OPTIMIZATION IN TUNNEL EXCAVATION: THE BRENNER BASE TUNNEL EXAMPLE

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Alessandro Laner – EnginSoft

tunnel design's peculiarities

section 1

Tunnel design:
designers and committee interests

typical questions by the committee

1. how much does the tunnel cost ???
2. how long does it take to build the tunnel ???
3. will the tunnel's structures resist ???

important variables for the designers

COST
TIME
RISK*

* measures the structures' suitability in a probabilistic way

A. to give an answer: evaluate the variables

B. to optimize: minimize their values

Tunnel design:
evaluation of the variables

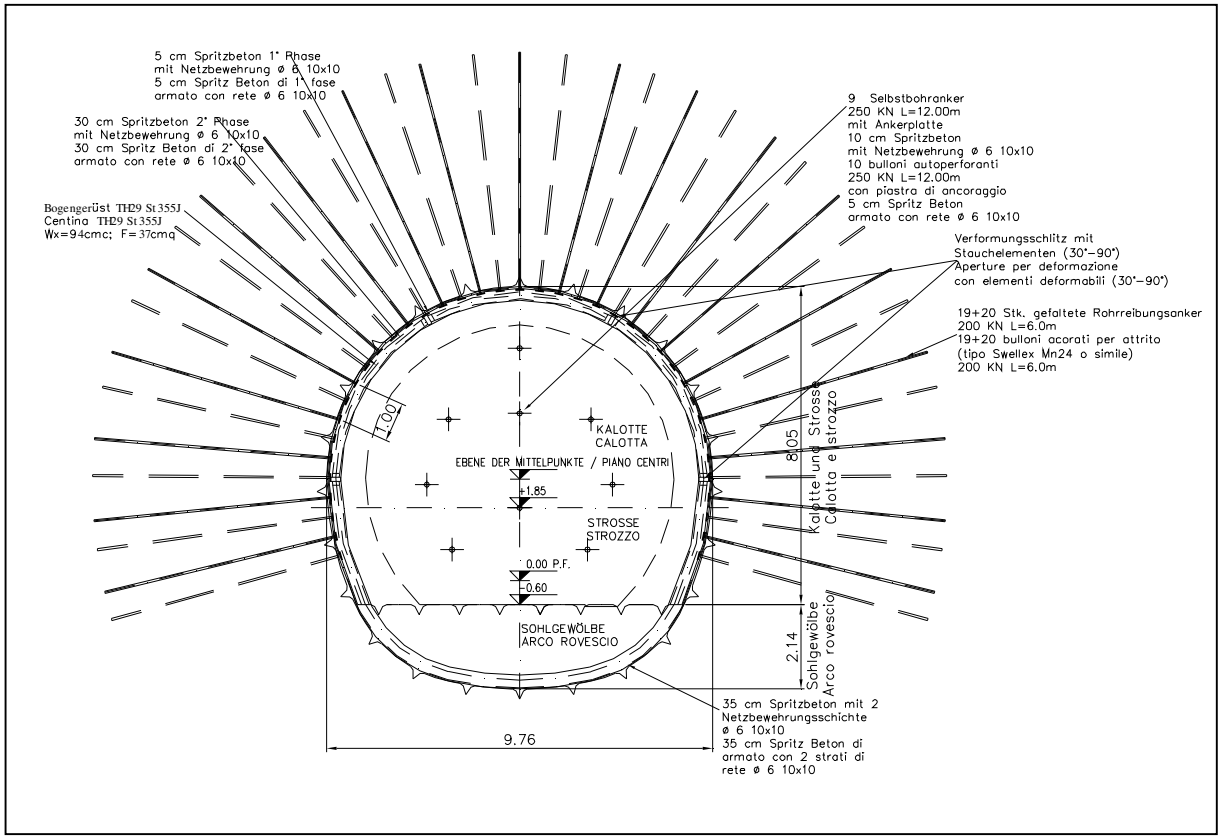
which **excavation technology ???**

conventional

mechanized (TBM)

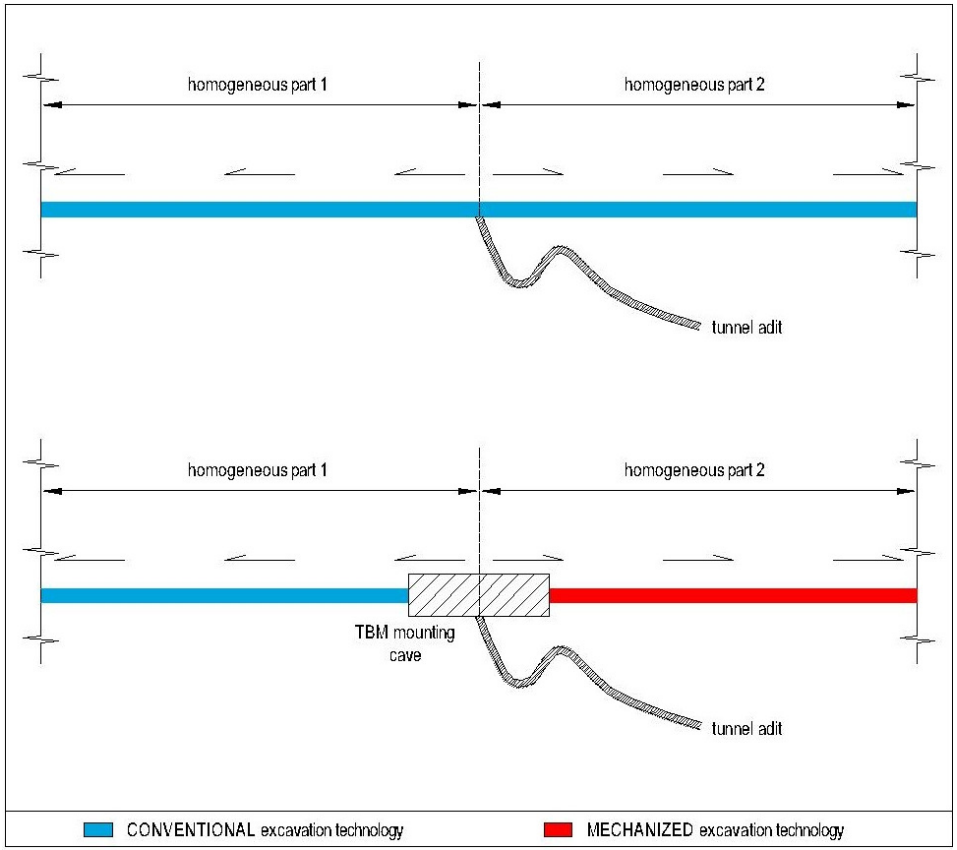
Tunnel design:
evaluation of the variables

which **type of support(s)** for the excavation **???**



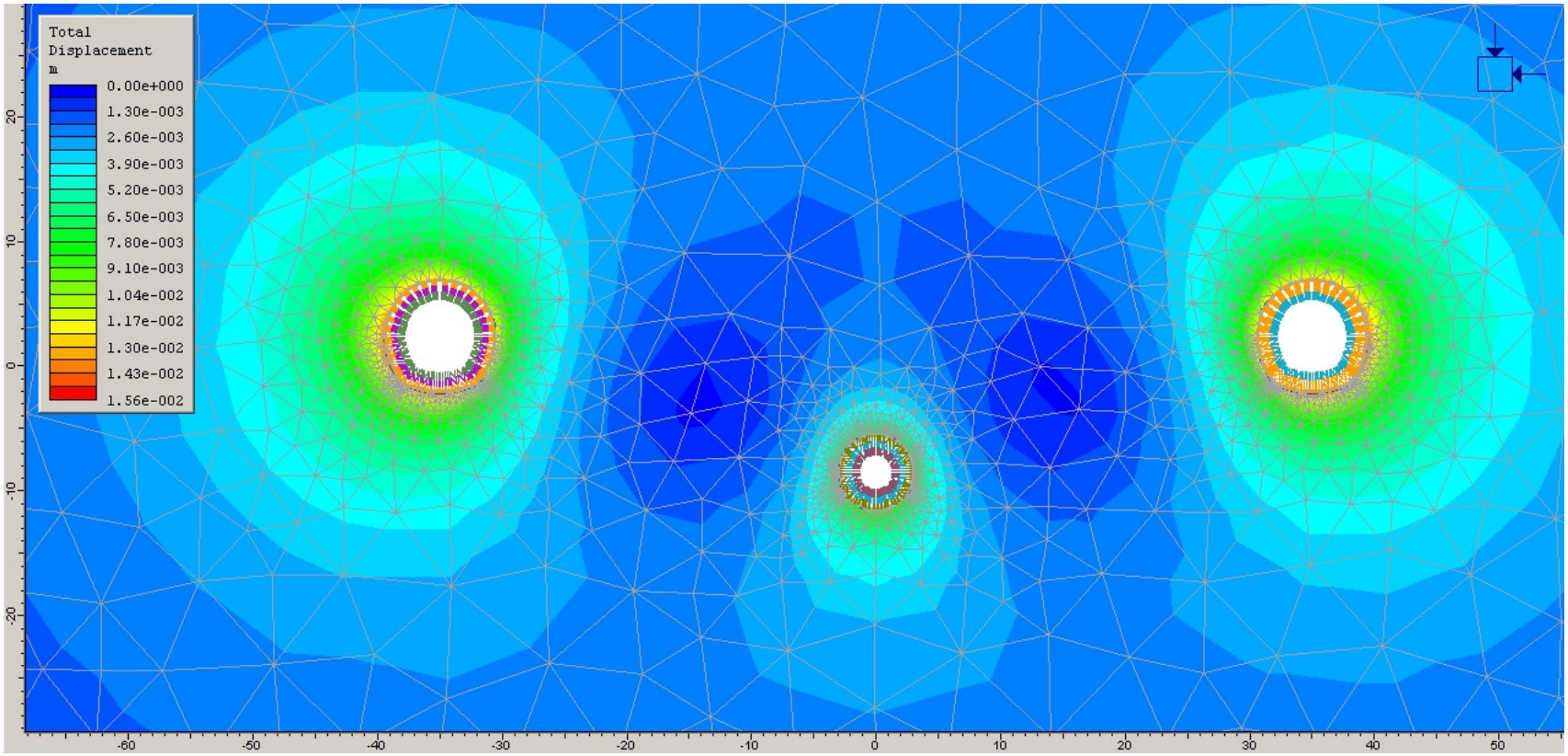
Tunnel design:
evaluation of the variables

