



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

Eidgenössisches Departement für Verteidigung, Bevölkerungsschutz und Sport VBS  
**Bundesamt für Landestopografie swisstopo**

wissen wohin  
savoir où  
sapere dove  
knowing where



# BIM Mont Terri

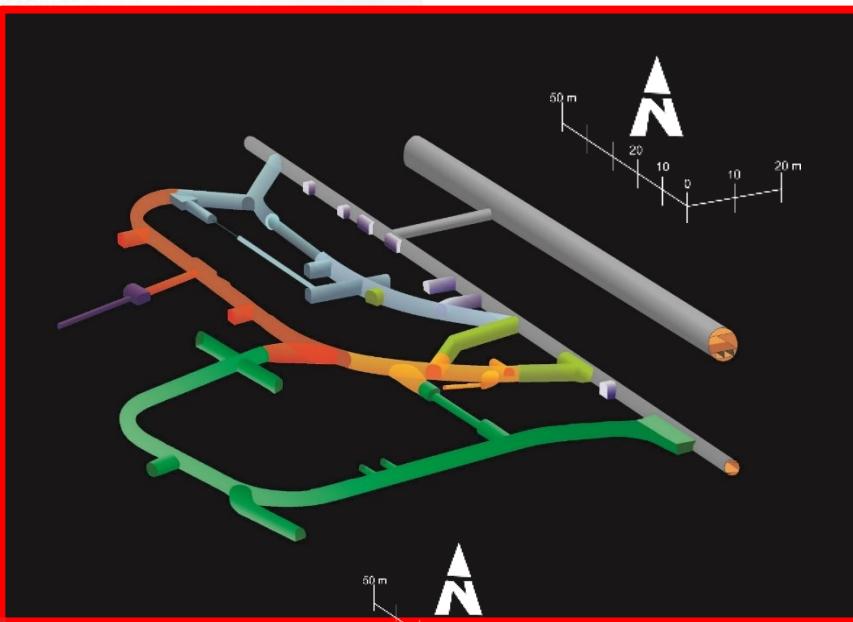
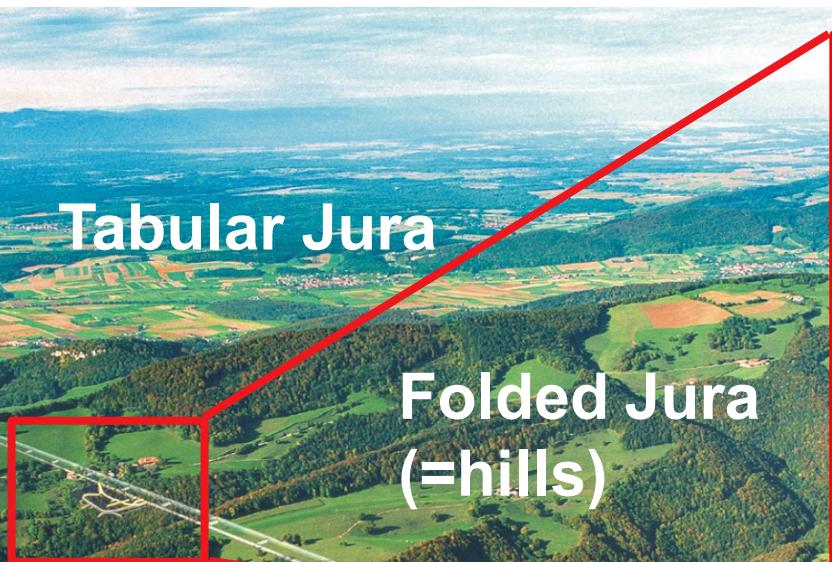
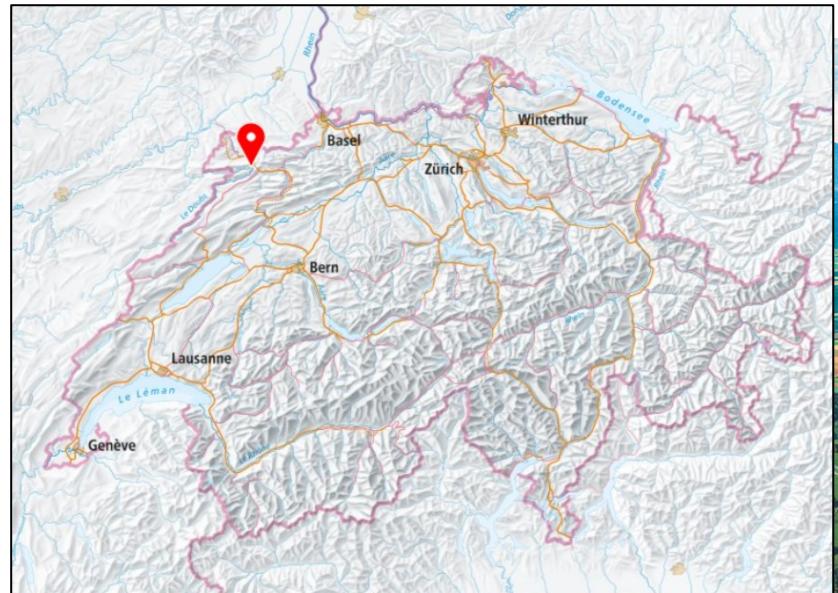
## Project overview

October 24, 2024 - ISSMGE TC222 5th Online Workshop

Stefan Volken, Project Manager BIM Mont Terri



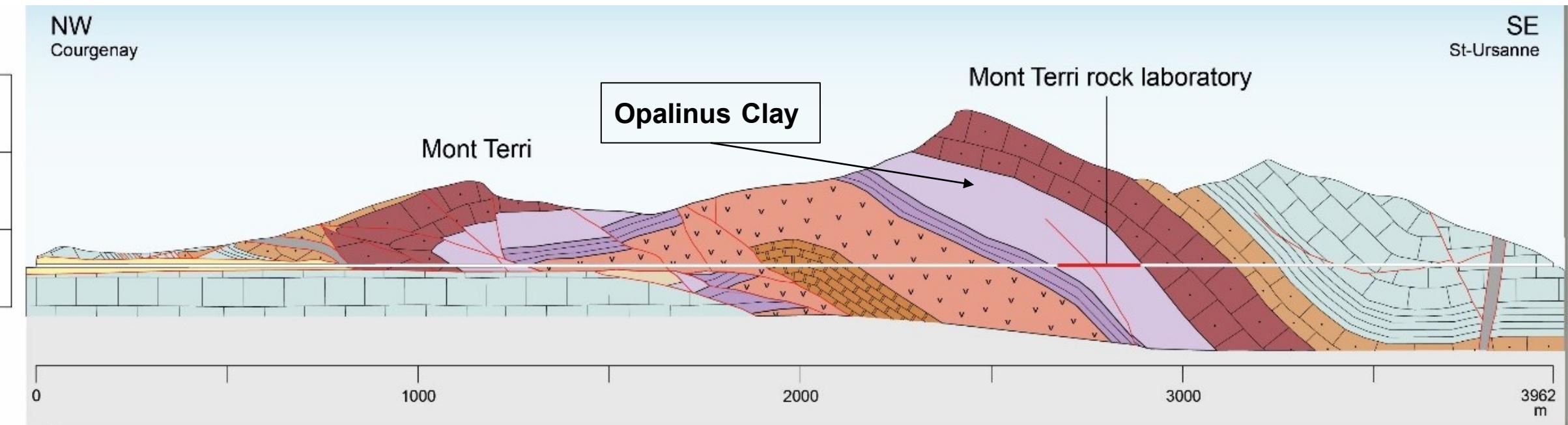
# Location of the Mont Terri rock laboratory





# The international Mont Terri project

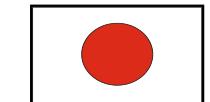
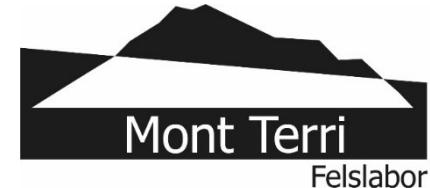
- International research project
- 28 years of **research into the** hydrogeological, geochemical and geotechnical **characterization of a clay formation, the Opalinus Clay**
- Opalinus Clay is the **only proposed host rock for high-level radioactive waste** in Switzerland.
- Making a significant **contribution to the safety and technical feasibility of a deep geological repository in the Opalinus Clay**.



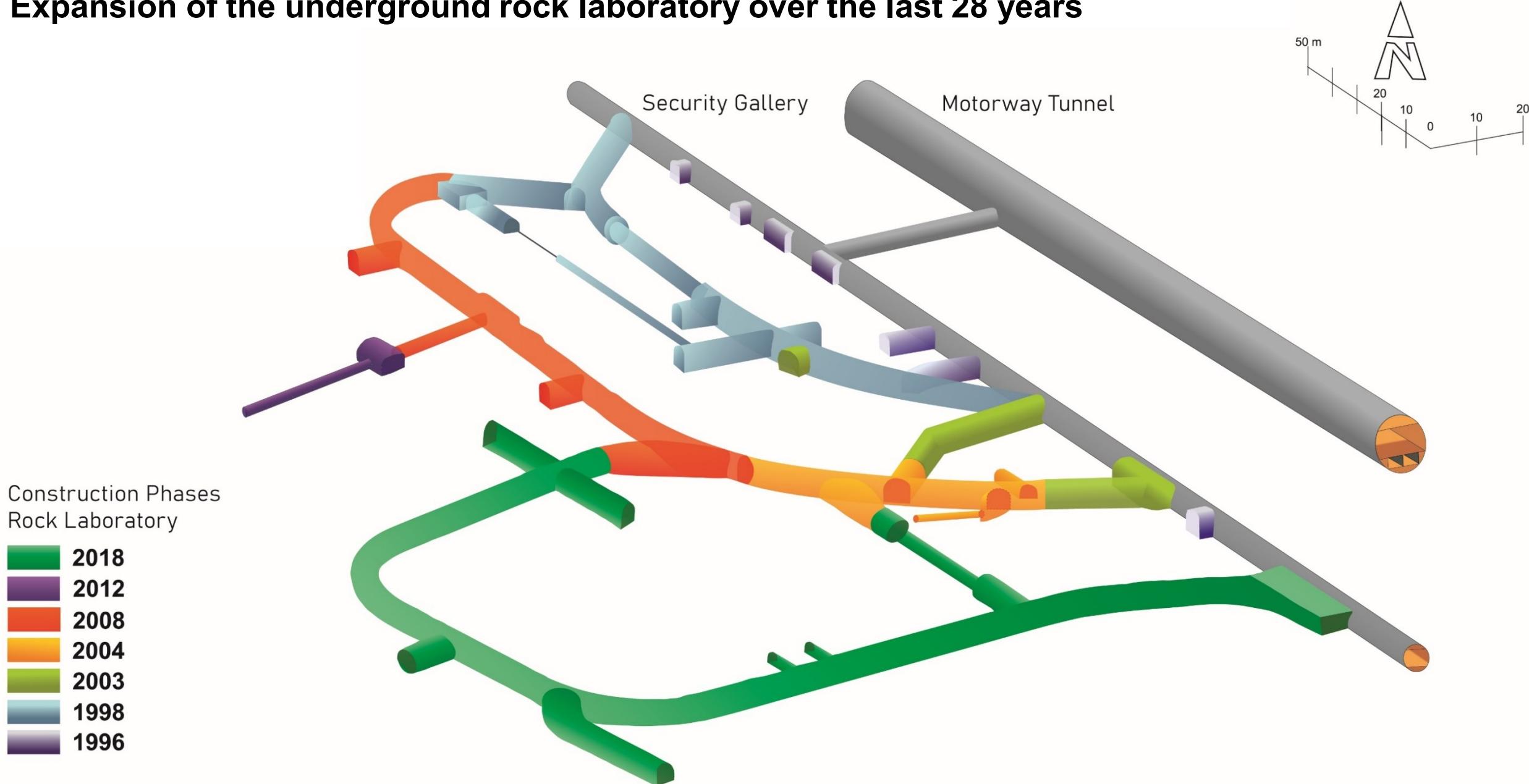


# Mont Terri project partners

- 22 partners from 10 countries
- Experiments:
  - 46 currently on-going
  - 128 already completed



