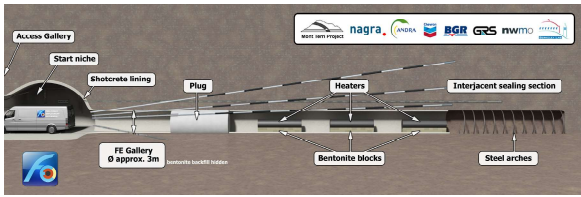


A 3D Spatial Information System for The Full-Scale Emplacement (FE) Experiment

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FE Experiment at the Mont Terri rock laboratory



Artist impression of the FE Project

The Full-scale Emplacement (FE) Experiment demonstrates the Swiss nuclear repository concept with an in-situ 1:1 scale experiment (Müller et al. 2017). Three electrical heaters simulate waste storage canisters.

With more than 1800 sensors, 30 TDR and 2.5 km of fiber optic distributed measurements (DTS) the FE experiment produces huge amounts of data. More than 1 million measurements are added daily. Monitoring will continue for at least 15 years. **The Problem:** Normal desktop programs (like EXCEL) are quickly overwhelmed by the experiment's complexity, wide ranging data types, formats and volume of data. Data management and well as evaluation and analyses become inefficient, costly and error prone.

The Solution: The FE database was created to work with a wide range of data types, formats and large volumes of data. It goes beyond traditional or GIS (map based) databases by spatially representing the experiment in a virtual 3D space. The FE Information System (FEIS) is a Internet browser single page application which works on any PC or MAC connected to the Internet. It provides easy, fast and efficient review, analysis and reporting with the feel of a desktop program.

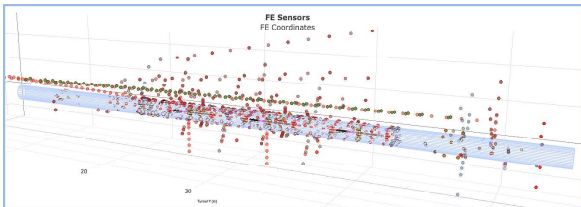
FE Data-Pipeline



Appends data from 9 contractors using different data acquisition systems

- FE Data-Pipeline appends the contractor's data within minutes of acquisition
- Each contractor uses unique data formats and protocols
- Metadata are assigned to measurements - no data are deleted
- Alarms for downloads, instrumentation, heating system, sensor limits
- Alarms send emails and SMS

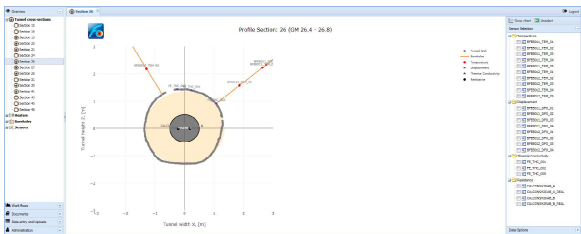
FE Database



3D image created by the FEIS showing some of the monitored sensors

- FE Database spatially represents the experiment in a virtual 3D space making spatial relationships simple, providing more investigation options and helps avoid errors
- Open source PostgreSQL 9.5 database with statistical R language extensions
- Geometric objects use custom linear algebra operators to calculate spatial relationships between objects
- All drawings and spatial relationships are calculated on-the-fly
- Dynamic system: add or modify an object and the tables, plots, calculations and even drawings are automatically updated

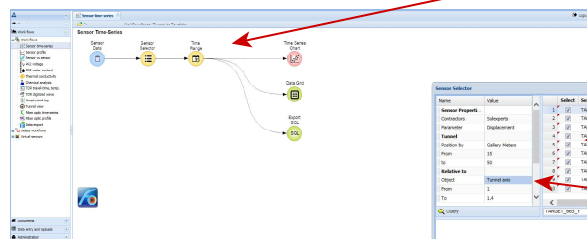
FE Information System (FEIS)



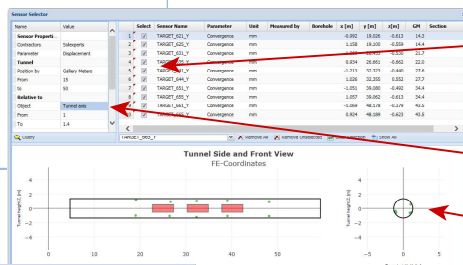
Overview tunnel cross-sections allow users to easily select sensors to review measurements

- FEIS is an Internet browser single page application
- Feels like a desktop program. Menu options:
 - Overview menu: provides quick and easy plotting and review
 - Workflow menu: provides custom data review, evaluation and analysis
 - Documents menu: provides database with complete text search functionality
 - Data entry uploads menu: provides manual data entry and document uploads
 - Administration menu: provides activity logs, alarm configuration, management, etc.
- Charts are interactive with zoom, scale, line type, color and labels
- Tables are dynamic with sortable columns
- User defined mathematical expressions (calculations, functions and statistics)

- Workflows show the sequence of steps to obtain, handle and process data
- Workflows contain widgets to retrieve, process, visualize or export data
- Clicking a widget opens a window to set parameters or display charts and tables
- Charts, tables and the SQL can be created, saved and exported (PNG, CSV, TXT)
- Workflows may be shared or saved individually



Workflows provide a visual map with clickable widgets



Example Selector Widget window

Drilldown tool to quickly select just the sensors of interest:

- Specify desired parameters, query and choose sensors. Then specify other parameters, query again and choose additional sensors.

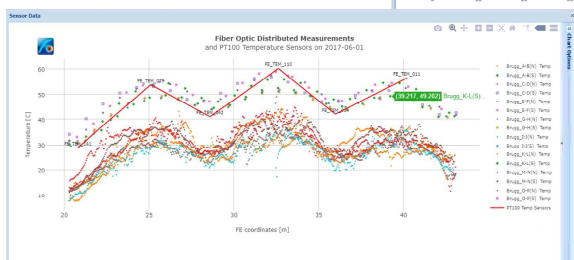
Select sensors by location and spatial relationship to key objects

Selected sensors are displayed in both tunnel side and front views

Charts are interactive and provide a fast responsive user experience:

- Plots can be zoomed and scrolled, shown or hidden, etc.
- Scales, data symbols, line types, colors can be modified
- Titles, labels and legend text and font can be modified
- Legend can be moved or dragged as desired

Charts can be saved or exported for printing
Chart data can be exported to CSV file



FEIS Chart of Neubrex and Smartec DTS with standard temperature sensors

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