what is the **direction** of the excavation **???**



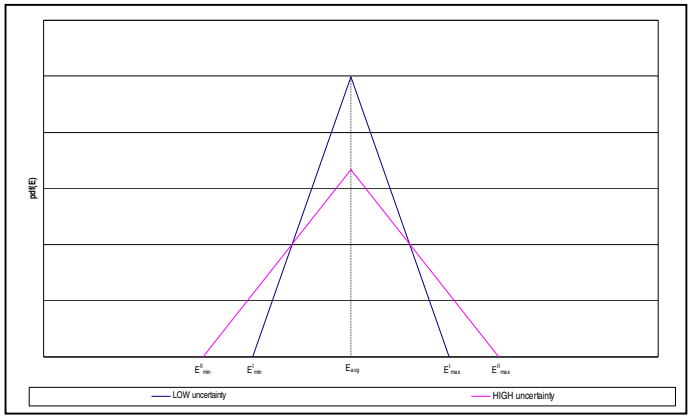
Tunnel design:
evaluation of the variables

what will the **rock mass** and the **structures behaviour** be **???**



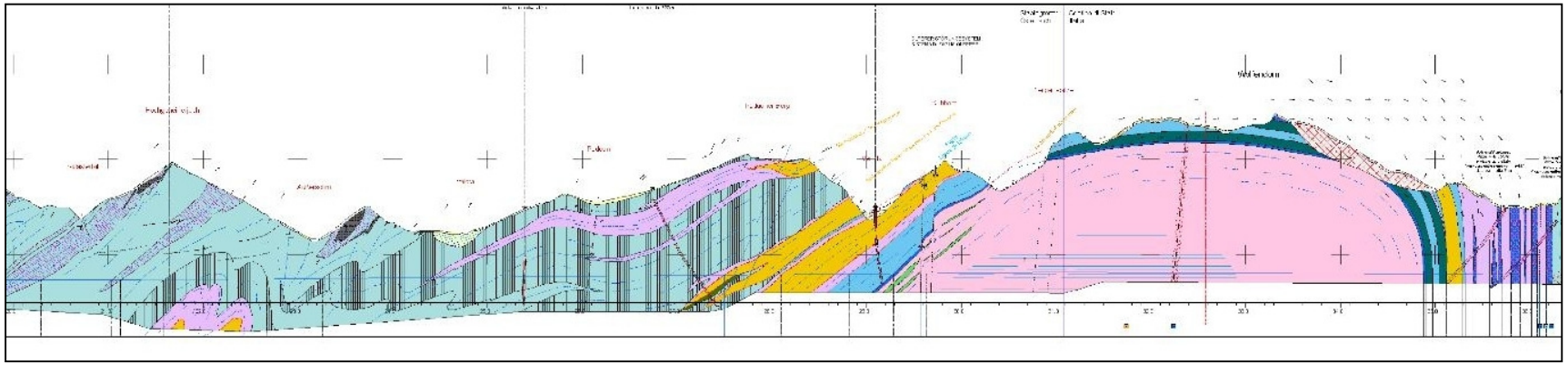
Tunnel design:
evaluation of the variables

what is the **reliability degree** on the geological and geotechnical data **???**



geotechnical parameters

geological model



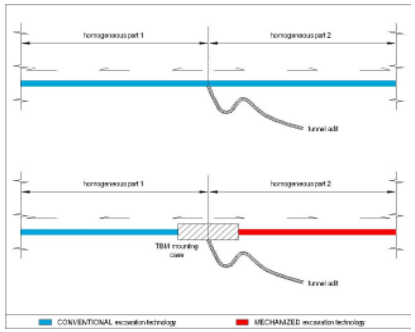
Tunnel design:
evaluation of the variables

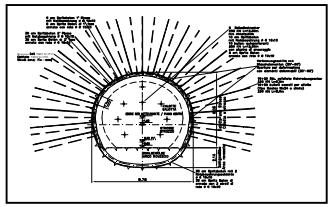
knowledge in each **homogeneous part** of the tunnel

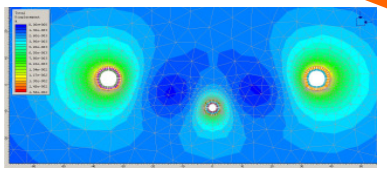
allows the evaluation of the variables

conventional

mechanized (TBM)