# Expansion of the underground rock laboratory over the last 28 years





# Tasks of swisstopo at the Mont Terri Rock Laboratory

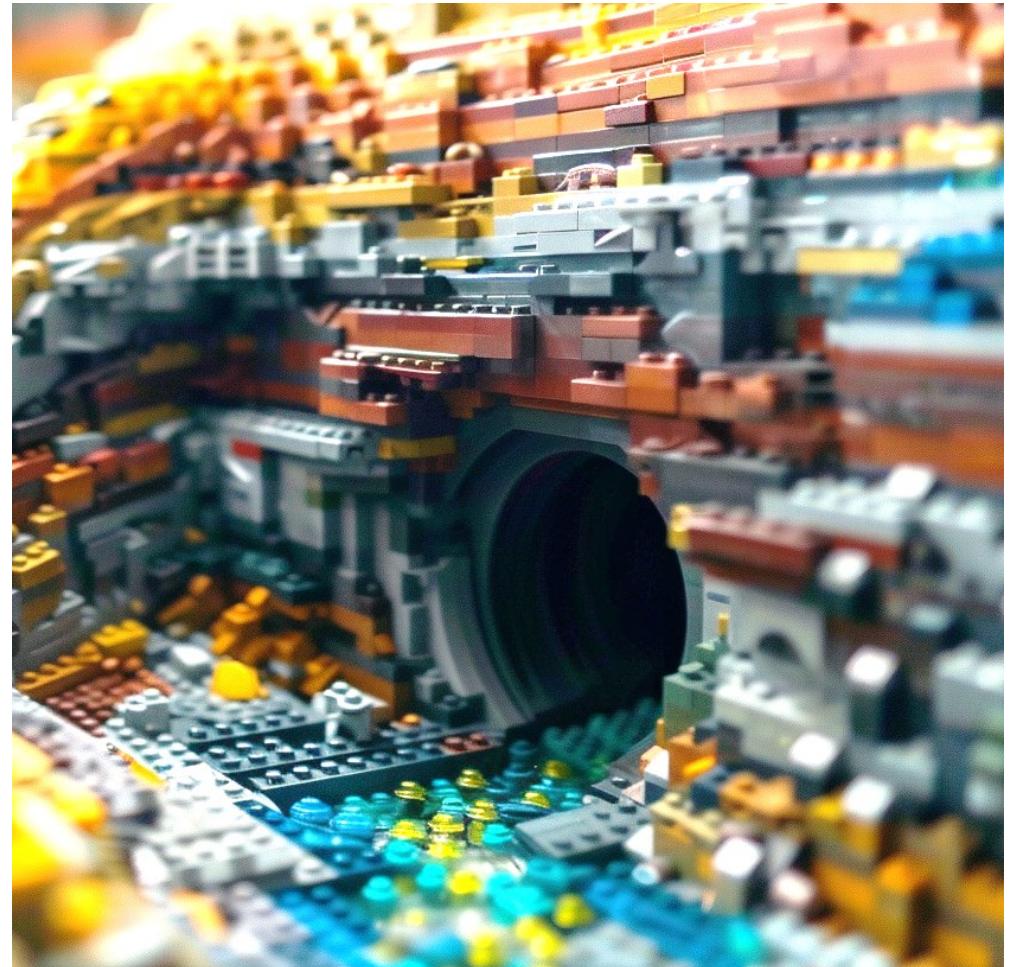
- Management of the international Mont Terri project
- Operation of the rock laboratory
- Ensuring underground safety
- Planning and conducting own experiments and supporting the experiments of partners
- Communication internally (partners) & externally (authorities, research institutes, industry, population → visitor center)





# Use cases BIM Mont Terri

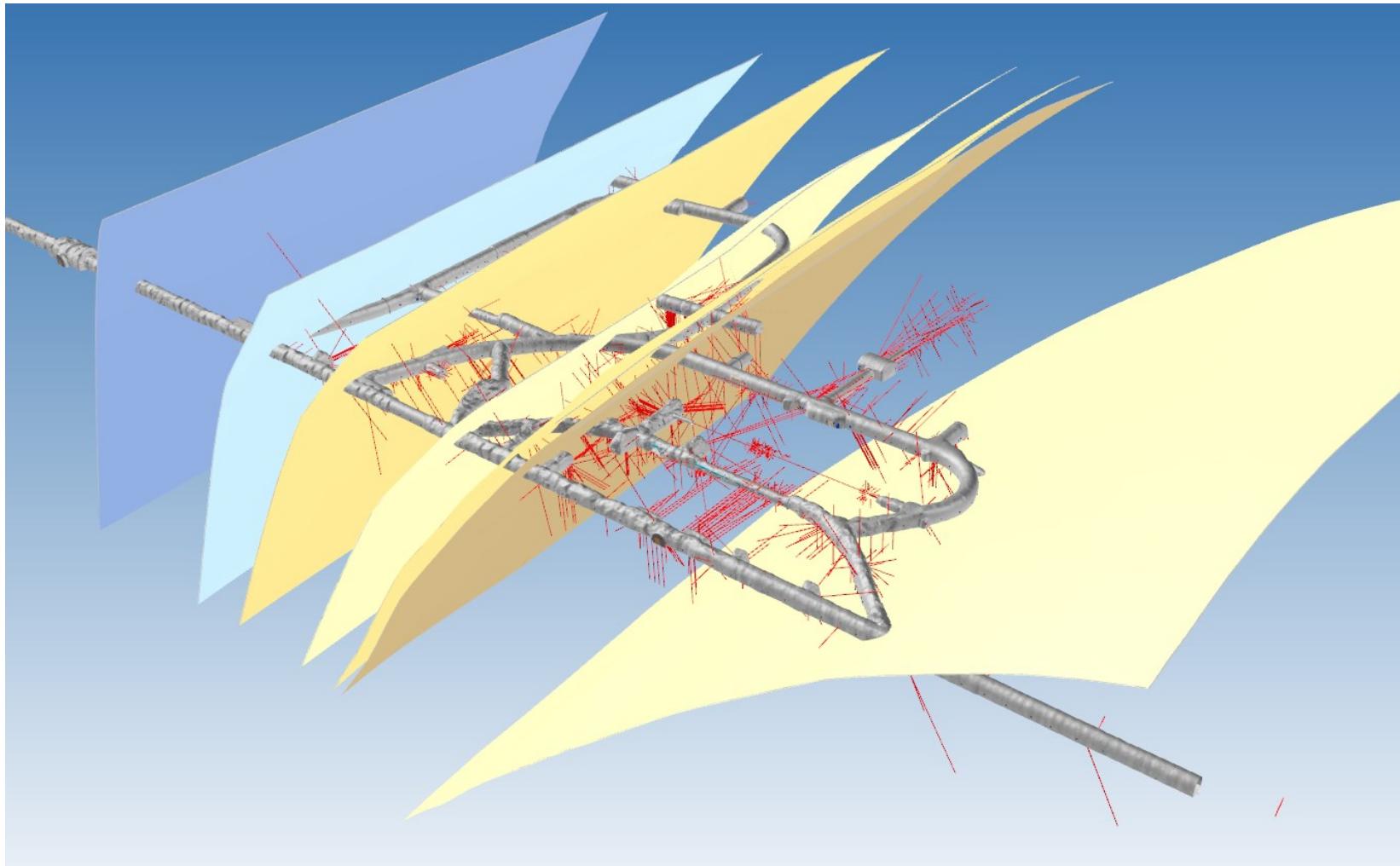
- **Interaction geology - laboratory infrastructure**
- Inventory of laboratory infrastructure → Retro BIM (incl. geological objects)
- Development of IFC interface for collaboration, exchange, projects → e.g. laboratory expansion
- Operation & maintenance (equipment maintenance, condition / damage assessment)
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- Basis for simulations (e.g., ventilation, fire)
- Basis for laboratory dismantling
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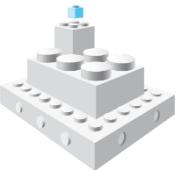




# Project background

Interaction of geology & laboratory infrastructure at the Mont Terri rock laboratory

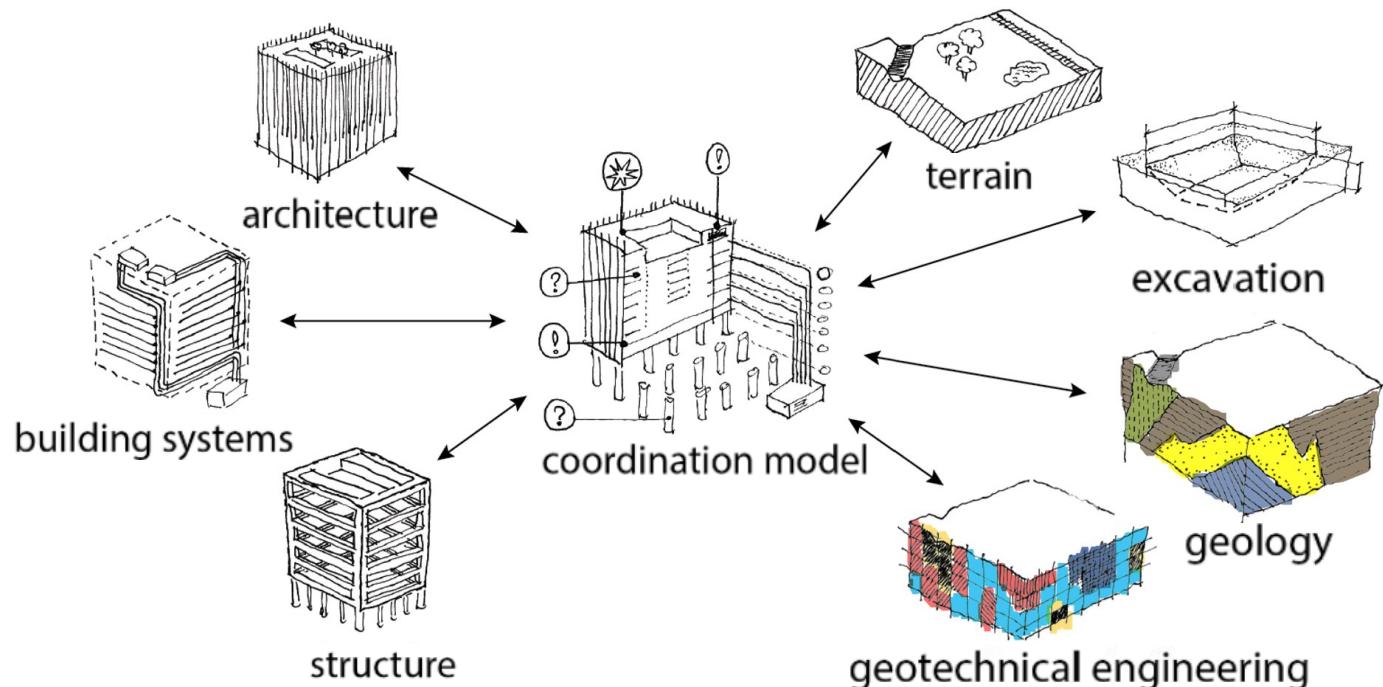




# Background: GEOL\_BIM innovation project (1/2)

## Target:

Integration of geology into the BIM method using case studies in the three use cases considered: tunnel construction, subsoil & natural hazards



