

ITA Cosuf, Rome, 22.06.2012

Tunnel Renewal + Safety @ SBB

Jan Dirk Chabot
SBB Bern, I-AT-IU-TEC
Roma, 22.06.2012



Tunnel Renewal + Safety @ SBB

Content

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- Number + age of tunnels SBB
- Damages / impacts
- Tunnel safety
- Renewal cases and methods

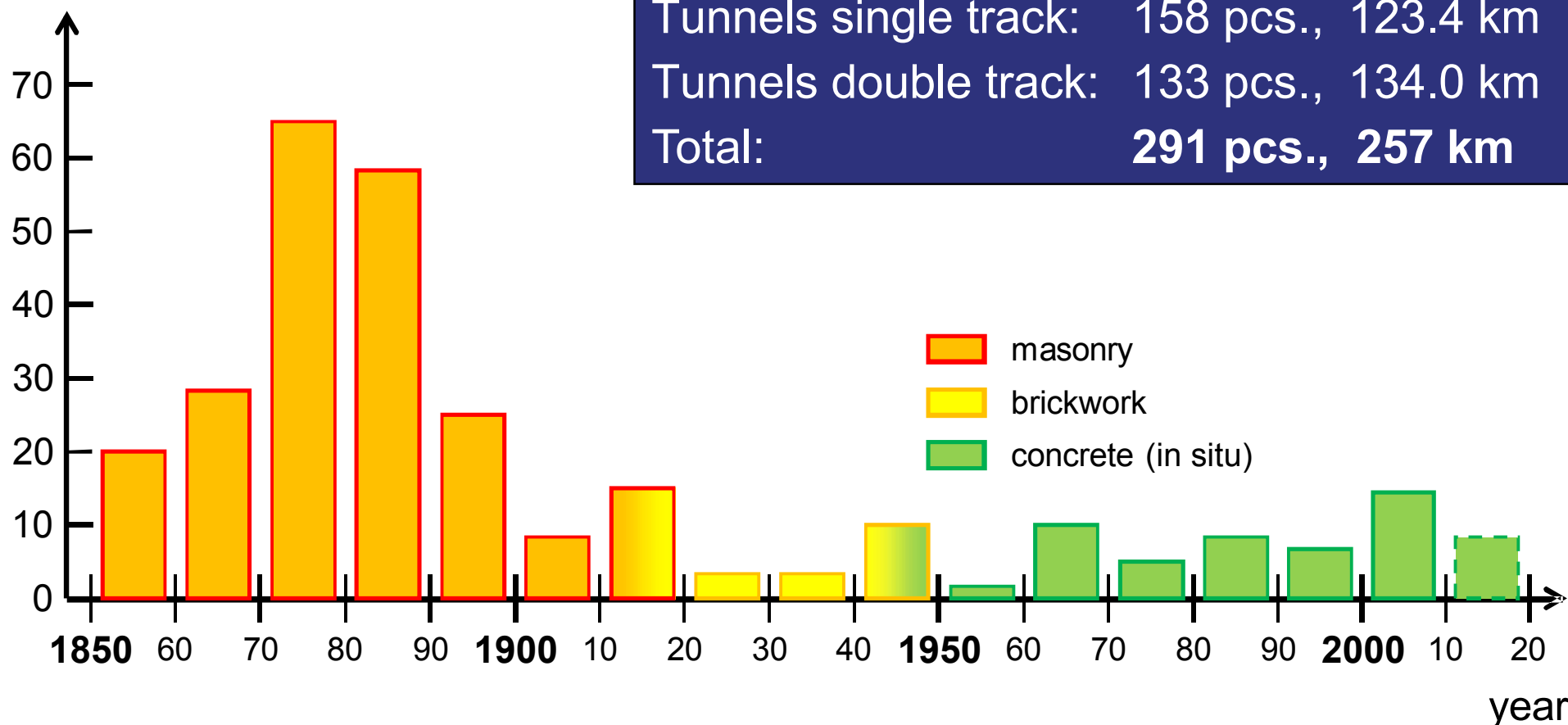
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Quantity + age of tunnels SBB