data uncertainty

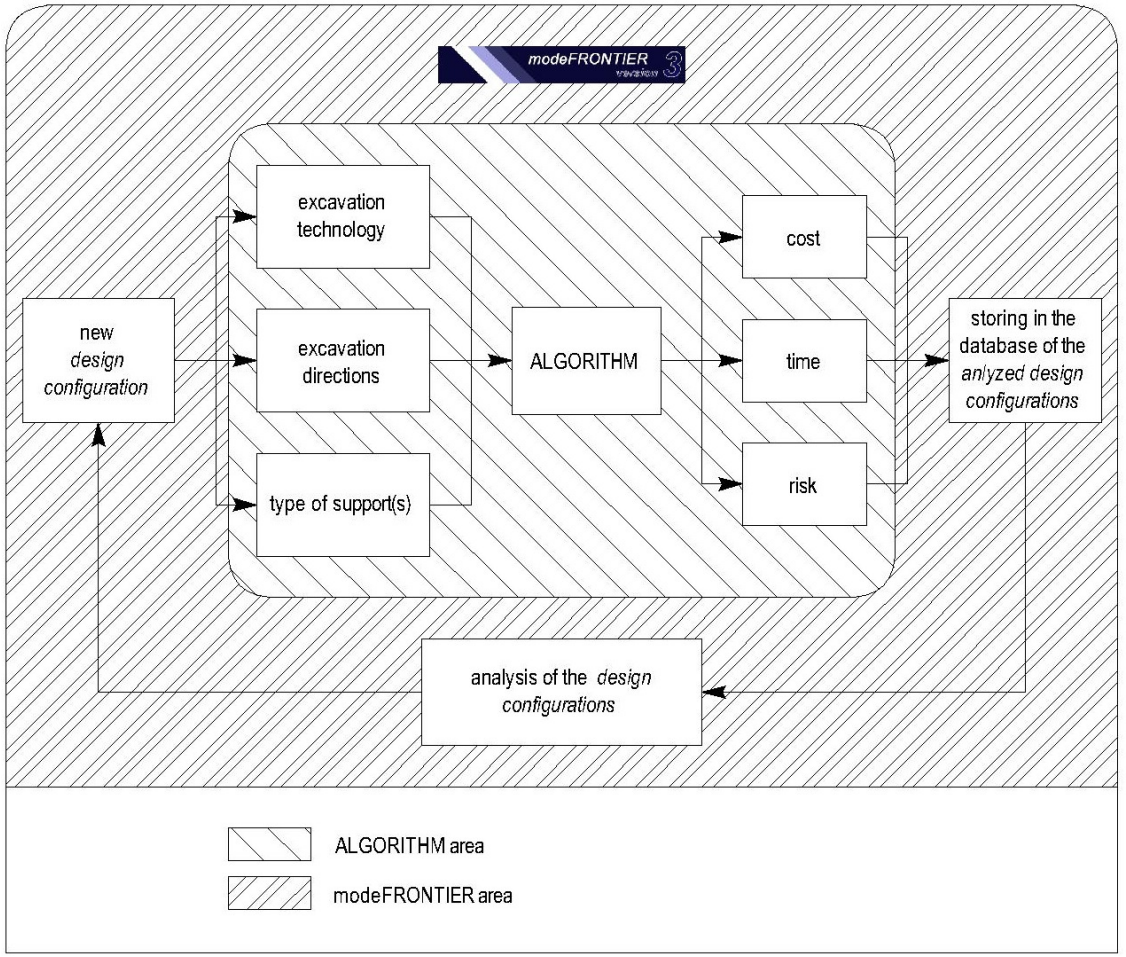
RISK

COST & TIME

a methodology to optimize a tunnel design

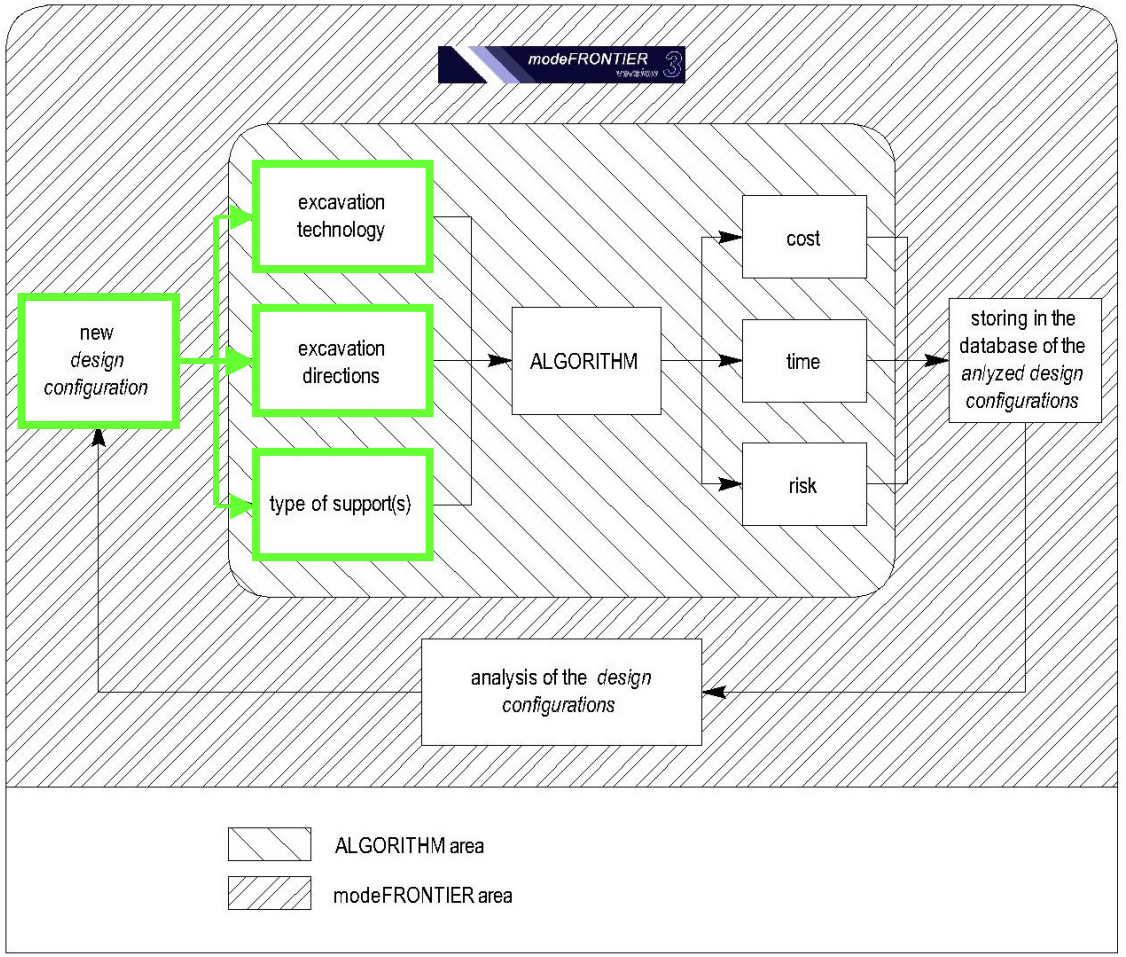
section 2

tunnel design optimization: using modeFRONTIER



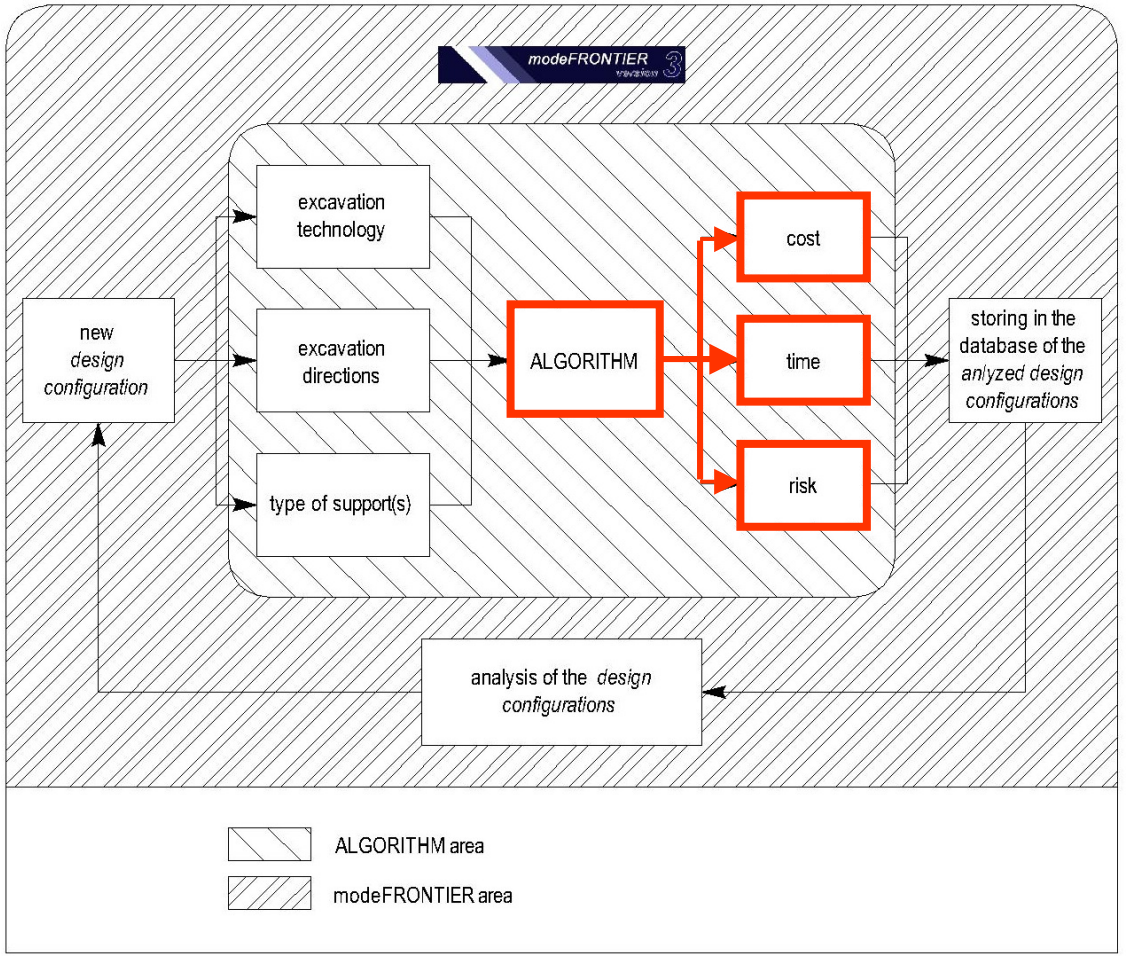
modeFRONTIER & **the algorithm** work together