## Project duration:

March 2020 until May 2022

## Project partners:

### Project management:

Swiss Geological Association  
Association suisse des géologues  
Associazione svizzera dei geologi

**CHGEOL**

### Implementation partner:

**Federal Office of Topography  
swisstopo**  
National geology

 Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

### Research partners:

Fachhochschule Nordwestschweiz  
Hochschule für Architektur, Bau und Geomatik

**n|w**

### Financial support through:

**Innosuisse - Swiss Agency  
for innovation promotion**

 Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra



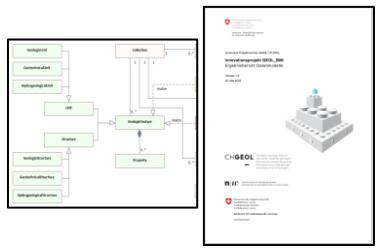
# Background: GEOL\_BIM innovation project (2/2)

## Results



### Basic reports:

- Geology [D]
- BIM method [D]



### GEOL\_BIM data model (based on GeoSciML):

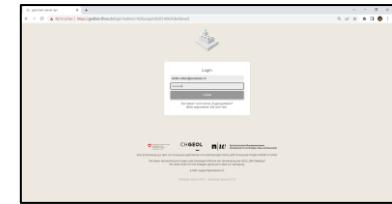
- UML (Enterprise Architect)
- Documentation [D]



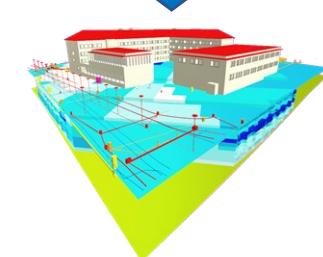
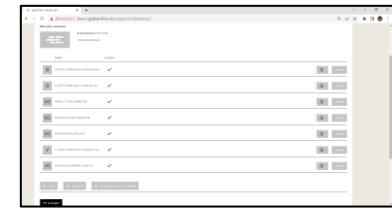
### Final report:

- GEOL\_BIM Final report [D] [EN]

### GEOL\_BIM Web App

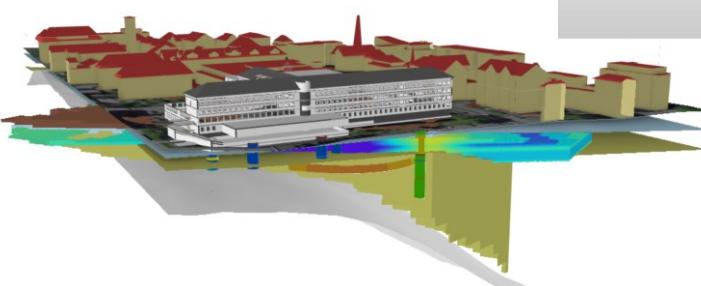
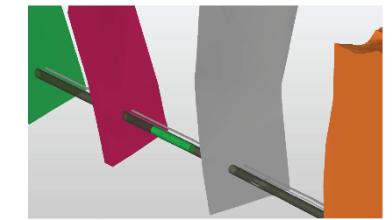
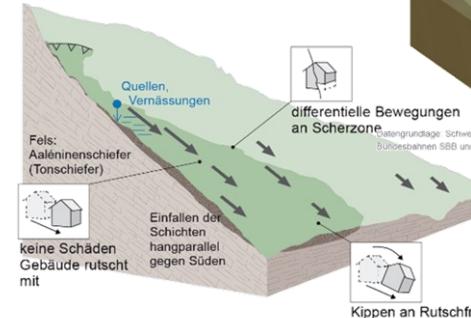


### IFC transformers



### Results of the application in case studies

Personenunterführung  
Bahnhof Muttenz



→ [https://chgeol.org/geol\\_bim](https://chgeol.org/geol_bim)

→ <https://geolbim.fhnw.ch> (order user account: oliver.schneider@fhnw.ch)

→ Video tutorial 33min [EN]: <https://www.youtube.com/watch?v=m5xyd6G83m8>



# Use cases BIM Mont Terri

- Interaction geology - laboratory infrastructure
- **Inventory of laboratory infrastructure → Retro BIM (incl. geological objects)**
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- Operation & maintenance  
(equipment maintenance, condition / damage assessment)
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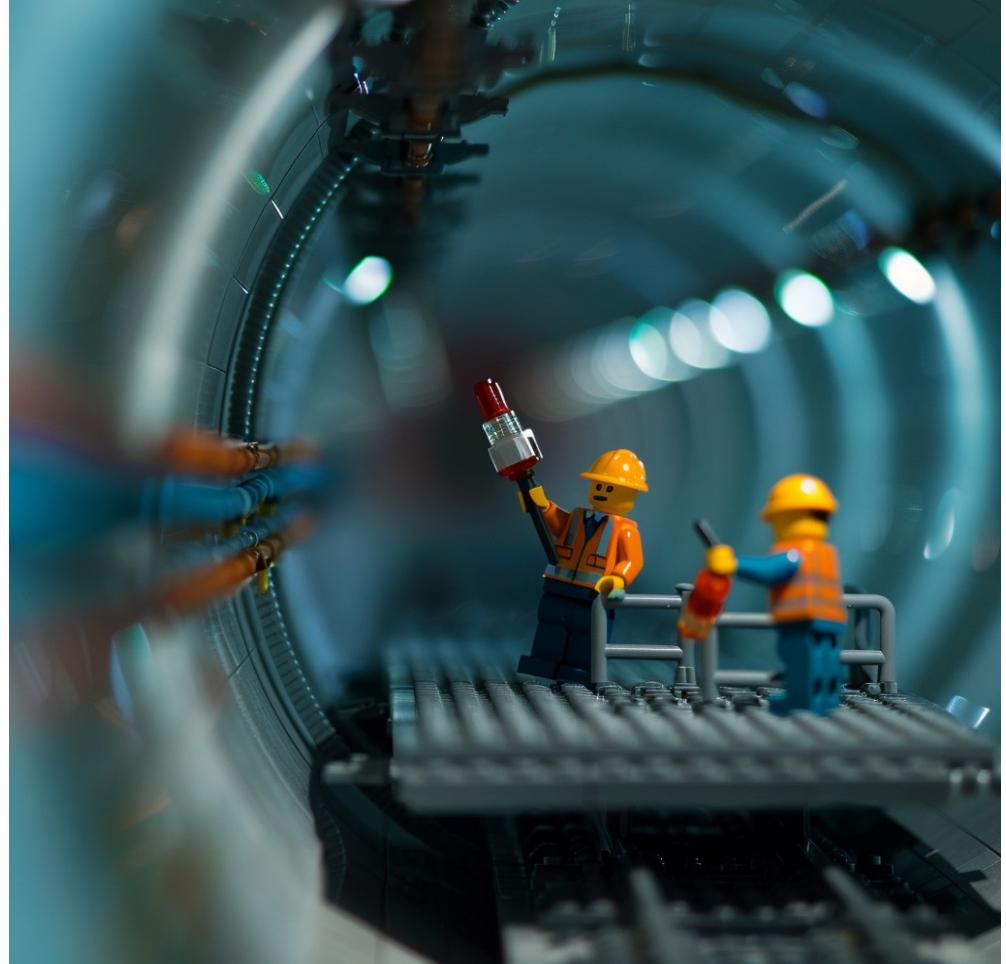
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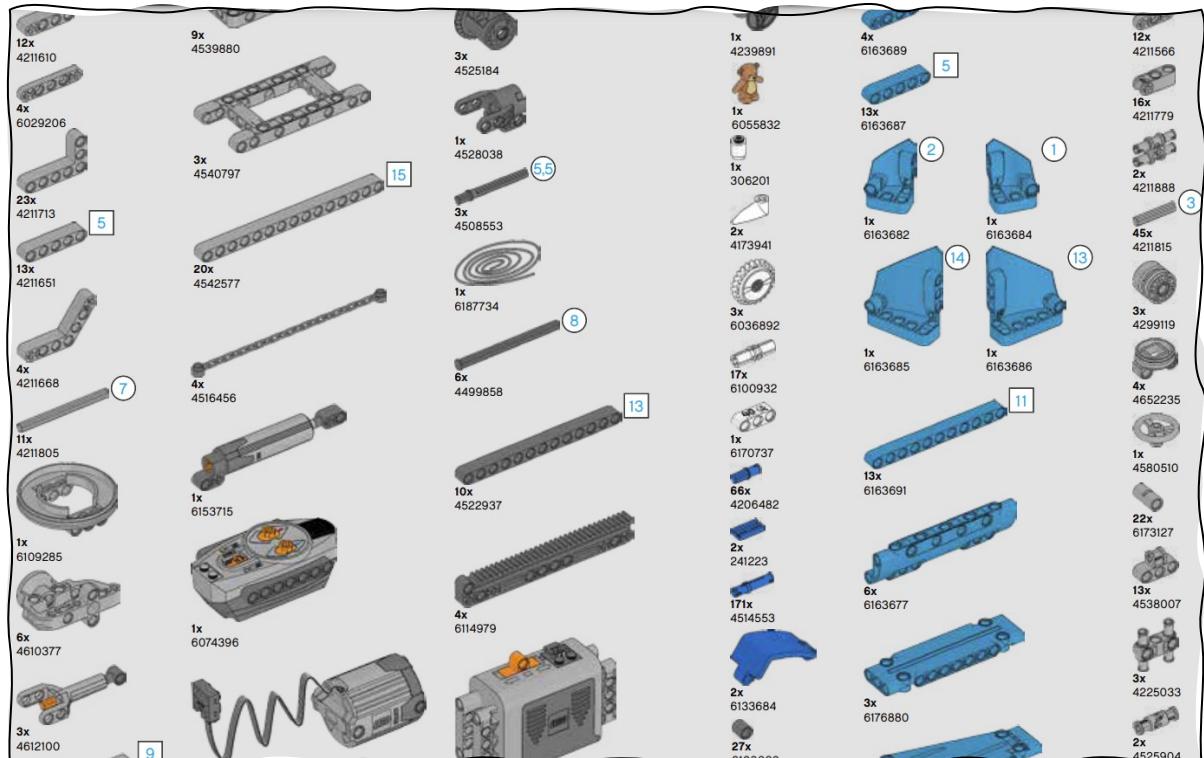




# Definition of information requirements

## Structure of the object catalog (1/4)

- Which **asset types**?
- What **information (attributes)** per asset type?
- **Geometric representation** of asset types (→ Level of Detail)?

