluations like volume evaluations or collision checks. Its Javascript API is applied to extract data via the REST interface of PROCON and link it with its corresponding digital representation in the BIM model. This data can be TBM data like sensor information, monitoring data or even document data.
Containing all relevant information, the BIM model can be applied for the generation of simulation models. The extraction of required parameters for the analysis of ground/surface deformations including TBM operation parameters enable an easy setup of simulation models with direct comparison of predicted vs. actual settlements.

Integrated BIM Viewer in PROCON

As described the management of the BIM model is performed in the Desite MD software. However, for data evaluation and data monitoring a simple BIM viewer can also be applied, which visualizes the existing models and displays the linked information. Therefore, PROCON has integrated a web-based BIM viewer in which the current BIM model of the demo project has been uploaded. Thus, the BIM model is also made available to PROCON users who do not have a Desite MD license. Information on the login and the display of the model can be found in the red box on the page.

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