Key Aspects of Long Railroad Tunnels

(e.g. Semmering Base Tunnel alignment selection process)

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Key Aspects of Long Railroad Tunnels

- Appropriate Alignment selection process
- Geological investigation and ground modelling
- Definition of maximum longitudinal gradient
- Definition of minimum horizontal radius
- Design speed selection/aerodynamic design
- Tunnel system selection (passenger trains only or mixed traffic, maintenance concept for railroad line)
- Tunnel Safety Infrastructure according to Internat. Standards
- Tunnel construction method(s) selection
- Construction contract selection/ fair risk share
- Construction budget availability
- Realistic construction time scenario
GHEGA-LINE (UNESCO WORLD HERITAGE)

- built from 1848 - 1854 by Carl Ritter von Ghega
- 41.8 km length from Gloggnitz to Mürzzuschlag (linear distance: 21 km)
- more than 20,000 workers
- 15 tunnels (total length 5,420 m) and 16 viaducts
- max. gradient 28 ‰ (25 km > 20 ‰)
- original speed 6 km/h, today max. speed 70 km/h
- 2 lokomotives for heavy cargo trains
DESIGN PARAMETER FOR BASE TUNNEL new

- maximum gradient 0.85 %
- minimum horizontal radius 3,000 m
- design speed 230 km/h
- 2 parallel single-track tubes
- emergency stop in the middle of the tunnel
- minimum inner clearance of 41 m²
- cross passages every 500 m
- „short construction time“ and „high flexibility in construction“
  → intermediate construction accesses, use of TBM
PLANNING PROCESS

1st Step: Development of Corridors
- Development of alignment alternatives
- Consideration of recommendations from „outside groups“

2nd Step: Alignment Selection
- Definition of criteria and weighting
- Evaluation of alignment alternatives
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3rd Step: Preliminary Design for Selected Alignment
- Design of tunnel, shafts, adits, cross passages, portals and auxiliary structures
- Environmental impact assessment
- Application of statutory approval
PLANNING AREA

300 km²

MÜRZZUSCHLAG

LANGENWANG

GLOGGNITZ

Connection point Gloggnitz

Connection area Muerzzuschlag Langenwang

Investigation area
Planning area
Connection points
STUDIED CORRIDORS FOR SBTnew

Existing Ghega Railway Line

Preiner Gscheid

SBT "old"

Ochnerhöhe

Kleiner Otter

Pfaffensattel

Ziegenburg

Mürzzuschlag

Höningsberg

Pichlwang

Langenwang

Gloggnitz

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SURFACE GEOLOGICAL MAP
PLANNING PROCESS

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2nd Step: Alignment Selection

- **DESIGN TEAM**
  - Definition of Criteria
  - Technical Evaluation of Alignment Alternatives

- **CLIENT**
  - Presentation of Criteria

- **ADVISORY GROUP**
  - Weighting of Criteria

- Combination of Evaluation Results and Weighting Factors

**SELECTION OF ALIGNMENT**
CATALOGUE OF CRITERIA

TRANSPORT + TECHNOLOGY
- Railway technology - infrastructure
- Railway technology – regular operation
- Railway technology – operation under special conditions
- Ground conditions
- Use of excavation material
- Construction logistics

SPACE + ENVIRONMENT
- Transport infrastructure
- Development of settlements
- Settlement areas, emissions
- Landscape and tourism
- Ground water and mountain water, protection of drinking water
- Surface water
- Natural environment and ecology

COSTS + RISKS
- Costs
- Risks of implementation
## CATALOGUE OF CRITERIA

### Subject
- Transport + Technology

### Main criteria
- Railway technology - infrastructure
- Railway technology – regular operation
- Railway technology – operation under special conditions (e.g. emergency)
- Ground conditions
- Use of excavation material
- Construction logistics

### Sub-criteria
- Design parameters
- Adaptation of techn. infrastructure
- Tunnel equipment
- Operation
- Route capacity
- Energy consumption
- Travel times
- Impacts of maintenance activities
- Tunnel safety
- Tunnel ventilation (emergency)
- Operation during construction
- Tectonic faults
- Sections in loose rock
- Mountain water
- Accuracy of geolog. prediction
- Balance of construction material
- Use of muck material
- Construction period
- material supply and muck disposal
- Site installation areas
- Permanent use of construction accesses
Space + Environment

Subject

Main criteria

Transport infrastructure
Development of settlements
Settlement areas, pollution damage to settlements
Landscape and tourism
Ground/mountain water, drinking water protection
Surface water
Natural environment and ecology

Sub-criteria

Accessibility, portals
Economic development
Proximity to settlement areas
opportunities of local development
Cultural assets
Noise exposure to settlements
Vibration exposure to settlements
Landscape
Recreation
Touristic development
Amount of mountain water ingress
Impact on drinking water supply
Natural springs
Impact on surface runoffs
Accuracy of forcast
Surface water (floodwater)
Water ecology
Nature reserves
Cultural landscape
Biotopes and habitats preserving
Humid habitats
Wildlife ecology
Fishery
Subject: Costs + Risks