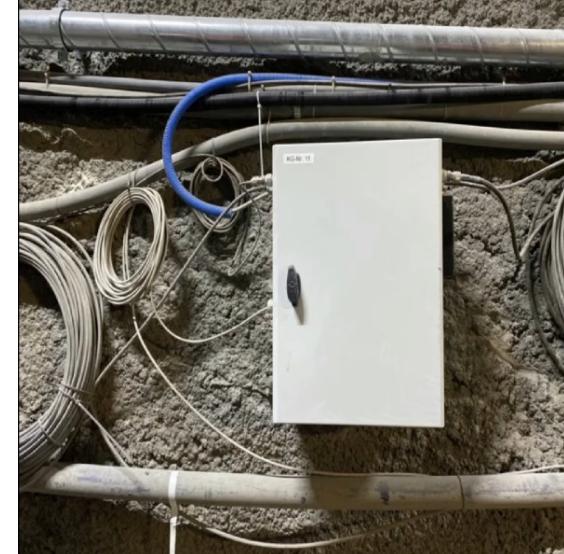




# Definition of information requirements

## Structure of the object catalog (2/4)

- Inspection of existing laboratory infrastructure data  
(CAD/PDF plans, Excel lists, etc.)
- Inspection of currently existing applications  
(e.g. BIS, Move, fulcrum)
- Photo documentation of the existing assets in the laboratory





# Definition of information requirements

## Structure of the object catalog (3/4)

### Definition of asset categories:

| Cat ID | Category name              |
|--------|----------------------------|
| 0      | Geodetic surveying         |
| 1      | Excavation support         |
| 2      | Water system               |
| 3      | Ventilation                |
| 4      | Electrical power supply    |
| 5      | Communication              |
| 6      | Person localization system |
| 7      | Alarm                      |

| Cat ID | Category name         |
|--------|-----------------------|
| 8      | Fire and emergency    |
| 9      | Research              |
| 10     | <b>Boreholes</b>      |
| 11     | Environmental sensors |
| 12     | Accessories           |
| 13     | Consumer              |
| 14     | <b>Geology</b>        |



# Definition of information requirements

## Structure of the object catalog (4/4)

Definition of > 80 asset types:

| Asset type | Asset type name              |
|------------|------------------------------|
| 001        | Survey point                 |
| 002        | Survey point shaft           |
| 003        | Convergence wire storage box |
| 004        | Convergence wire cabinet     |
|            | Supported and unsupported    |
| 101        | excavation surface           |
| 102        | Steel arch segment           |
| 103        | Rock bolt                    |
| 201        | Drainage line                |
| 202        | Drainage shaft               |
| 203        | Freshwater pipe              |
| 204        | Freshwater valve             |
| 302        | Exhaust gas line             |
| 303        | Exhaust gas fan              |
| 304        | Fan interruption switch      |
| 401        | Cable conduit open           |
| 402        | Recess cover                 |
| 403        | Ground cable fixation board  |
| 404        | Ground                       |
| 405        | 16kV-cable                   |
| 406        | 400V-cable                   |

| Asset type | Asset type name          |
|------------|--------------------------|
| 407        | Ribbon cable junction    |
| 408        | Power control cabinet    |
| 409        | Power access board       |
| 410        | Power access point       |
| 411        | Bypass cabinet           |
| 412        | Transformer              |
| 413        | Safety cage              |
| 414        | Isolating switch         |
| 415        | Generator                |
| 416        | Light bar                |
| 417        | Light spot               |
| 418        | Light switch             |
| 419        | Circuit breaker switch   |
| 420        | Junction box             |
| 421        | Power access point 125 A |
| 422        | Traffic lights           |
| 423        | Traffic lights control   |
| 501        | Landline telephone box   |
| 502        | Telephone horn           |
| 503        | Wifi antenna             |
| 504        | Polycom Radio antenna    |

| Asset type | Asset type name                         |
|------------|---|
| 505        | Radio antenna cable                     |
| 506        | Telematic cabinet                       |
| 601        | Localization control unit               |
| 602        | Localization antenna                    |
| 701        | Alarm lamp                              |
| 702        | Alarm siren                             |
| 703        | Highway alarm box                       |
| 801        | Control unit for fire alarm             |
| 802        | Safety curtain                          |
| 803        | Safety curtain control                  |
| 804        | Safety curtain switch                   |
| 805        | Safety door                             |
| 806        | Smoke detector                          |
| 807        | Manual fire alarm switch                |
| 808        | Fire extinguisher                       |
| 810        | Compressed air battery                  |
| 811        | Emergency handlight                     |
| 901        | <b>Geological window</b>                |
| 902        | <b>Geological portal</b>                |
|            | Experiment controller without enclosure |
| 903        |   |

| Asset type | Asset type name                       |
|------------|---------------------------------------|
|            | Experiment control and device cabinet |
| 904        |                                       |
| 905        | Bar extensometer                      |
| 906        | Experiment shaft                      |
| 1001       | <b>Borehole</b>                       |
| 1005       | Borehole shaft                        |
| 1101       | Environmental controller              |
|            | External environmental sensor         |
| 1102       |                                       |
| 1201       | Tool container                        |
| 1202       | Tool rack                             |
| 1203       | Defibrillator                         |
| 1204       | First-aid kit                         |
| 1205       | Lavatory                              |
| 1301       | Lan switch                            |
| 1302       | Computer                              |
| 14xx       | <b>Borehole</b>                       |
| 14xx       | <b>Fault</b>                          |
| 14xx       | <b>Geological unit</b>                |
| 14xx       | <b>Geological Contact</b>             |



# Object extraction from laser scan & point cloud cleaning

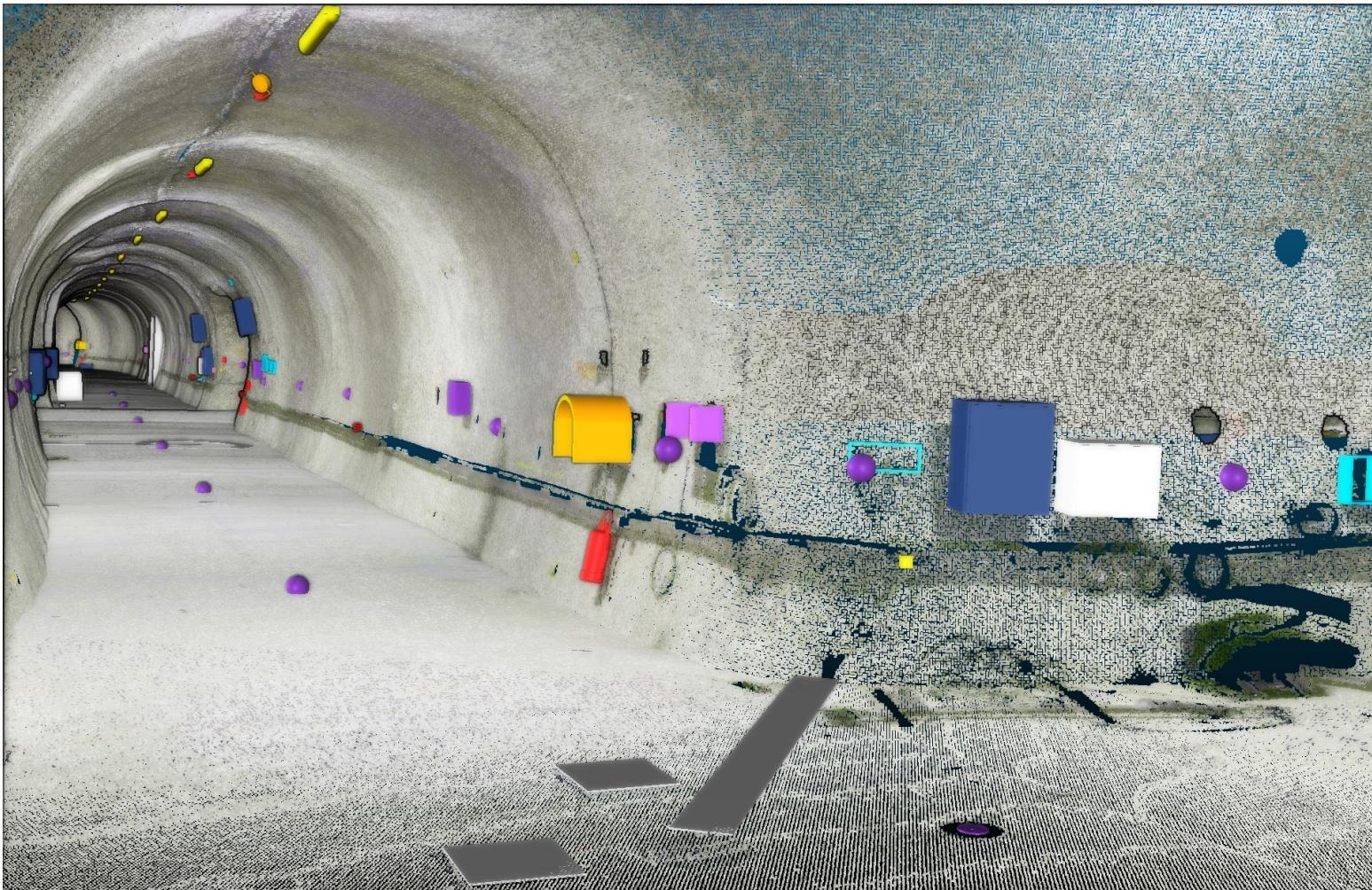


## Laserscan:

- New laser scan of the entire Rock laboratory
  - > 400 stations
  - > 40 billion points
- Cleaned pointcloud



# Object extraction from laser scan & point cloud cleaning



## Laserscan:

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## Scan2BIM:

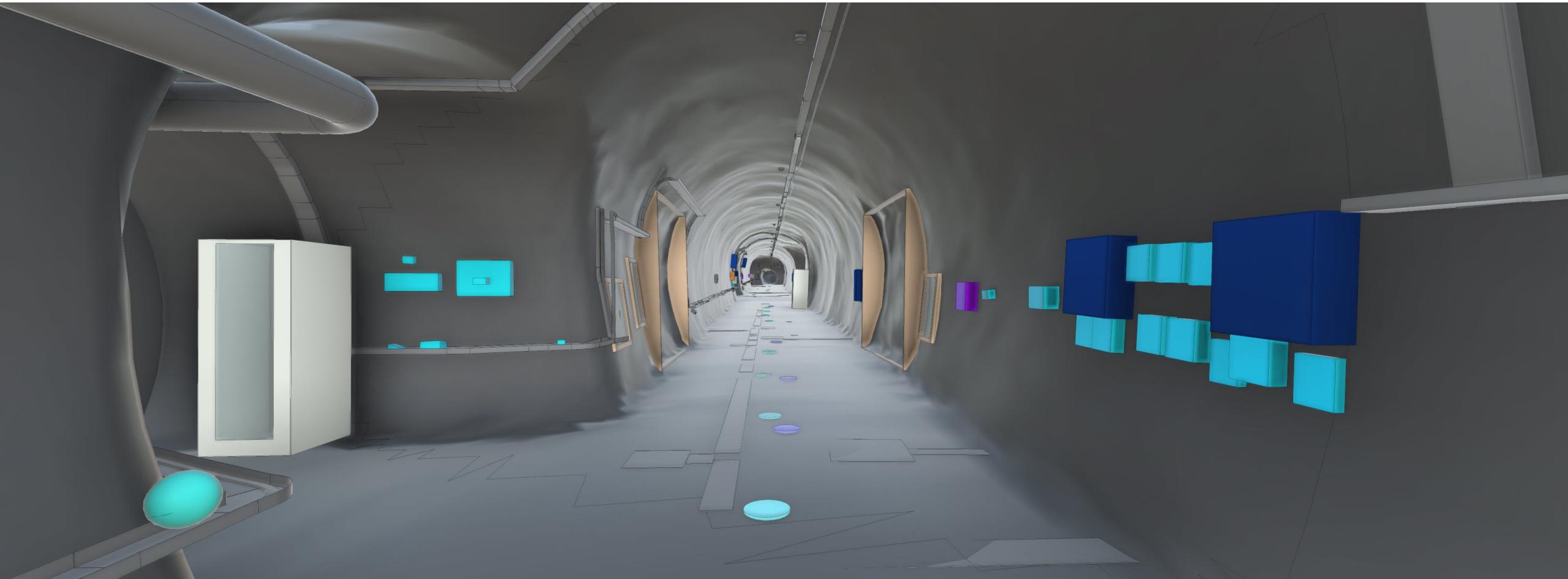
### Extraction of:

- > 4,000 individual assets
- Linear assets with a total length of > 5 km (cable trays, power and communication cables, fresh water and drainage pipes, exhaust air pipes)