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Number + age of single + double track tunnels on SBB network

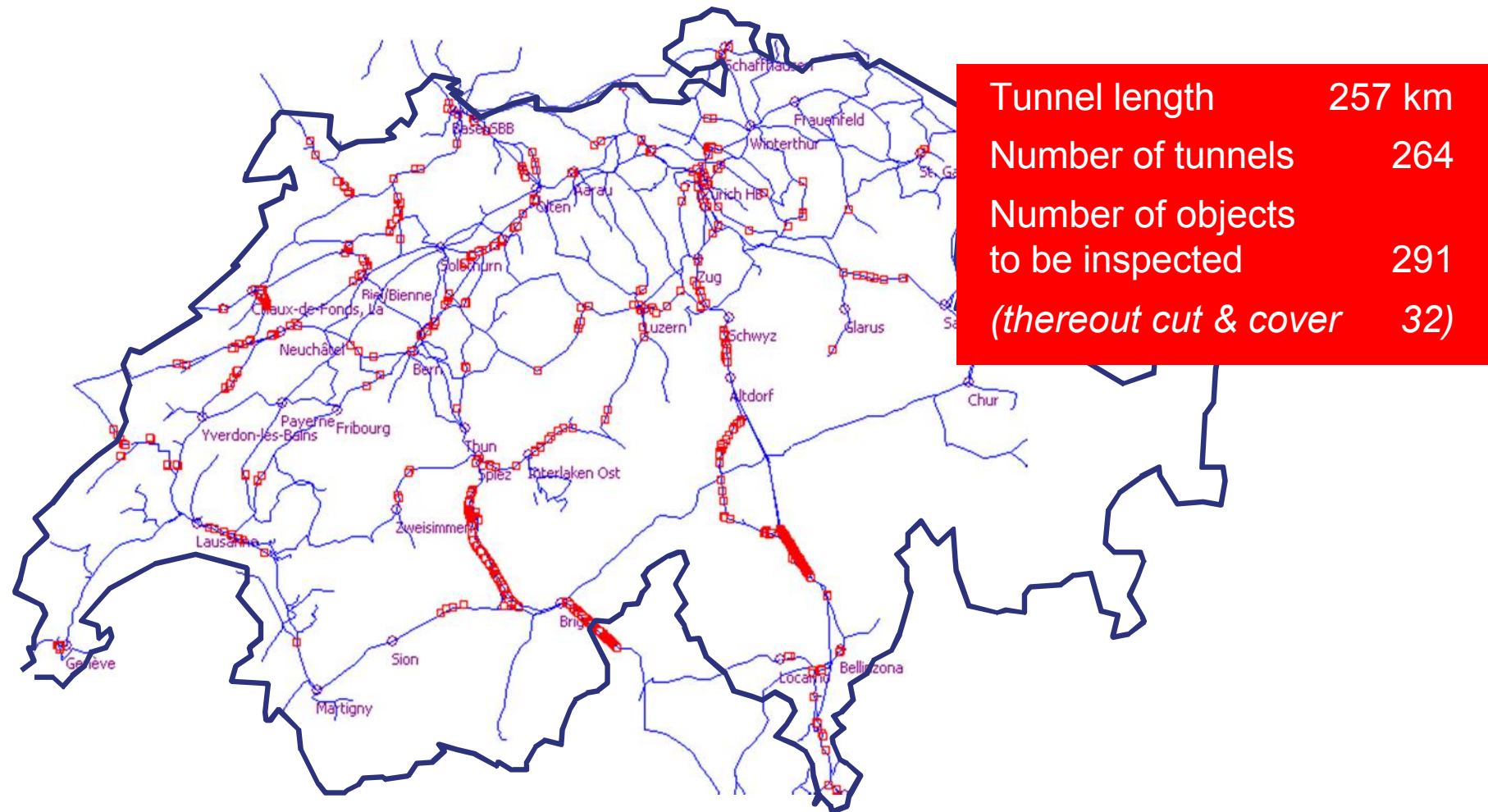
Number of
tunnels SBB



