3D Overarching Scientific Information System for the FE Experiment

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Full-scale Emplacement (FE) experiment at the Mont Terri rock laboratory

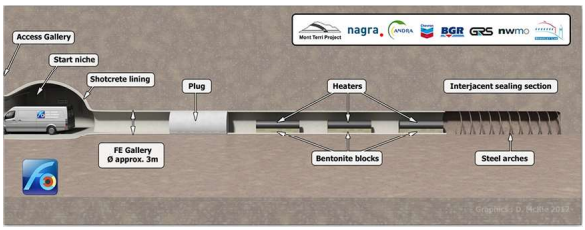


Illustration of the FE Project

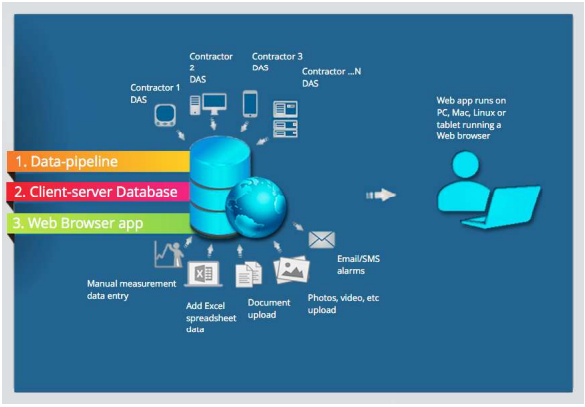
The FE experiment simulates on 1:1 scale (Müller et al. 2017) the Swiss concept for a spent fuel / high level waste repository tunnel. Three heaters simulate heat output of disposal canisters.

The FE monitoring program includes more than 1800 standard static fixed "point" sensors and 2.5 km of fiber optic cables for distributed temperature sensing (DTS) and distributed strain sensing (DSS). More than 1 million measurements are acquired daily and monitoring is foreseen for more than 10 years.

The Problem: Management and overview of hardware, operations and monitoring is challenging for larger experiments. Data quickly overwhelmed standard desktop software making review, evaluation and analysis both labour intensive and time consuming.

The Solution: OASIS – Overarching Scientific Information System manages all FE information (construction details, monitoring data, geophysical logs, chemistry data and documentation). Review, evaluation, plotting, reporting and data export are fast even with nearly 2 billion measurements recorded to date. Nagra refers to OASIS for the FE experiment as the FE Information System (FEIS).

FE Information System (FEIS)



Appends data from multiple contractors using different data acquisition systems

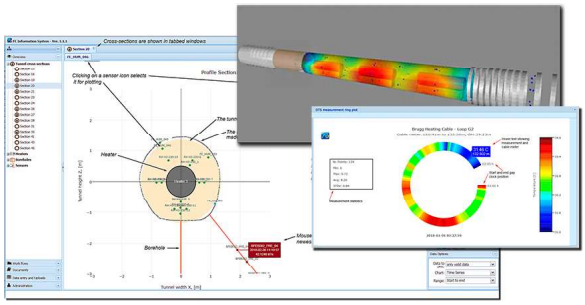
FEIS centralizes all project information in one location. The system provides project information and data management:

- Automatic data collection from multiple contractors
- Verifies, evaluates and applies metadata to monitoring data
- Document content management system with keyword and full text searches
- Web browser app is quick and feels like a desktop program
- Dynamic interactive plots and reports
- Document, chart and data downloads to your computer

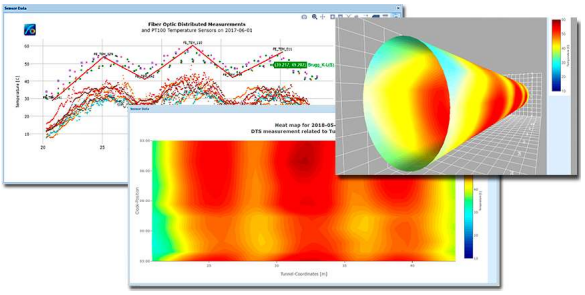
Transforms raw incoming data into actionable and meaningful information. By linking data sets across different systems the complexity and nuances of data relationships can be discovered. Data management, stewardship and tractability are improved along with findability, accessibility, interpretability, transparency, consistency and reuse of the project' s valuable digital assets.

The open source (license free) database extends GIS by modeling the experiment in virtual 3D space. Data in tables, plots, calculations and even drawings are created on-the-fly at run time.

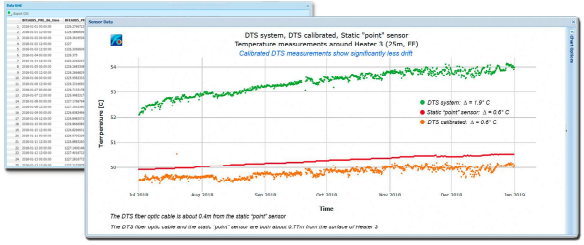
3D spatial model and DTS measurements



Tunnel cross-section, 3D thermal map and tunnel, Thermal loop chart



Static and DTS measurements, 2D and 3D thermal charts



FEIS calibrated DTS measurements are more accurate and compensate for drift

DTS systems make one measurement after another (nose-to-tail) along the length of the fiber optic cable. Using the database 3D model and DTS cable fingerprints (heating the cable at known locations and noting the cable length at the temperature response) the FEIS calculates the 3D position of the measurements within the experiment. DTS measurements can be plotted with static "point" sensors and referenced to objects and positions in the project in just seconds. Charts are interactive with edit, zoom, scroll, pan, roll, etc. Tables are dynamic with sortable columns.

Measurements can be viewed from multiple perspectives:

- Profile chart - measurements with respect to distance at a specific time
- Time-series chart - measurements through time at a specific location
- Loop chart - tunnel circumference measurements at a specific time and location
- Both 2D and 3D thermal maps

Quickly viewing measurements from multiple perspectives leads to greater insights into data relationships and temporal and spatial variations.

Accuracy of DTS measurements is greatly improved with comprehensive calibration:

- Cables pass through two water baths spanning the expected temperature range
- Water bath temperatures are measured with high precision sensors
- The "data-pipeline" downloads and appends the water bath temperature and raw DTS Raman backscatter (Stokes and anti-Stokes) measurements
- FEIS compensates the DTS Raman backscatter measurements for signal step loss
- FEIS determines dynamic coefficients for every DTS cable measurement
- FEIS calculates significantly more accurate temperatures that compensate for cable properties and instrumentation.

The database stores the complete DTS measurement data (file header details and measurements) as well as the DTS coefficients, bath temperatures and cable signal loss. Temperatures are calculated on-the-fly and are traceable because all calculation parameters are stored. The DTS coefficients and cable signal loss can be plotted over-time for evaluation of instrument drift and fiber aging.

FEIS provides daily summary emails, alarms and report options to assist with management and overview of the hardware, operations and monitoring.

OASIS for Nagra's FE experiment by Robert Yeatman and Wolfgang Koenig
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