tunnel design optimization: using modeFRONTIER



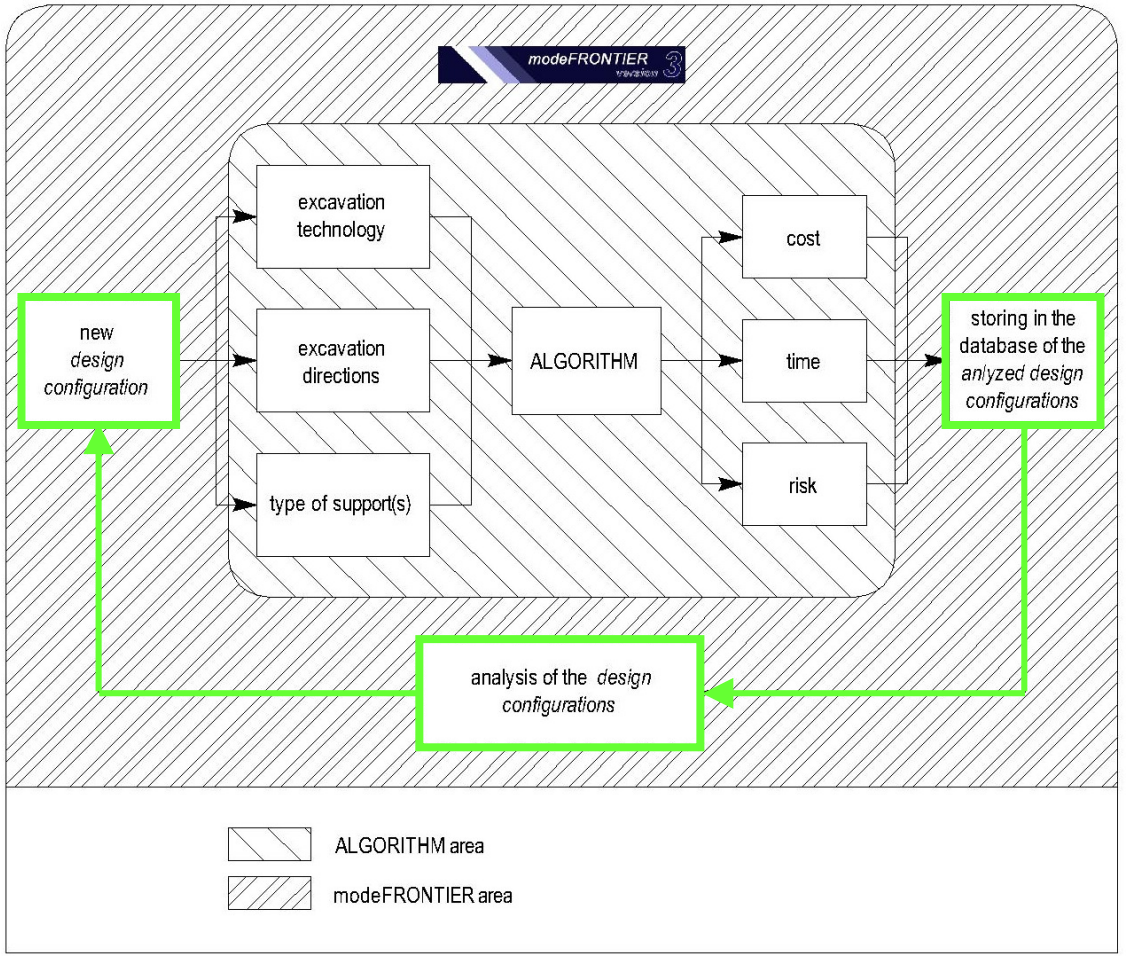
1. modeFRONTIER **defines the tunnel's peculiarities**

tunnel design optimization: using modeFRONTIER



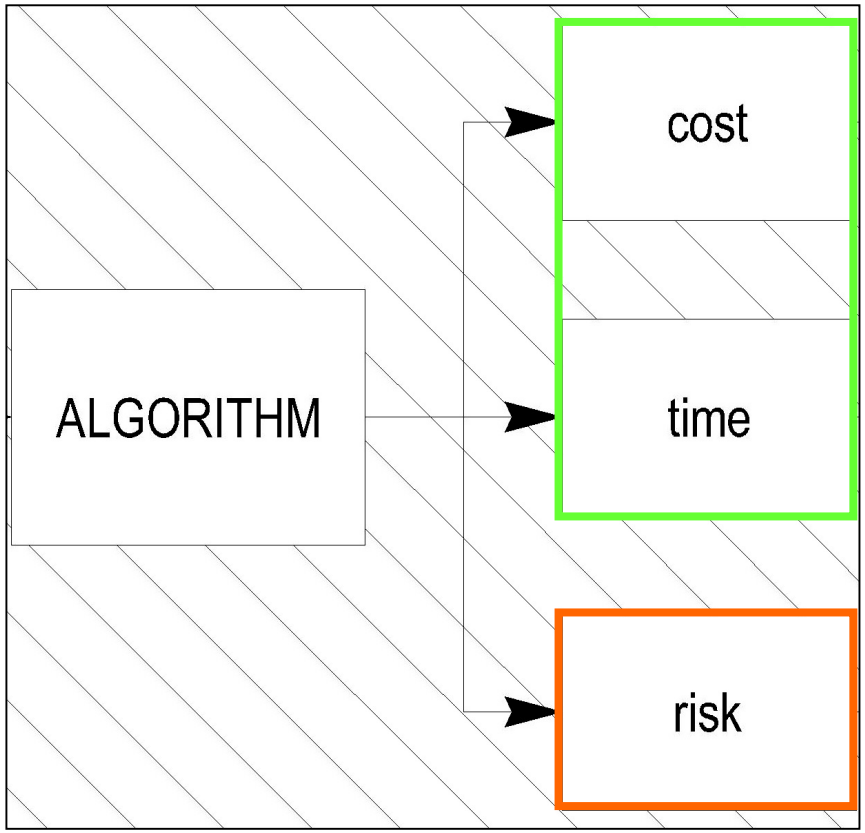
2. the algorythm **evaluates the variables' values**

tunnel design optimization: using modeFRONTIER



3. modeFRONTIER **analyzes the results** and **starts a new cycle**

tunnel design optimization: algorithm tasks & structure



tasks: evaluations of the variables

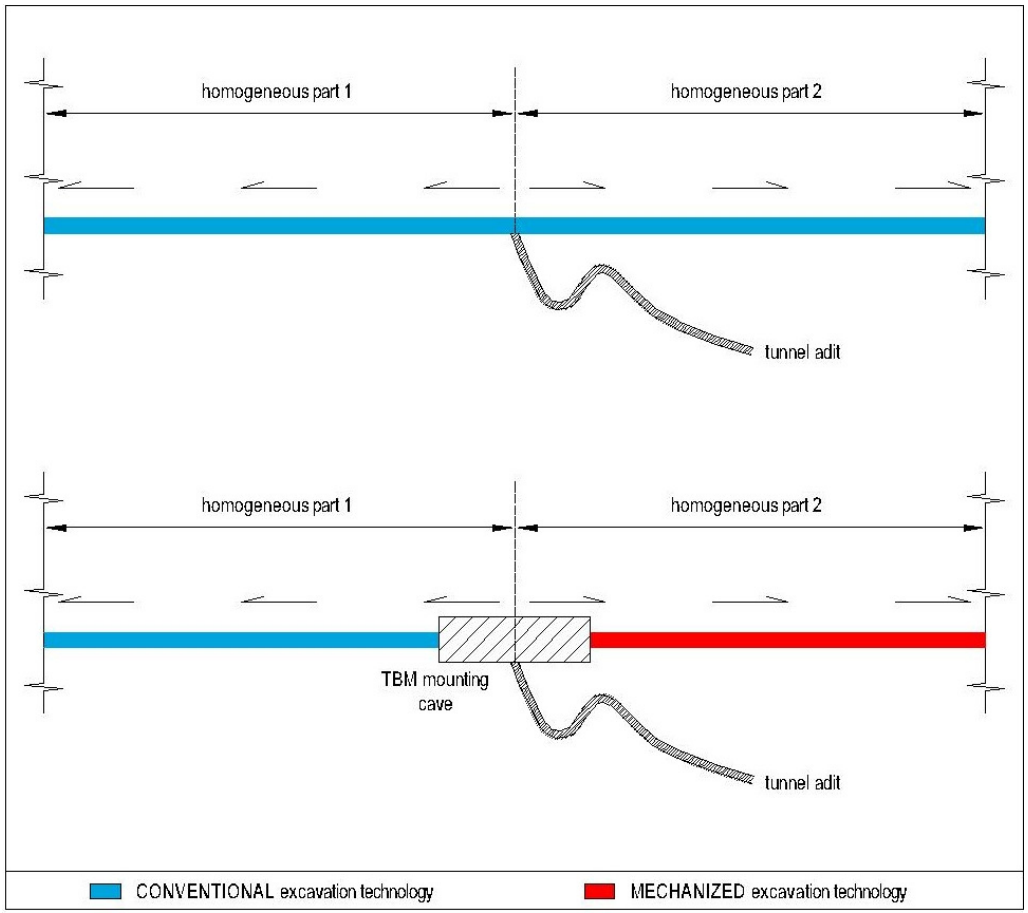
structure: 2 modules

- cost&time evaluator
- risk evaluator

tunnel design optimization: cost & time evaluation

given the **tunnel layout**…

(tunnel adits, caves // directions and technologies of excavation)

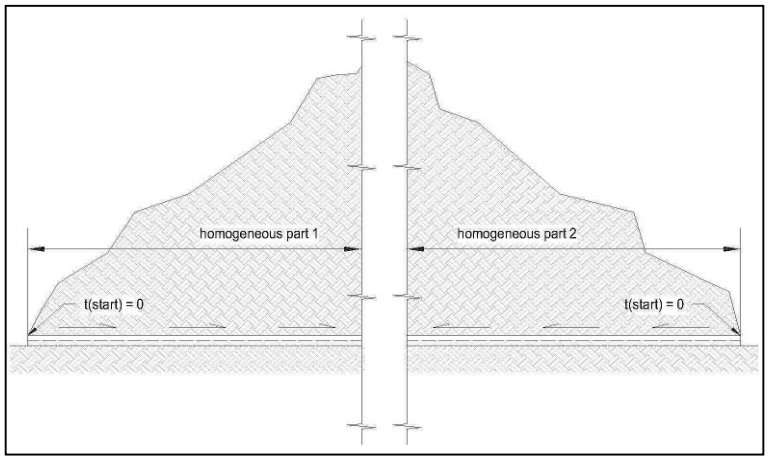


tunnel design optimization: cost & time evaluation

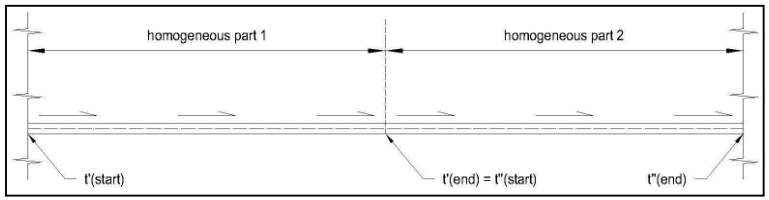
A. **cost = Σ_i** (unit cost x extension)$_i$