Main criterion:

Costs

Sub-criteria:
- Investment costs
- Maintenance costs
- Integration of previous investments
- Operational costs

Risks of implementation
<table>
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<th>Subject</th>
<th>Main criteria</th>
<th>Sub-criteria</th>
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<td>Site installation areas</td>
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<td>Permanent use of construction accesses</td>
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</table>
INNER LINING, INSTALLATION OF EQUIPMENT
SUB-CRITERIA: CONSTRUCTION PERIOD

MAIN PARAMETER:
- CONSTRUCTION TIME

![Construction Period Diagram]

- KO - HB
- KO - PW
- KO - LW
- KO - ZB
- KO - MZ
- OH - HB
- OH - PW
- OH - LW
- PG - HB
- PG - PW
- PG - LW
- PG - ZB
- PF - MZ

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RESULT OF CONSTRUCTION LOGISTICS

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<th>1.6 Construction logistics</th>
<th>KO-Hb</th>
<th>KO-Pw</th>
<th>KO-Lw</th>
<th>KO-Zb</th>
<th>KO-Mz</th>
<th>OH-Hb</th>
<th>OH-Pw</th>
<th>OH-Lw</th>
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<th>Score</th>
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<td>5</td>
<td>EXCELENT Corresponds completely to the project-goals</td>
</tr>
<tr>
<td>4</td>
<td>GOOD Corresponds to the project-goals in a high degree</td>
</tr>
<tr>
<td>3</td>
<td>AVERAGE Corresponds in the essential points to the project-goals</td>
</tr>
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<td>2</td>
<td>BELOW AVERAGE Fulfills substantial project-goals only insufficiently</td>
</tr>
<tr>
<td>1</td>
<td>BAD Does not fulfil substantial project goals</td>
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RISKS IN IMPLEMENTATION
SELECTED ROUTE „PFAFFENSATTEL“

SBT „old“
- 22.1 km
- 9.5 – 11.3 %

SBT „new“
- 27.5 km
- 8.5 %
PLANNING PROCESS

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CONSTRUCTION DETAIL NATM

- Shotcrete Lining
- Waterproofing System
- Inner Concrete Lining
- Cable Duct
- Sidew. Drainage
- Invert Slab

~ 9,0 m

~ 9,8 m
CONSTRUCTION DETAIL TBM

- Segmental Lining
- Tail Void
- Waterproofing System
- Inner Concrete Lining
- Cable Duct
- Sidew. Drainage
- Invert Slab

TUNNEL AXIS

~ 9.7 m

~ 9.7 m

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SITE INVESTIGATION

(1) GROUND INVESTIGATION FOR 4 PROPOSED CORRIDORS
- 75 core drillings (total length 10,900 m), max. depth of 350 m
- Documentation and monitoring of 3,700 springs, wells, creeks

(2) GROUND INVESTIGATION FOR SELECTED ALIGNMENT
- Additional 55 core drillings (total length 17,500 m), max. depth of 720 m
- Geophysical and geoelectrical investigation (totally 15 profiles)
- In-situ (borehole) testing (acoustic scan, sonic lock, vertical seismic profiling, insitu stress measurements by hydro frac)
- Laboratory testing
“SCHLAGL FAULT ZONE”
CONSTRUCTION CONCEPT

INNER LINING, INSTALLATION OF EQUIPMENT

PORTAL GLOGGNITZ  ACCESS GÖSTRITZ  ACCESS FRÖSCHNITZGRABEN  ACCESS GRAUTSCHEHOF  PORTAL MÜRZ-ZUSCHLAG

Bridge Schwarza  TBM  NATM  TBM  NATM  Emergency stop
Key Aspects of Long Railroad Tunnels, *what typically can go wrong with long railroad tunnels*

- **Construction cost estimates** are much too optimistic (maybe for political reasons) bringing the project in jeopardy
- **Geological investigation and ground modelling** are insufficient, too little time and budget (yielding troubles with ground conditions during construction and usually creates great time and cost overruns) Reasons maybe selection process for site investigation company (think about how you select your medical doctor or your lawyer)
- **Unsuitable construction methods** were chosen as to insufficient ground model, tunnel may be stopped to excavation difficulties
- **Construction contract** selection not optimal
- **Construction budget** not available in time
- Unrealistic construction time **assessments**
Melen Istanbul Water Supply Project • BC1 Marmaray Project • Bahce Nurdağı Tunnel • Gerede System Isikli Tunnel • Kargi Dam and HEP • Metro Market Istanbul Solar Cooling • Avali Dam • Bursa Metro • Dogancay HEP • Bandırma Gas Power Plant • Pembelik HEP • Yenikapi Turnback Tunnel • Polatli Tunnel • Ankara Metro Ulus Keciören • Ermenek HEP • Bursa Opel Environmental Audit • Konaktepe HEP and Dam • Esen II HEP • Cine RCC Dam • Bogazkoy GT Power Station • Bolu Tunnel after Düşce Quake • Niksar and Akincı HEPS • Erdemir Power Station • Obruk Baraj • Karacasu Dam • Mursal HEP