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Tunnels SBB today

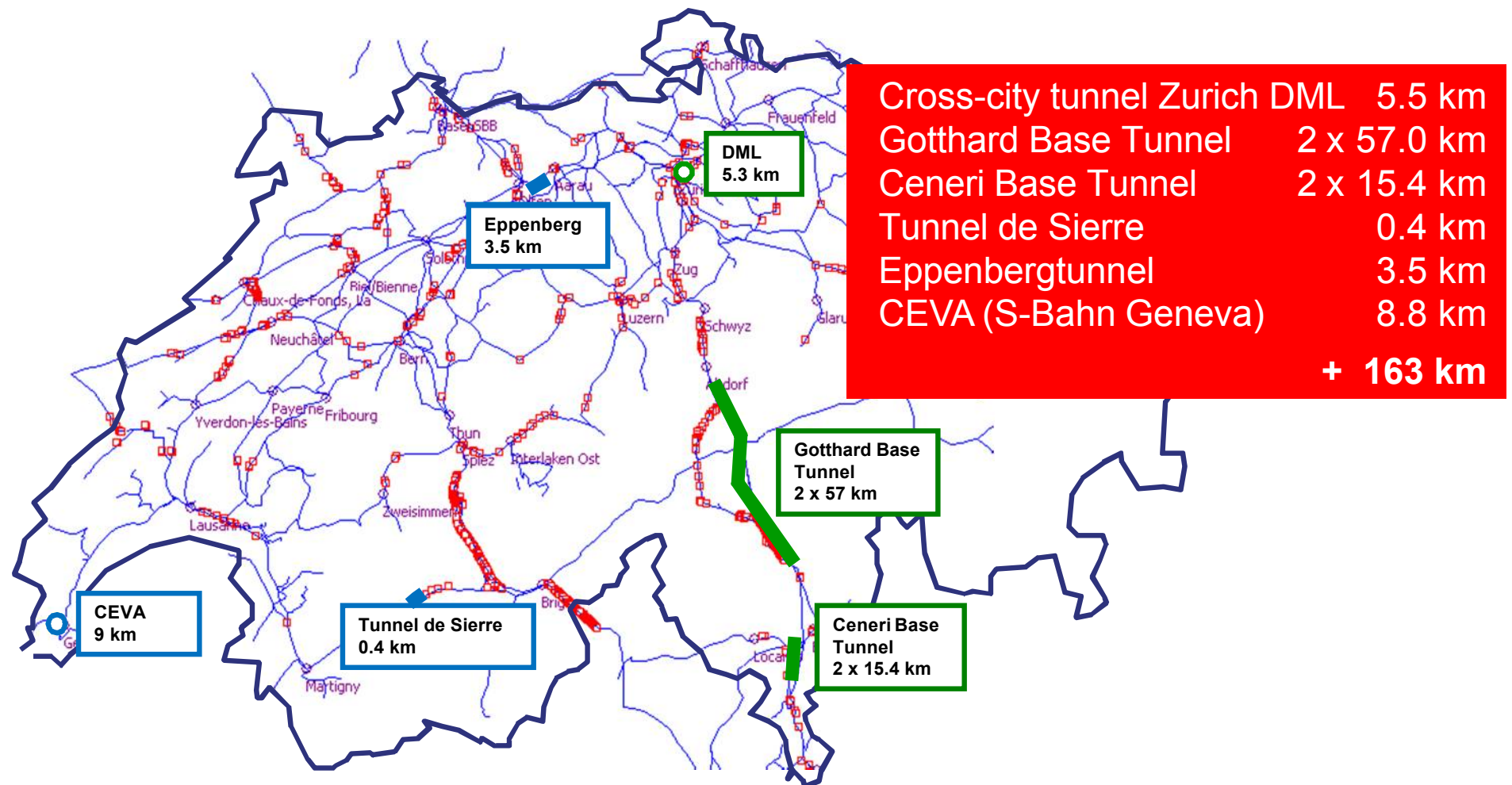
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Tunnels SBB tomorrow (-2019)