B. **time = Σ_i** (unit time x extension)$_i$**… and…**computation by means of the following rules…

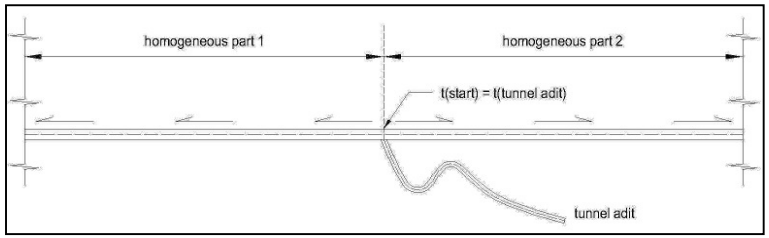
rule 1: the time at the entrances of the tunnel is equal to zero



rule 2: the initial time of an homogeneous part of the tunnel is equal to the final time of the previously excavated homogeneous part

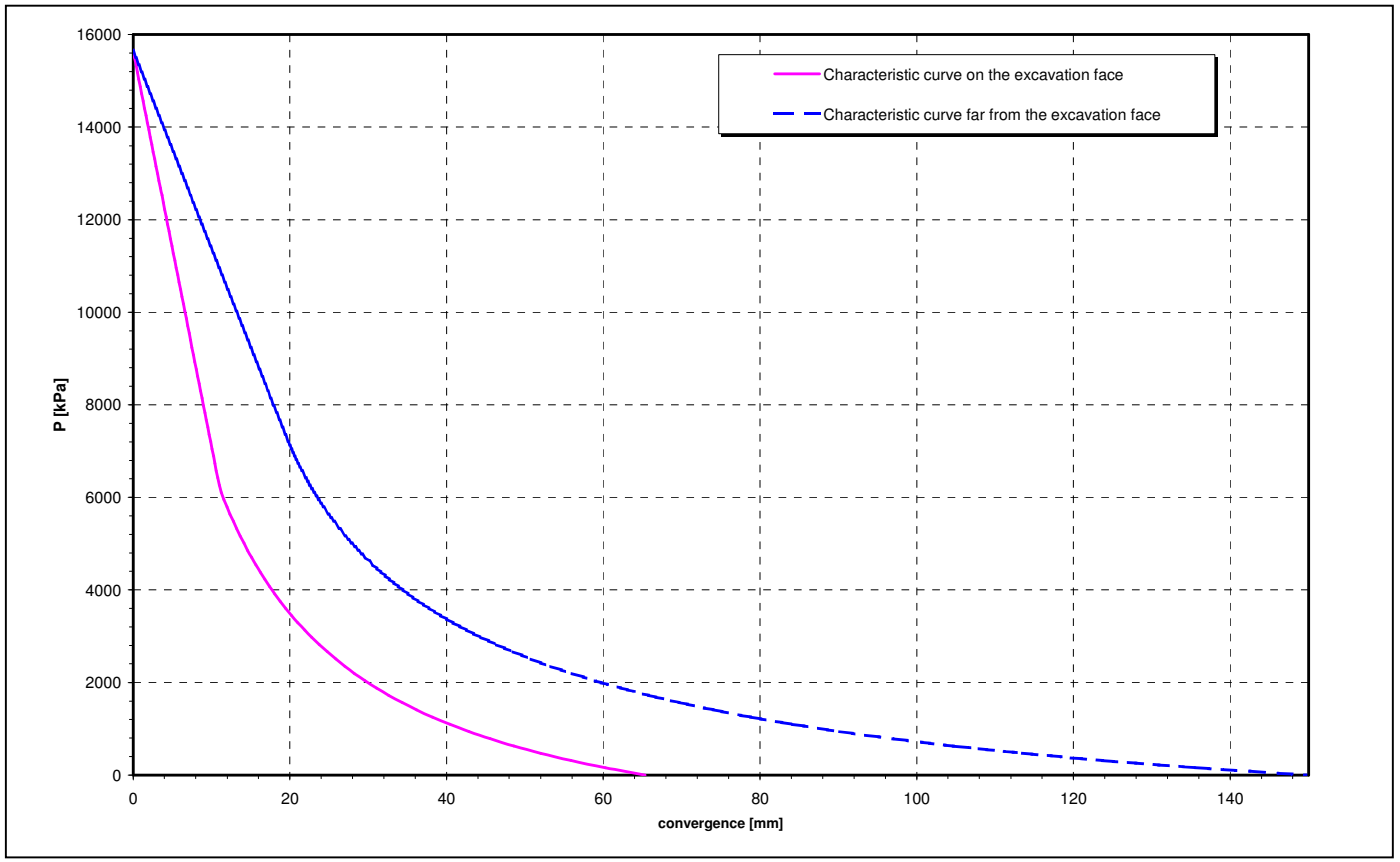


rule 3: the initial time of two adjacent homogeneous parts with opposite direction of excavations is equal to the time required to excavate the necessary tunnel adit