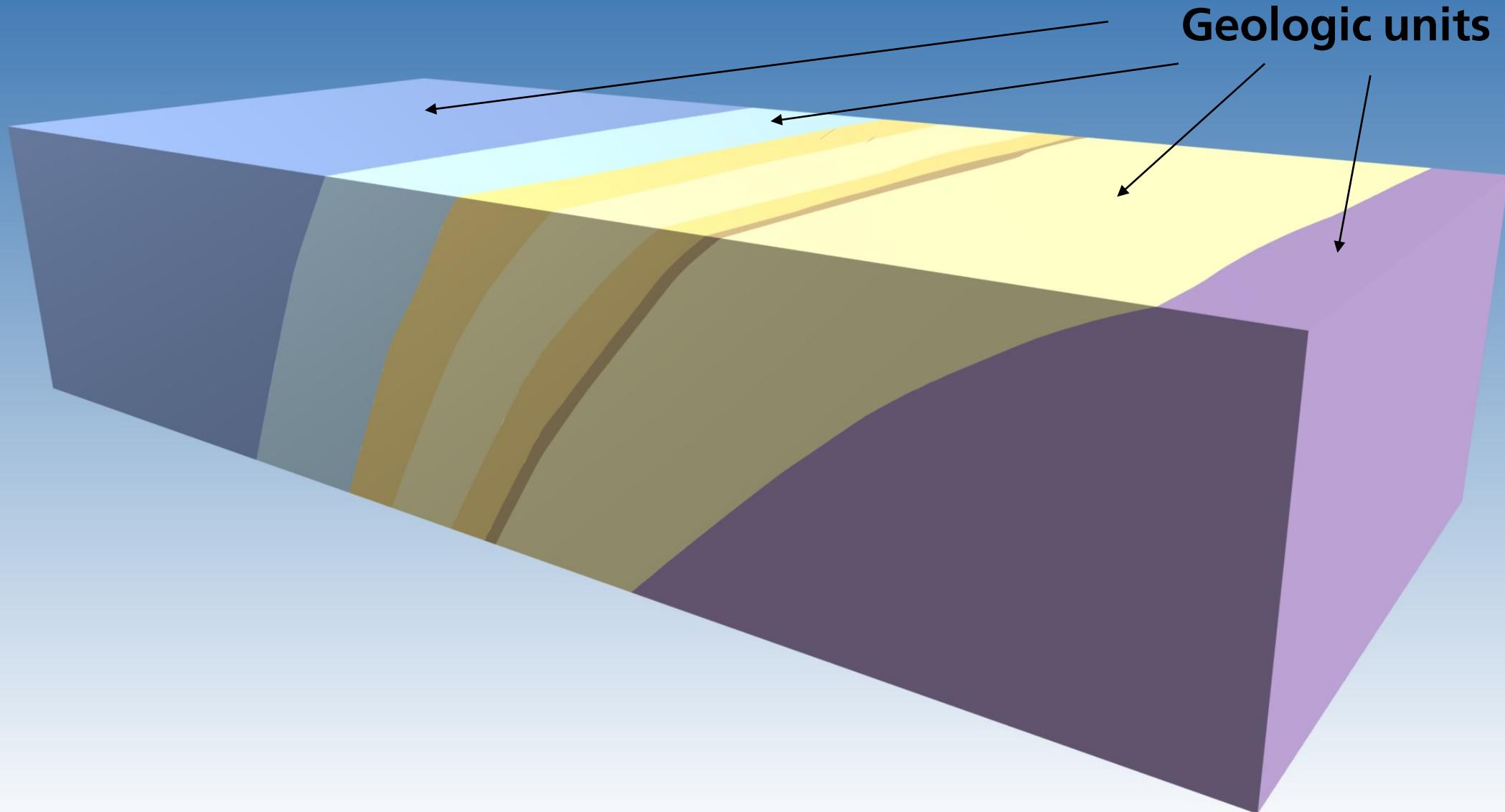


# Object extraction from laser scan & point cloud cleaning

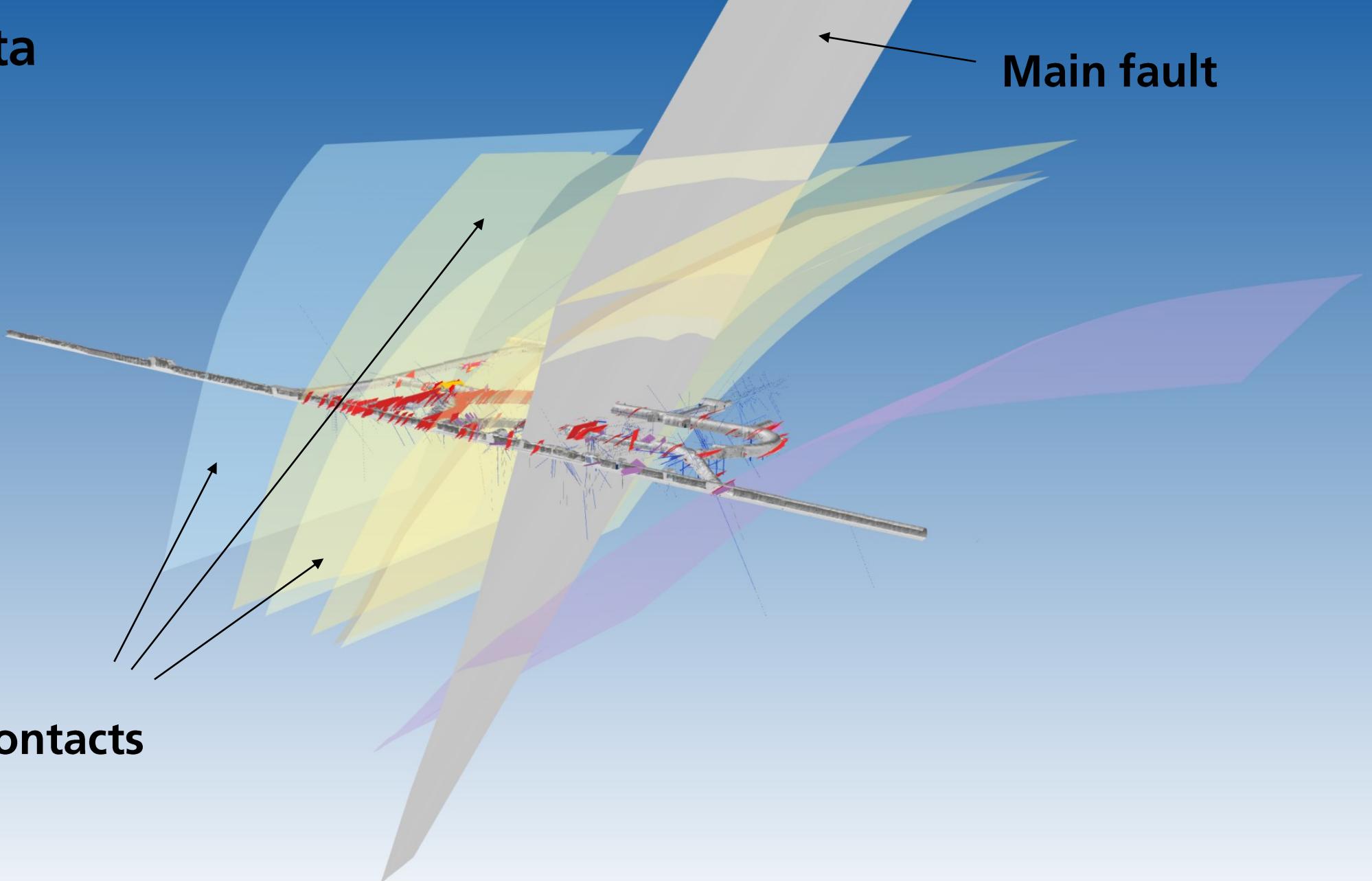
Animation: virtual lab tour



# Geologic data



**Geologic data**

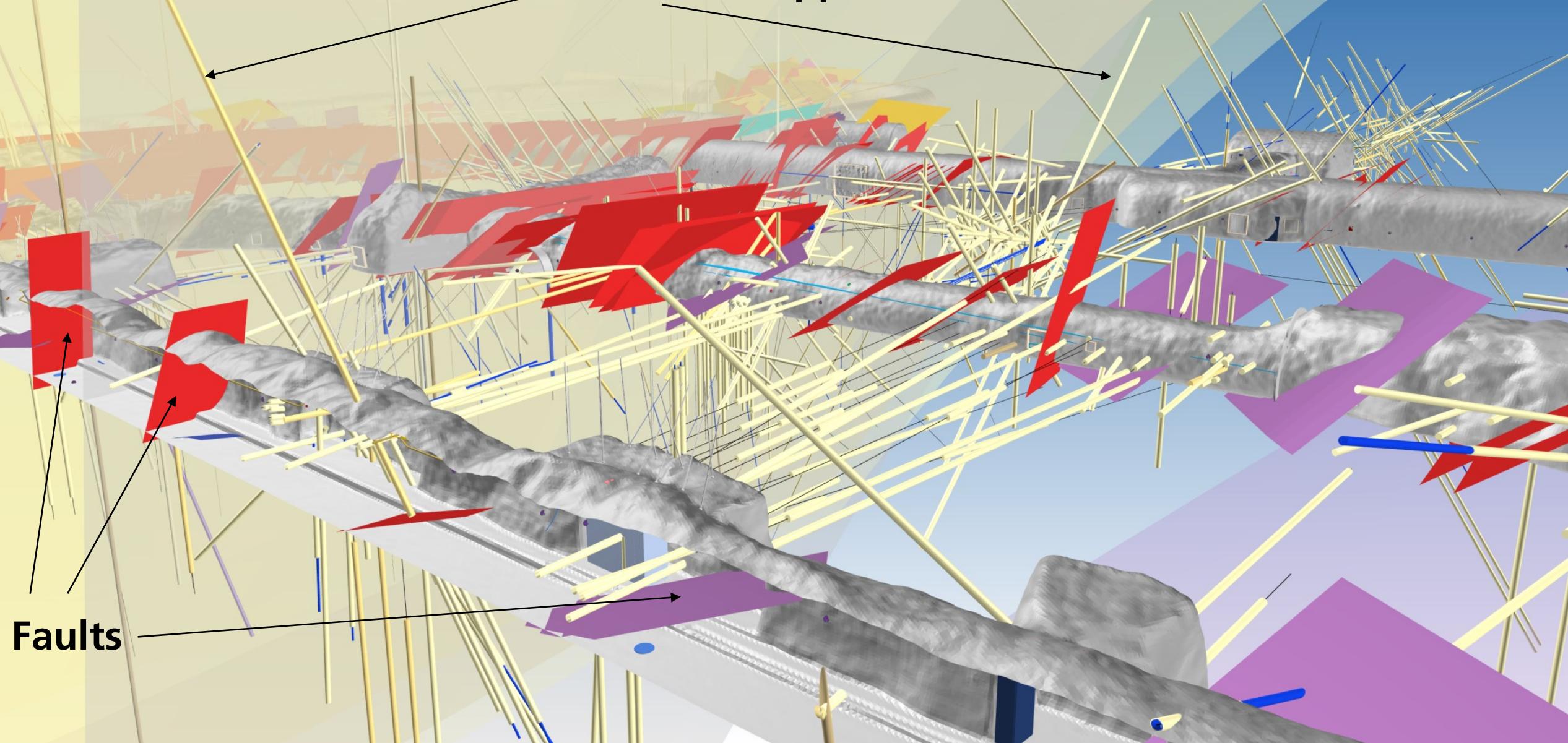


**Main fault**

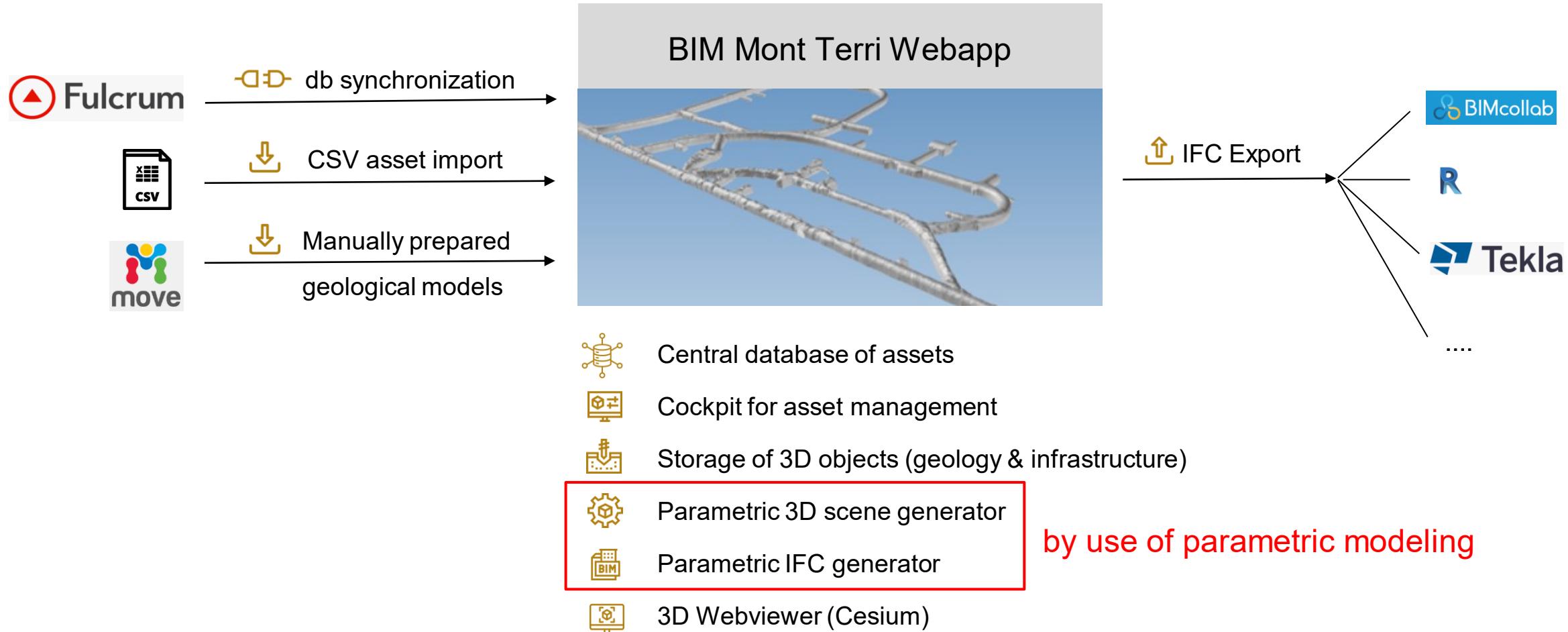
**Geologic contacts**

# Geologic data

Boreholes (approx. 1400)



# The 'BIM Mont Terri' web application

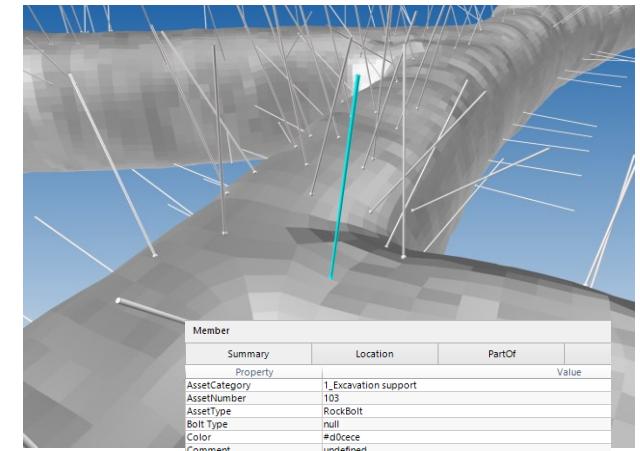
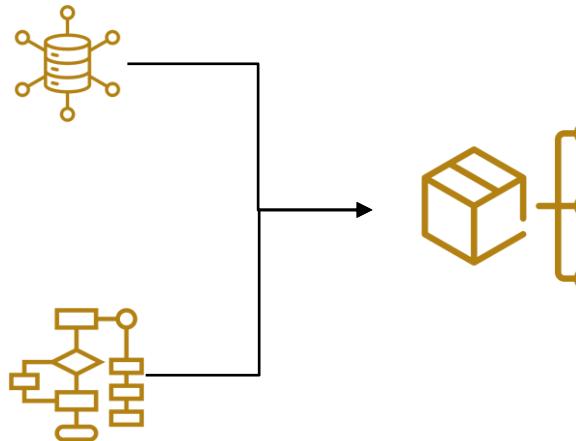
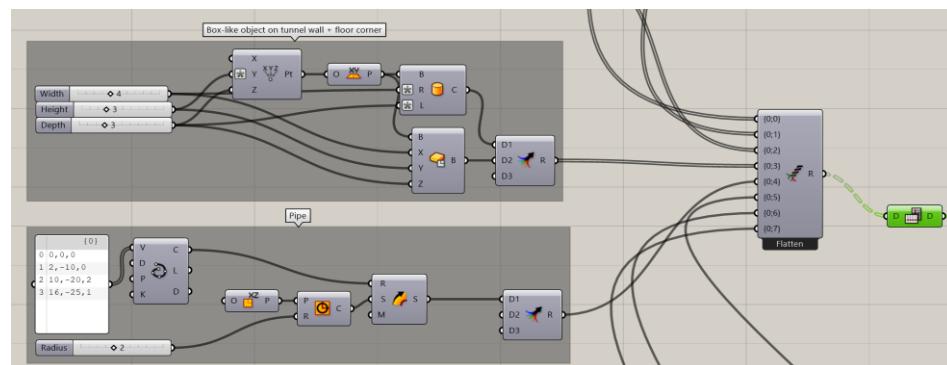