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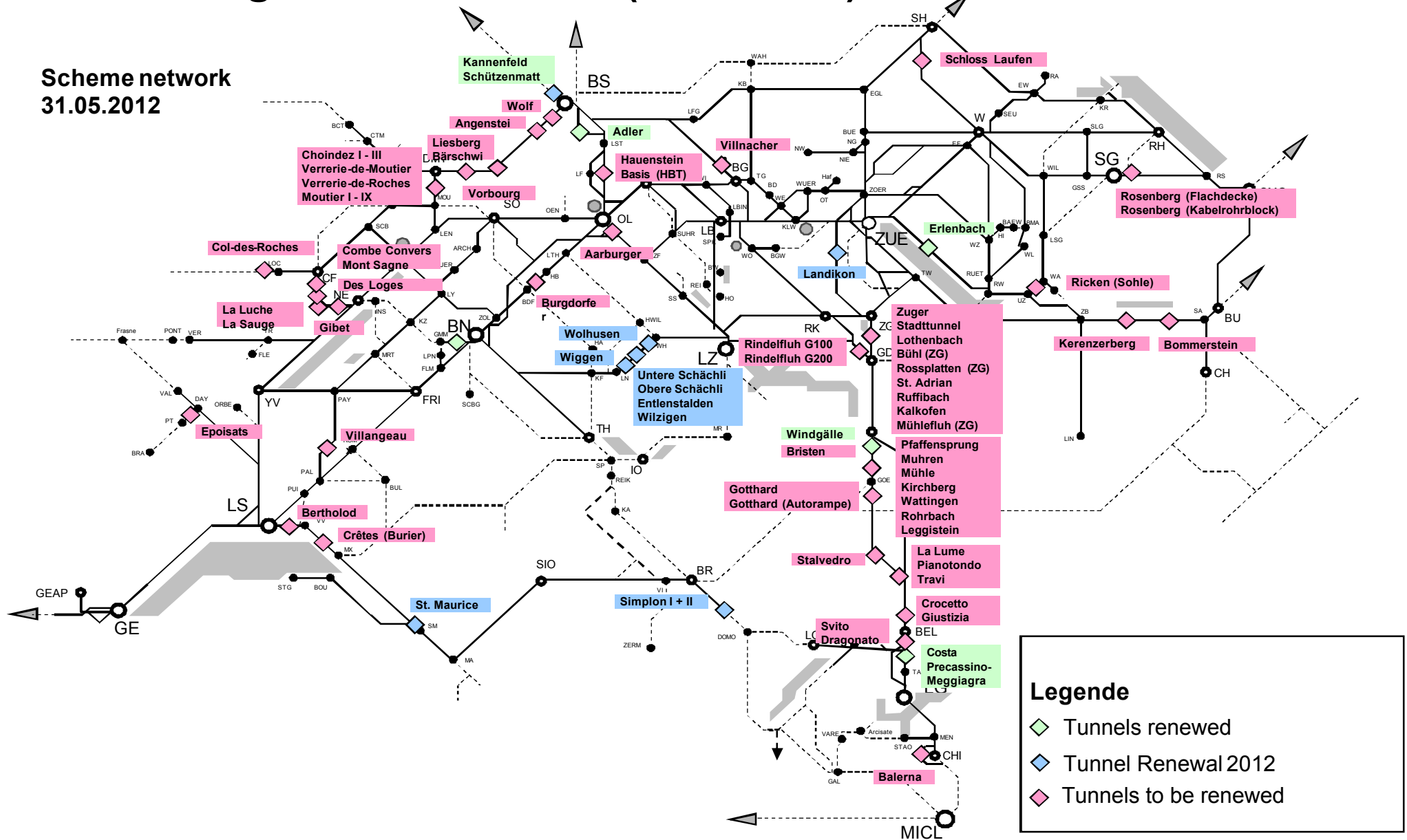