tunnel design optimization: risk evaluation

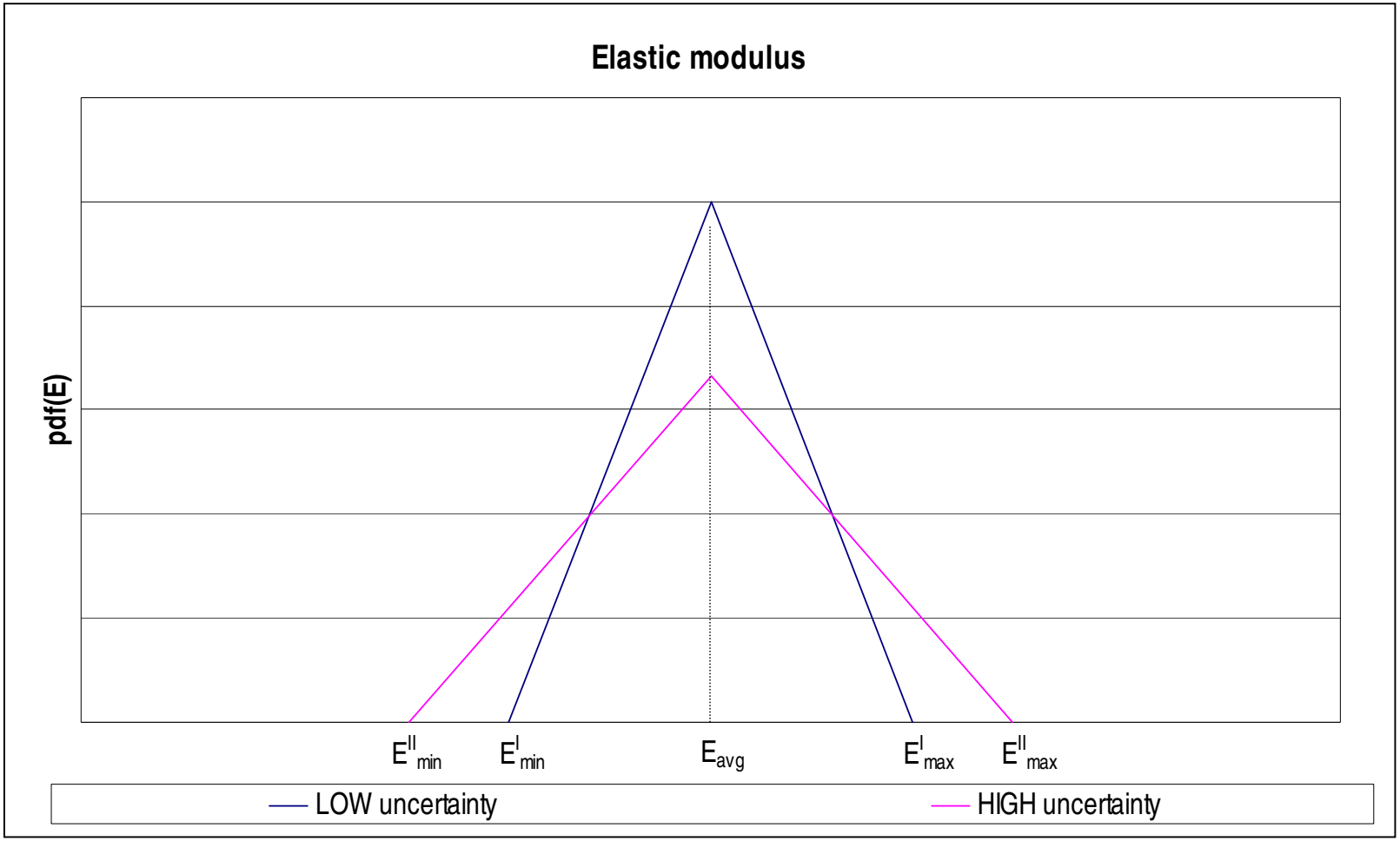
method of the characteristic curves



forecasts the **convergence** given the **geotechnical parameters**

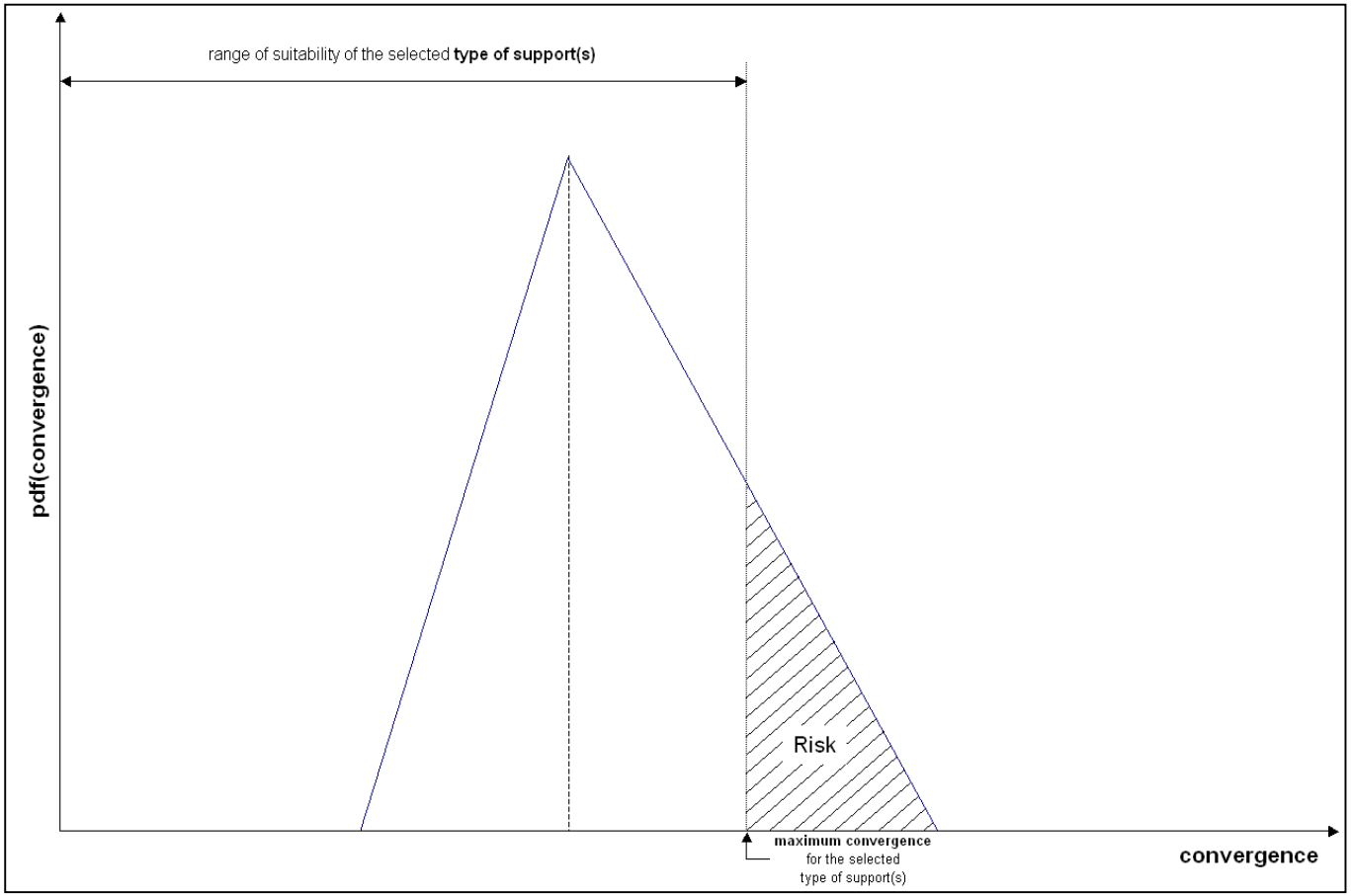
tunnel design optimization: risk evaluation (geotechnical uncertainty)

- assuming the **geotechnical parameters** as statistic variables



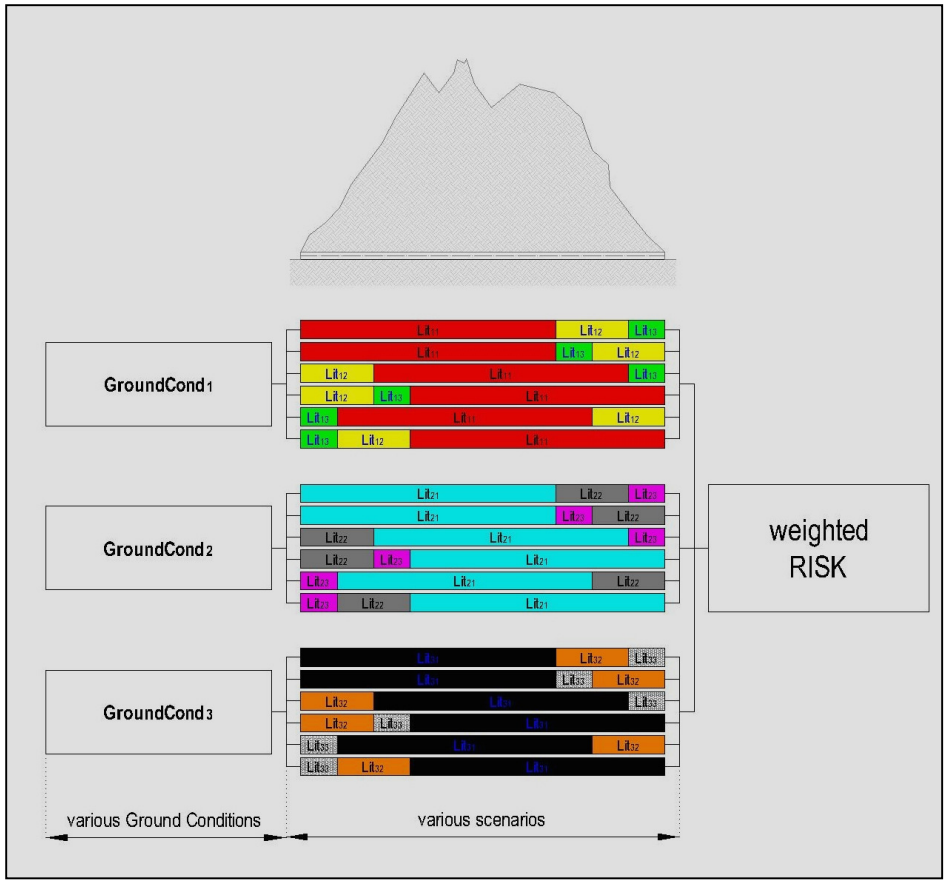
tunnel design optimization:
risk evaluation (geotechnical uncertainty)

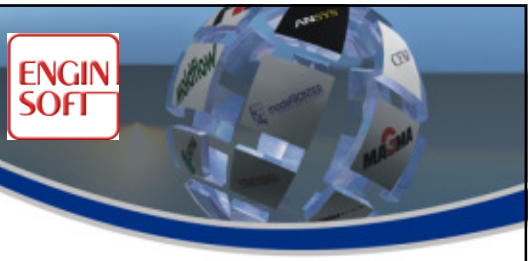
- assuming the **geotechnical parameters** as statistic variables
- the **evaluated convergence** is a statistic variable as well



tunnel design optimization:
risk evaluation (geological uncertainty)