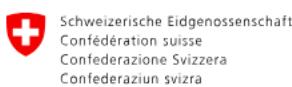
# Parametric modeling

- In parametric modeling, 3D geometry, element properties and the relationship between the elements are defined by alphanumeric parameters and rules.
- In the BIM Mont Terri project, asset information such as anchor length, anchor inclination, insertion coordinate or material type is stored in a database.
- The rules for recording and attributing the asset are defined in the Grasshopper CAD plugin. This allows 3D scenes to be generated 'at the touch of a button' and exported as an IFC file, for example.

```
1 #asset_type_name=Rock bolt
2 #asset_type_number=103
3 #version=1
4 X,y,z,wX,wY,wZ,anchor,tag,tun
Presentation last saved: Just now
5 75.788563,-108.696091,-4.183154,0.525742,-0.420907,-0.739211,FaceTopCenter,Not specified,Security Gallery Sisto
6 76.284364,-110.071187,-4.0541,0.26071,0.059647,-0.963573,FaceTopCenter,Not specified,Security Gallery Sisto
7 77.056793,-111.044833,-3.750052,0.287694,-0.176818,-0.941259,FaceTopCenter,Not specified,Security Gallery Sisto
8 78.292791,-110.071388,-3.74185,-0.114453,-0.156273,-0.98106,FaceTopCenter,Not specified,Security Gallery Sisto
9 77.889611,-109.12352,-3.833022,-0.110029,-0.131876,-0.985141,FaceTopCenter,Not specified,Security Gallery Sisto
10 77.152116,-108.125639,-4.102828,0.064269,-0.762713,-0.643536,FaceTopCenter,Not specified,Security Gallery Sisto
11 79.247036,-108.51047,-4.121119,-0.296609,-0.120796,-0.947329,FaceTopCenter,Not specified,Security Gallery Sisto
12 78.476488,-107.475938,-4.338343,0.021318,-0.718187,-0.695523,FaceTopCenter,Not specified,Security Gallery Sisto
```



| Property              | Summary   | Location | PartOf | Value |
|-----------------------|---|----------|--------|-------|
| AssetCategory         | I_Excavation support                                  |          |        |       |
| AssetNumber           | 103   |          |        |       |
| AssetType             | RockBolt  |          |        |       |
| Bolt Type             | null  |          |        |       |
| Color                 | #d0ecec   |          |        |       |
| Comment               | undefined   |          |        |       |
| Description           | null  |          |        |       |
| Deviation Cone Factor | null  |          |        |       |
| Diameter [mm]         | 40  |          |        |       |
| Furculum ID           | null  |          |        |       |
| ID                    | 3886  |          |        |       |
| IfcElementType        | IfcGroundReinforcementElementTypeEnum.ROCKSUPPORTBOLT |          |        |       |
| Label                 | undefined   |          |        |       |
| Length [mm]           | 3000  |          |        |       |
| Scale                 | null  |          |        |       |
| Tag value             | undefined   |          |        |       |
| Tunnel meter          | null  |          |        |       |



BIM Mont Terri

## Assets

+ Add Asset



Import assets

Sync with Fulcrum

Create scene

| CATEGORY ↓            | ASSET TYPE ↓     | ASSET NAME ↓ | TAG ↓ | TUNNEL ↓       | TUNNEL-M ↓ | ORGANIZATION ↓ | USER ↓ | ACTIONS |
|-----------------------|------------------|--------------|-------|----------------|------------|----------------|--------|---------|
| 00 Geodetic surveying | 001 Survey Point | 127          | -     | Gallery 98     | 67.3       | -              | -      |         |
| 00 Geodetic surveying | 001 Survey Point | 126          | -     | Gallery 98     | 71         | -              | -      |         |
| 00 Geodetic surveying | 001 Survey Point | 119          | -     | Gallery 18     | 336.7      | -              | -      |         |
| 00 Geodetic surveying | 001 Survey Point | 114          | -     | Gallery 18     | 318.1      | -              | -      |         |
| 00 Geodetic surveying | 001 Survey Point | 106          | -     | Niche Sandwich | 7.8        | -              | -      |         |
| 00 Geodetic surveying | 001 Survey Point | 104          | -     | Niche Sandwich | 14.6       | -              | -      |         |
| 00 Geodetic surveying | 001 Survey Point | 102          | -     | Niche Sandwich | 20.2       | -              | -      |         |
| 00 Geodetic surveying | 001 Survey Point | 100          | -     | Niche Sandwich | 13.5       | -              | -      |         |
| 00 Geodetic surveying | 001 Survey Point | 96           | -     | Niche CO2      | 14.8       | -              | -      |         |



Asset Catalogs



Users &amp; Organizations



Stefan Volken





Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

BIM Mont Terri



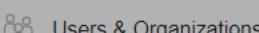
Assets



Asset Catalogs



3D Scenes



Users & Organizations



Stefan Volken

## Assets



CATEGORY ↓

ASSET TYPE

00 Geodetic surveying

001 Survey



## Filter

[Clear all](#)

[Save filter](#)

[Apply filter](#)

### Assets

Category

02 Water system

04 Electrical power supply

Asset-Type

202 Drainage shaft

203 Freshwater pipe

403 Ground cable fixation board

406 400kV cable

Tag-ID

Select...

### Boundaries

Tunnel section

Gallery 18

From

93

To

271

### Actors

Organizations

Select...

Users

Select...

## Assets

+ Add Asset

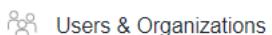
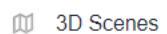
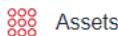


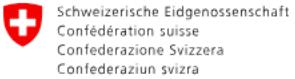
Import assets

Sync with Fulcrum

+ Create scene

| CATEGORY ↓                 | ASSET TYPE ↓                    | ASSET NAME ↓ | TAG ↓         | TUNNEL ↓   | TUNNEL-M ↓ | ORGANIZATION ↓ | USER ↓ | ACTIONS |
|----------------------------|---------------------------------|--------------|---------------|------------|------------|----------------|--------|---------|
| 02 Water system            | 202 Drainage shaft              | -            | -             | Gallery 18 | 168.6      | -              | -      |         |
| 02 Water system            | 202 Drainage shaft              | -            | -             | Gallery 18 | 104.7      | -              | -      |         |
| 02 Water system            | 202 Drainage shaft              | -            | -             | Gallery 18 | 128.6      | -              | -      |         |
| 04 Electrical power supply | 403 Ground cable fixation board | -            | -             | Gallery 18 | 153.9      | -              | -      |         |
| 04 Electrical power supply | 403 Ground cable fixation board | -            | -             | Gallery 18 | 221.1      | -              | -      |         |
| 04 Electrical power supply | 403 Ground cable fixation board | -            | Npt specified | Gallery 18 | 257.4      | -              | -      |         |
| 04 Electrical power supply | 403 Ground cable fixation board | -            | -             | Gallery 18 | 132.2      | -              | -      |         |
| 04 Electrical power supply | 406 400kV cable                 | -            | -             | Gallery 18 | 211.5      | -              | -      |         |
| 04 Electrical power supply | 406 400kV cable                 | -            | -             | Gallery 18 | 178.5      | -              | -      |         |
| 04 Electrical power supply | 403 Ground cable fixation board | -            | -             | Gallery 18 | 180.8      | -              | -      |         |



**BIM Mont Terri****Mtterri Demo Scene**

Demo scene

Ivan Pasic | 24. April 2024

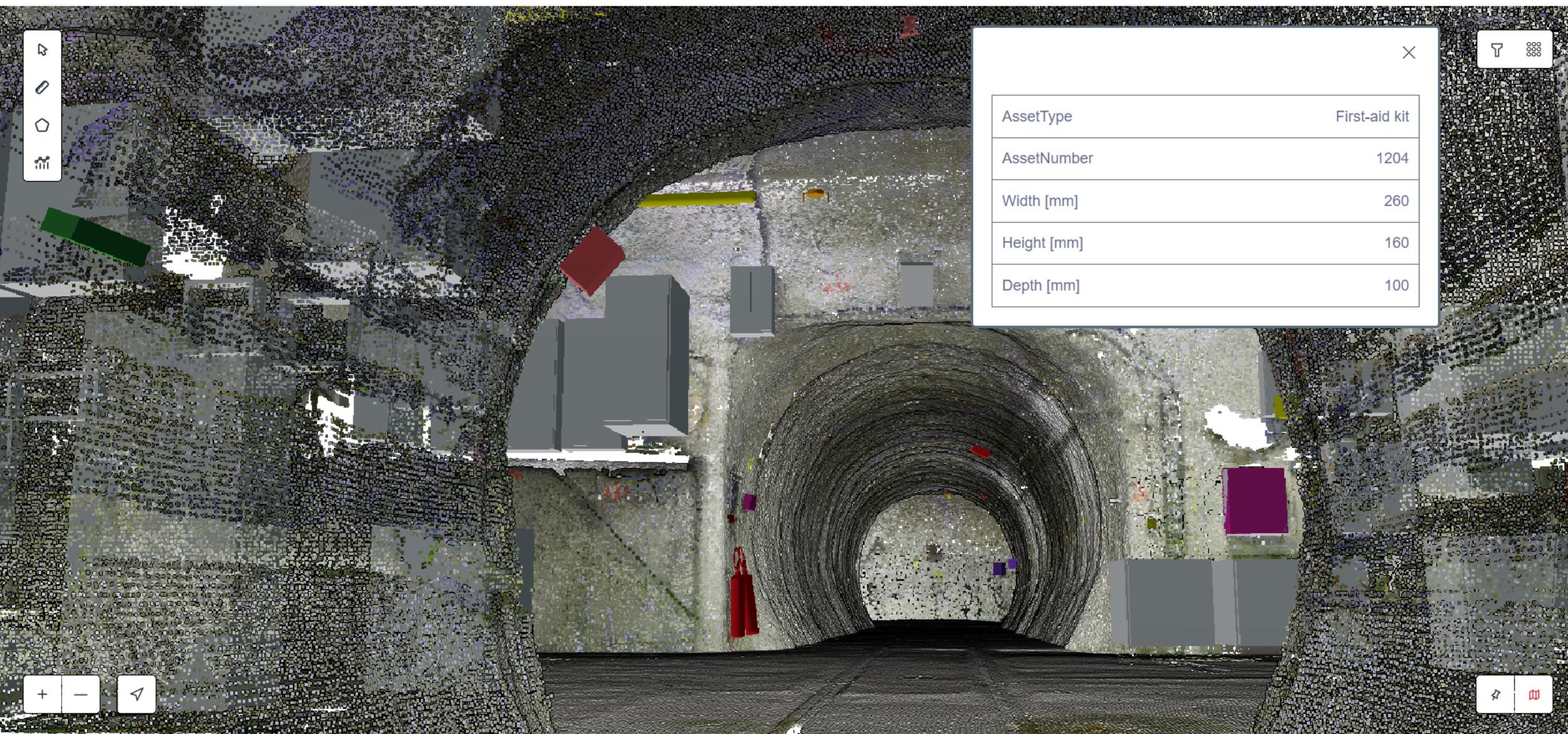
[Download IFC](#)[Open →](#) Assets Asset Catalogs 3D Scenes Users & Organizations 3 Stefan Volken

[← Back](#)**Mtterri Demo Scene**[Default View](#)