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Clustering Tunnel Renewal (2010-2019)

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Scheme network
31.05.2012



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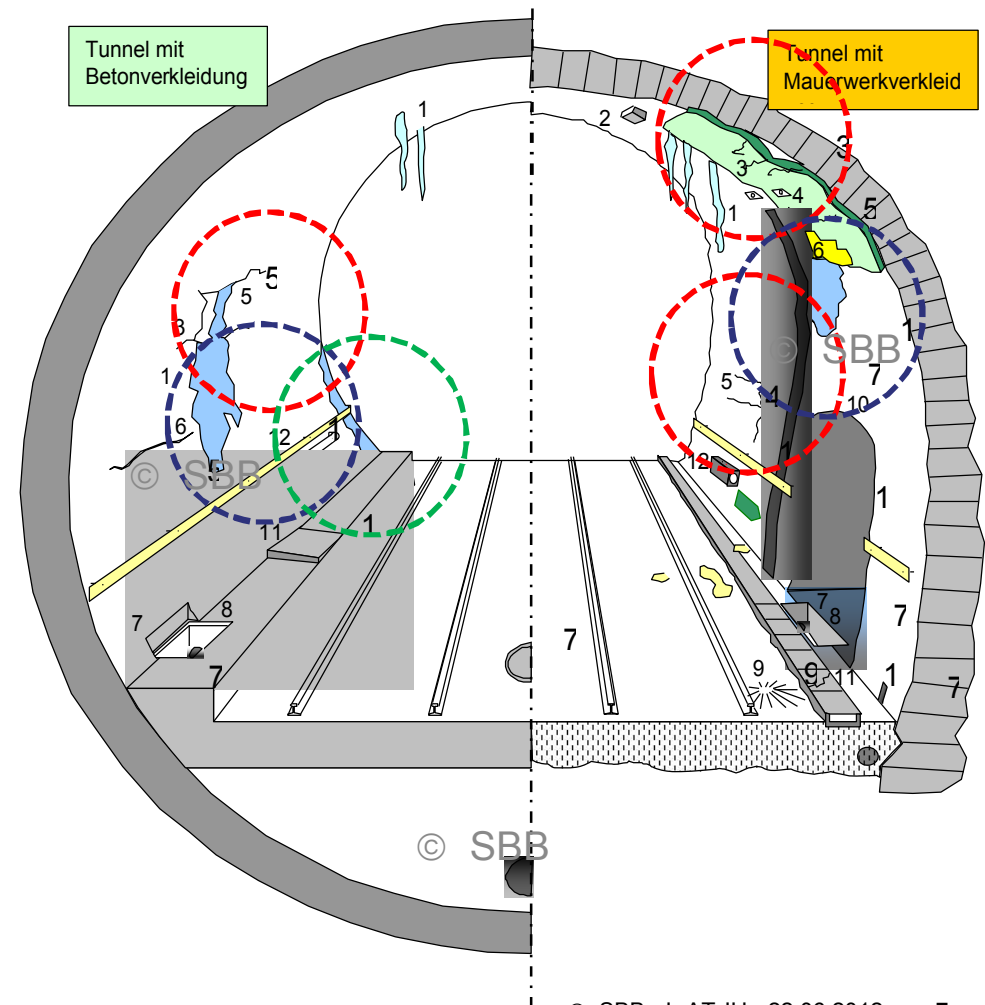
typical damages / refurbishment works

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→ After approx. > 40-60 years of use 1st refurbishment / Renewal
resp. next refurbishment of an earlier refurbishment.