- different **ground conditions** to be considered
- different **scenarios** to be considered





example: optimization of the Brenner Base Tunnel design

section 3

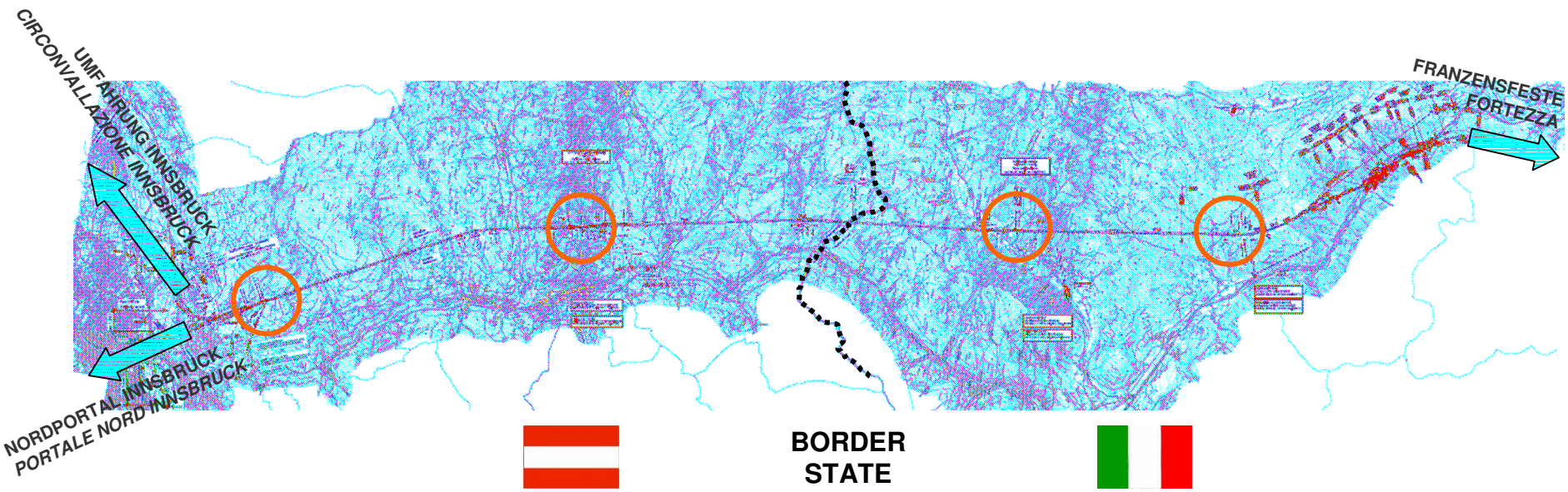
the BBT peculiarities: huge extension

Tunnel length of about 55 km

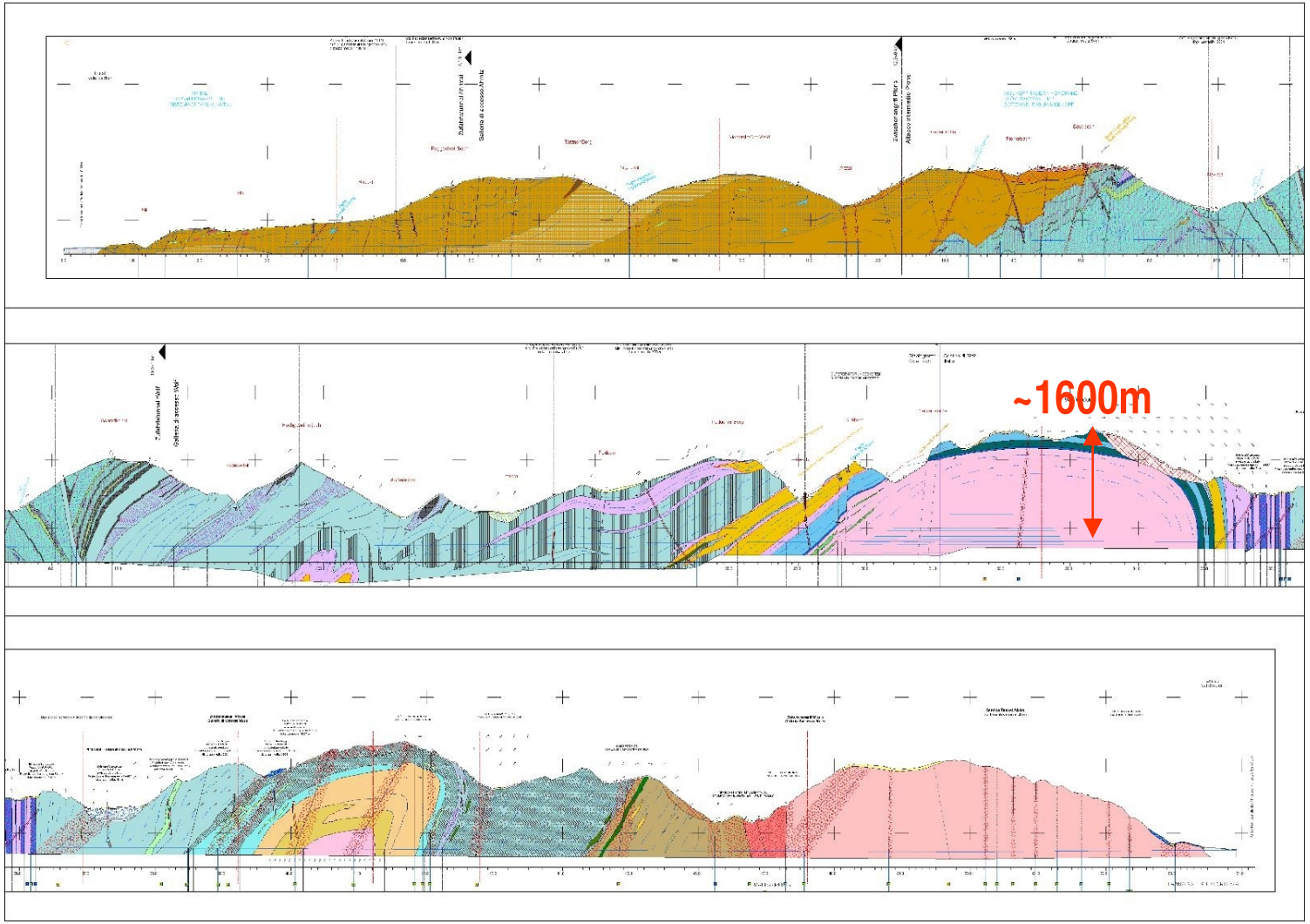
nearly **half extension in Italy** and **half extension in Austria**

links **Innsbruck (AUT)** with **Fortezza (ITA)**

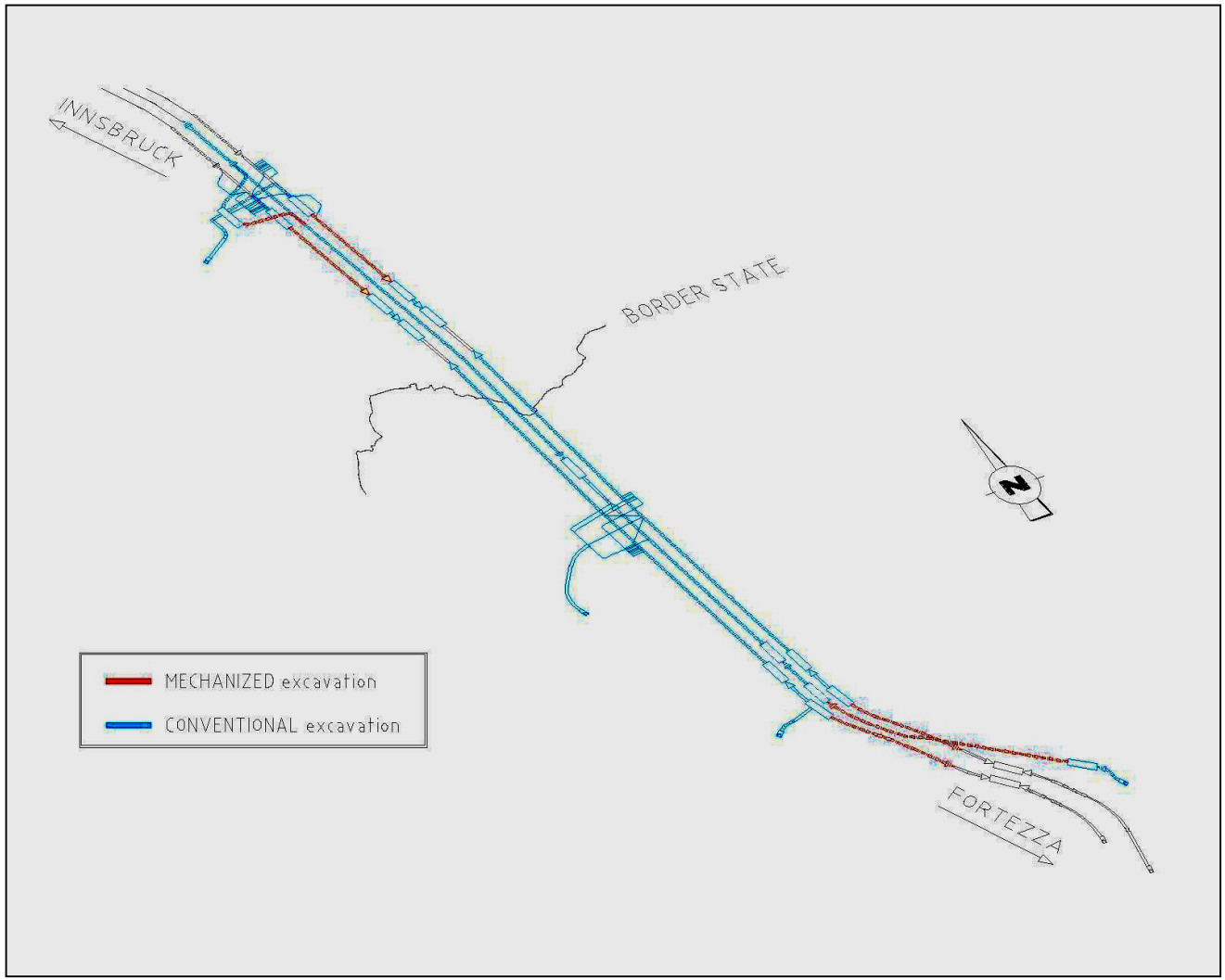
4 tunnel adits (about 20km far)