More than 25 design and/or consultancy contracts since the year 2000
Project management, project control, project organisation and controlling, construction contracts and award of contracts, cost management and scheduling, "Turn Key Engineering" and "Total Project Management", BOT (Build-Operate-Transfer) and PPP (Public-Private-Partnership), Due Diligence, feasibility studies, services as experts and consultants and construction logistics.
Office Building Zagreb Tower, Croatia
Building Physics Design Europlaza – Construction Phase 4, Austria
Raiffeisen Centrum Prague, Czech Republic
Iride Business Park, Romania
New IMBA-GMI Science Laboratory Building, Vienna, Austria
Millennium Tower III, Slovakia
Serious Crimes Court, General Contractor, Tirana, Albania

Design of buildings and industrial structures, site supervision, structural design of buildings and supporting structures, concrete buildings, steel constructions, composite constructions and timber constructions, building physics, general contractor and construction management, expert statements in the fields of building construction, Due Diligence
Design (preliminary design, concept, tender design, detailed design), site supervision, building services engineering, including heating, air-conditioning, ventilation, sanitary equipment, electrical engineering (low voltage and high voltage current), special facilities (safety engineering, measuring and control technology, data line), building construction and industrial construction, transport facilities, municipal utilities

**MECHANICAL & ELECTRICAL ENGINEERING**

Palais Mollard, Rehabilitation, Vienna 1, Austria
Europe Business Centre, Belgrade, Serbia, Montenegro
Public Retirement and Nursing Home in Wallsee, Austria
HVB – Headquarters, Hungary
Monastery of Klosterneuburg, Austria
MIA Malta International Airport, Malta
Kaiserin Elisabeth Hospital, Austria

Ankara, March 28th, 2012  Dr. Johannes Kleberger IC consultant
Lainzer Tunnel, Austria
Wienerwald Tunnel, Austria
U2 Underground Vienna, U2/5 Section, Interconnecting Track, Austria
Sentvid Tunnel, Slovenia
Cine Dam Project, Turkey
Egnatia Odos Motorway, Greece

Investigation, design, project management and supervision for underground projects.

Geological, hydro-geological and geophysical investigations;
geotechnical and structural design of tunnels, caverns and shafts using
conventional (NATM) or mechanical (TBM) tunnelling methods;
environmental impact studies, risk analyses, geotechnical measurements;
studies und design of measures for air quality, noise and vibration protection
Biomass plants, district heating networks, solar energy, geothermal energy, co-generation, biofuels, alternative cooling systems, small hydropower plants.

Immission protection: noise, vibrations, air pollutants, electromagnetic fields, public approval, environmental impact assessment, services during construction, commissioning, commercial enterprises, industrial plants, shopping centres, road, rail.

Extensive measuring equipment: remote controlled immission monitoring, air quality measurement container, VibroScan®, acoustic camera etc.
Studies, consulting, planning, project management and site supervision for water supply installations and sewage disposal; special services such as leakage analyses, water loss evaluation, water management concepts; waste analyses, planning of waste management facilities.

Development of waste management concepts and development and optimisation of logistics of waste management systems.
Sustainable Transport Infrastructure and Intermodal Transport Concepts for Northern Central Europe
IMONET - Intermodal Cargo Transport Node Network - Central Europe
Optimisation of Local Traffic Westbahn, Austria
Qaf Thane – Pogradec Road, Conceptual Design, Albania
Development of Design Standards for Road Construction, Kosovo

Transport concepts, feasibility studies and master plans for public transport and individual traffic, investment assessment, cost calculation and controlling for transport projects, regional development, site analysis and optimisation, transport telematics, airports, road and railways.
GO Tolling System for Bus and Truck, Austria

Science Centre Vienna – Network Consulting, Austria

Business and Economic Software Efficiency Analysis Based on Linking Sales Data and In-house Costs

Consulting, system analysis, concept development, network infrastructure, licensing, (structured) cabling, project planning and management, controlling, quality management;
IT security, firewalls, virus protection, VPN solutions, security audit, maintenance, training, tailor-made software solutions.

Ankara, March 28th, 2012 Dr. Johannes Kleberger iC consulten
iC group of companies

iC consulnten, Vienna, Austria

iC consulnten, Salzburg branch office, Austria

iC consulnten, Lower Austria branch office, Austria

iC consulnten, Athens office, Greece

iC consulnten, Sofia office, Bulgaria

Elea iC, Ljubljana, Slovenia

iC projekt d.o.o., Sarajevo, Bosnia-Herzegovina

iC projecte, Vienna, Austria
LOB iC, Vienna, Austria

iC clean energy solutions GesmbH, Vienna, Austria

iC consulenten, Bratislava, Slovakia

iC consulenten, Bucharest, Romania

iC artprojekt, Zagreb, Croatia

iC consulenten, Belgrade, Serbia

iC consulenten, Tirana, Albania

iC consulenten, Priština, Kosovo

iC consulenten, Kiev project office, Ukraine