SV

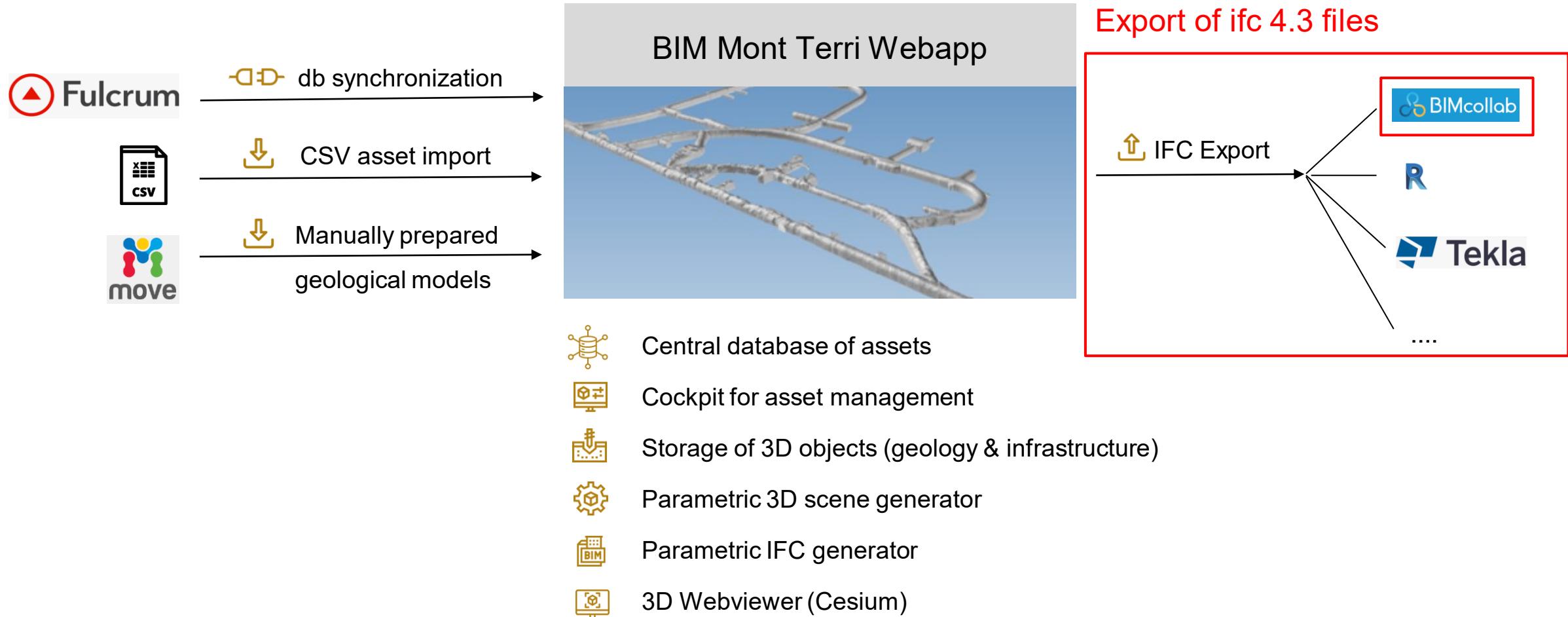
Stefan Volken







# The 'BIM Mont Terri' web application



# Virtual Tour through BIM model (BIMCollab Zoom)

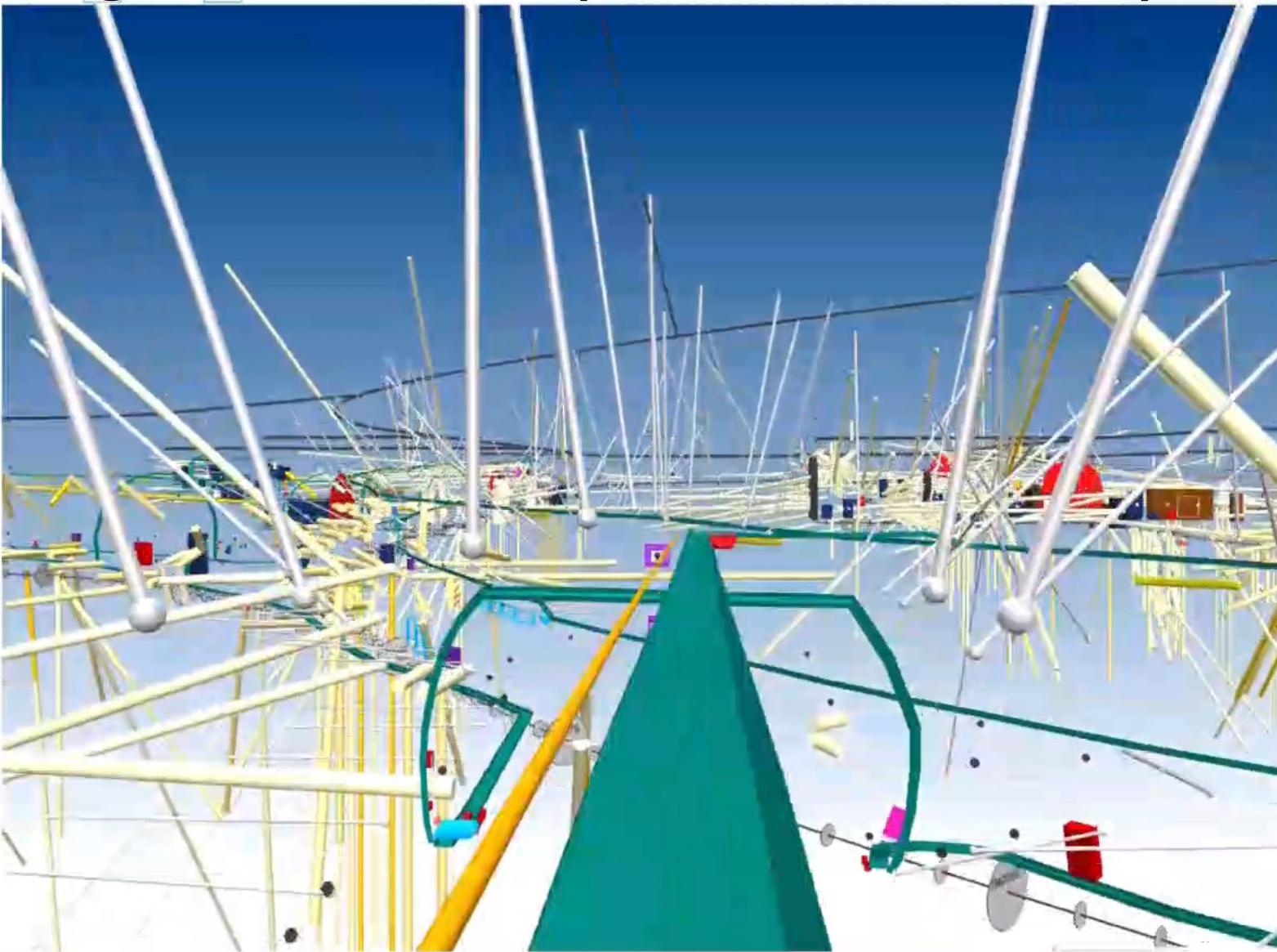
Navigation Smart views Conflicts Lists Issues

Offline

- ASSETS\_ALL\_PARAMETRIC\_20241003
- GEOLOGY\_CONTACTS
- GEOLOGY\_FAULTS
- GEOLOGY\_MAINFAULT
- GEOLOGY\_UNITS
- TUNNEL\_3D\_METERING (2)
- TUNNEL\_SEGMENTS
- TUNNEL\_WALLMESH\_FULL\_SIMPLIFIED

## Project

| File        | Summary                         | PartOf |
|-------------|---------------------------------|--------|
| Property    | Value                           |        |
| Model       | TUNNEL_WALLMESH_FULL_SIMPLIFIED |        |
| Prefix      |                                 |        |
| Name        | Mt.Terri                        |        |
| Long name   |                                 |        |
| Phase       |                                 |        |
| Type        |                                 |        |
| Description |                                 |        |
| GUID        | 3Z9QVZoeX18u1s11ZKoBXQ          |        |
| Object Type |                                 |        |



Free mode Buy now

My view: 0 Selected: 1



# Lessons learned

- **Well-structured object catalog is a must**, requires (time-consuming) creation.
- **Parametric modeling increases flexibility/individuality** to a high degree & enables efficient interface development.
- Generic, central data storage optimizes the possibilities of parametric modelling.
- **IFC is a suitable exchange format** (small amount of data, high-performance representation), but version 4.3 is not yet widely supported



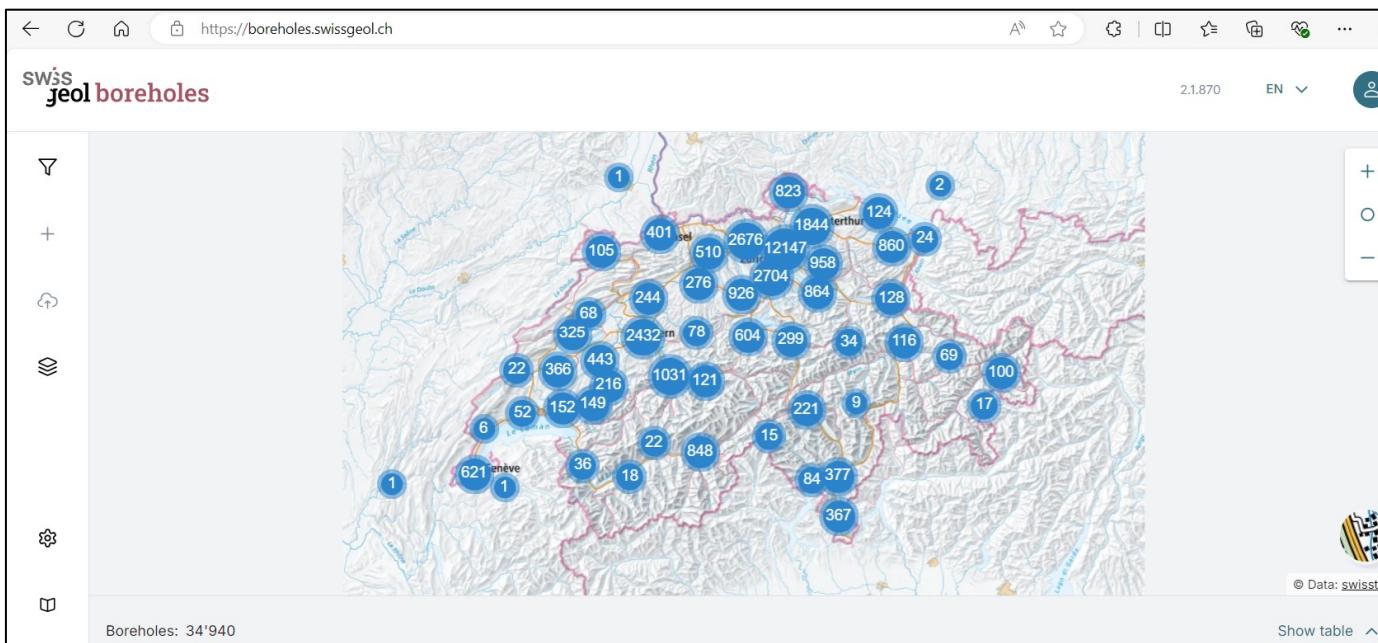
# Next steps for «geological» BIM @ SGS/swisstopo

## BIM Mont Terri:

- Project completion by the end of 2024
- Start of operations in early 2025

## Swiss boreholes data management application ([boreholes.swissgeol.ch](https://boreholes.swissgeol.ch)):

- Implementation of an IFC export interface by 2025





# Questions

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