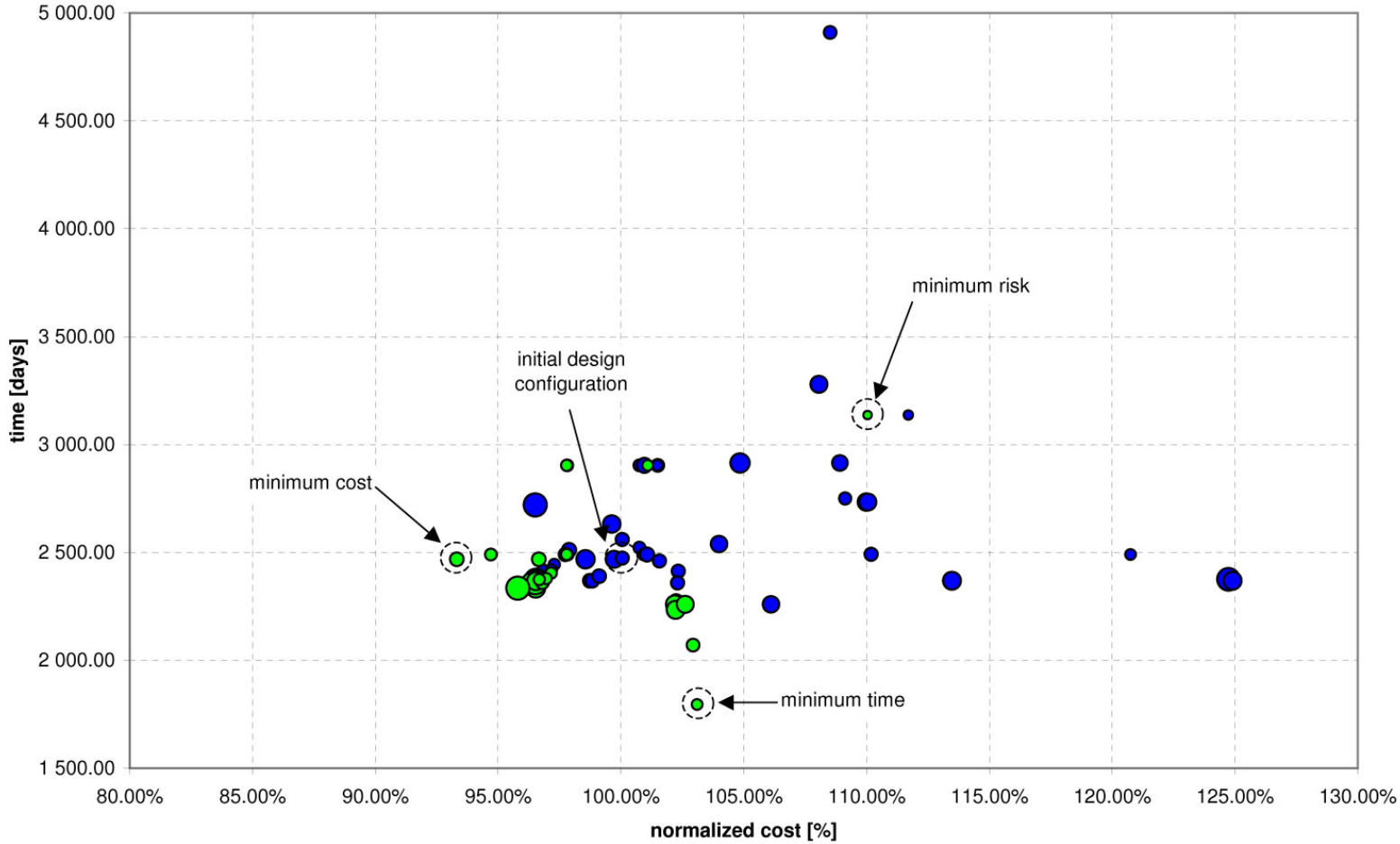
the BBT peculiarities:
huge coverage and lots of different lythotypes



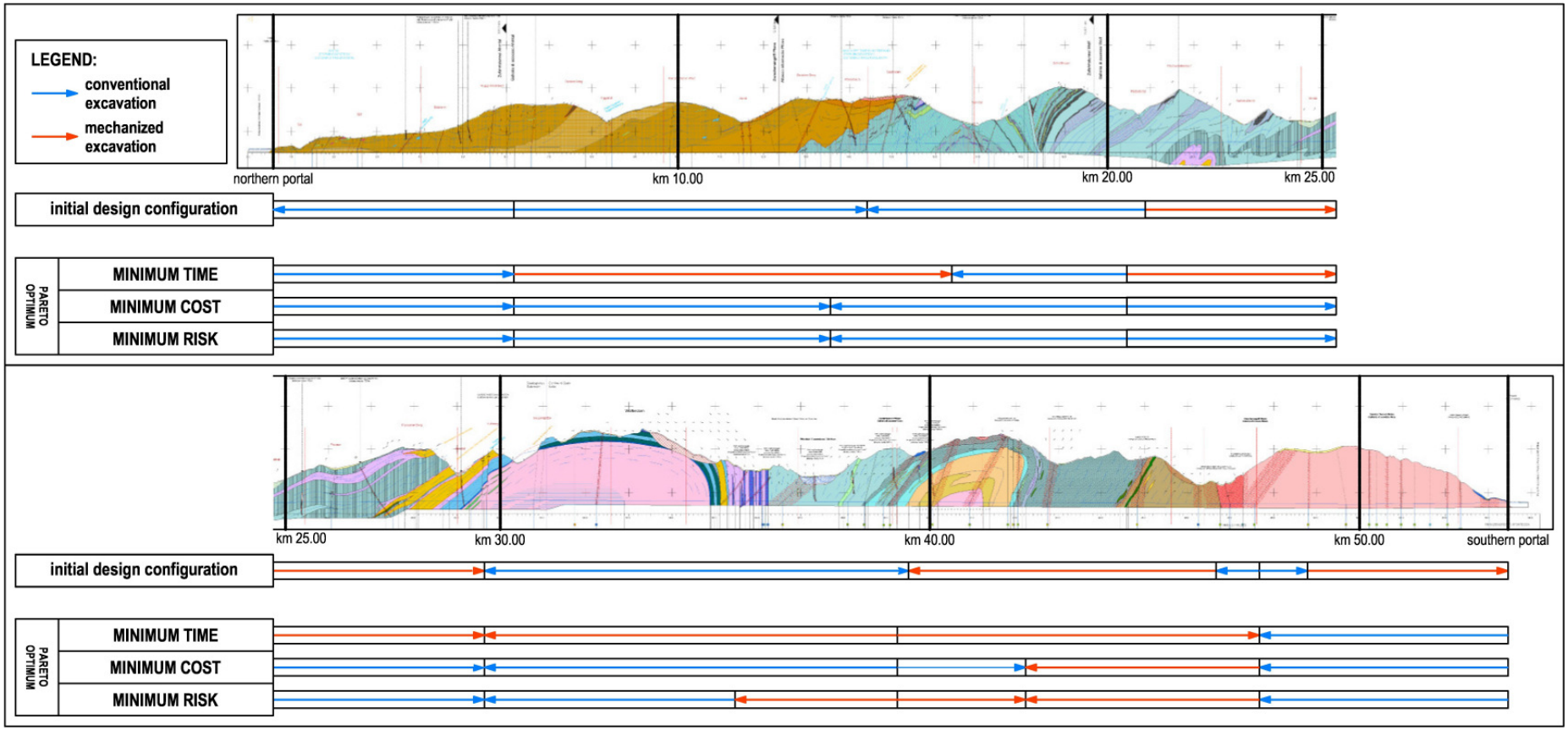
the BBT design optimization: initial design configuration



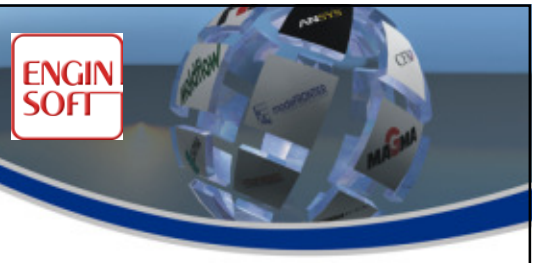
the BBT design optimization: results



the BBT design optimization: results explanation



the BBT design optimization: conclusions



- the optimization process led to:
  - analysis of a group of trade-off optimal solutions

    the methodology proposed is also a decision support tool
  - reduction of costs: ~ 7% (*)
  - reduction of time: ~ 700 days (*)
  - reduction of risk: ~ 10% (*)

(*) reductions evaluated comparing the initial design configuration with the minimum (respectively) cost, time, risk solutions