→ Causes / origin:

- **Enlarging tunnel profiles**
(e.g. Optimizing profile in tunnel,
higher / wider trains)
- **Damages masonry / lining**
(contact with groundwater / frost)
- **Water ingress** (dripping / ice
formation) / defective drainage
- **Retrofit Safety elements**
escape way, tunnel lighting,
signalization



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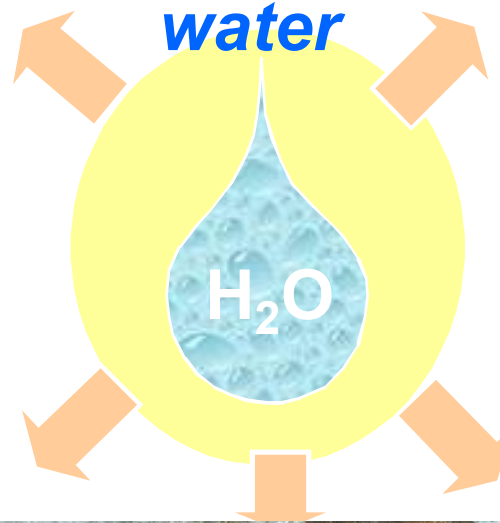
Impact: Water

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Lime deposits

(Re-) Actions of water



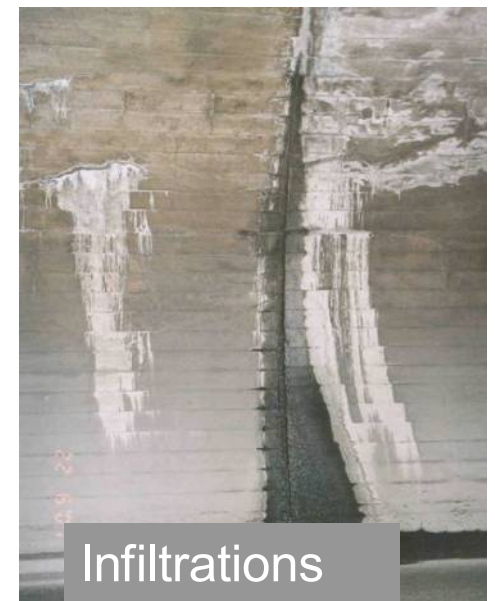
Swelling



Concrete-«corrosion» /
(Weathering)



Corrosion of steel +
technique



Infiltrations

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Impact: Water

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Example of damages:

- water ingress, leakage, damages of lining,
- repair of joints



→ **Ecological electricity??**

Pic. Marti Renesco AG

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Impact: Water

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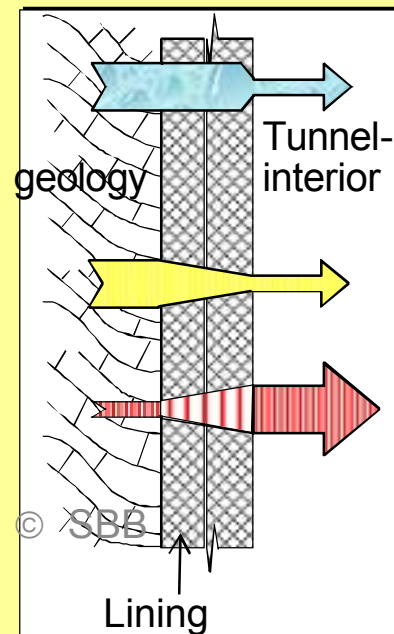
Weathering of tunnel lining due influence of mountain- / groundwater
(**evaporation-induced salt-enrichment** in mortar / concrete)

+ Humidity-contact for decades + Δ Temperature

+ influence of surrounding geology



Accumulation of harmful salts in the concrete or mortar due a „stream“ of humidity for decades trough the lining or invert.



- **Amount of ground water evaporation**
- **Concentration of salts in groundwater**
Partially detention in the lining
- **Concentration salts in lining**
accumulation of salts until / destruction of cement (crystallization and / or Ettringite / Thaumasite).

Esp. where change dry / wet

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Typical damages & Problems: Water

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Most tunnels have a **drained concept** → drainage system,

No water pressure behind lining / under vault – **permanent function!**



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Fire prevention

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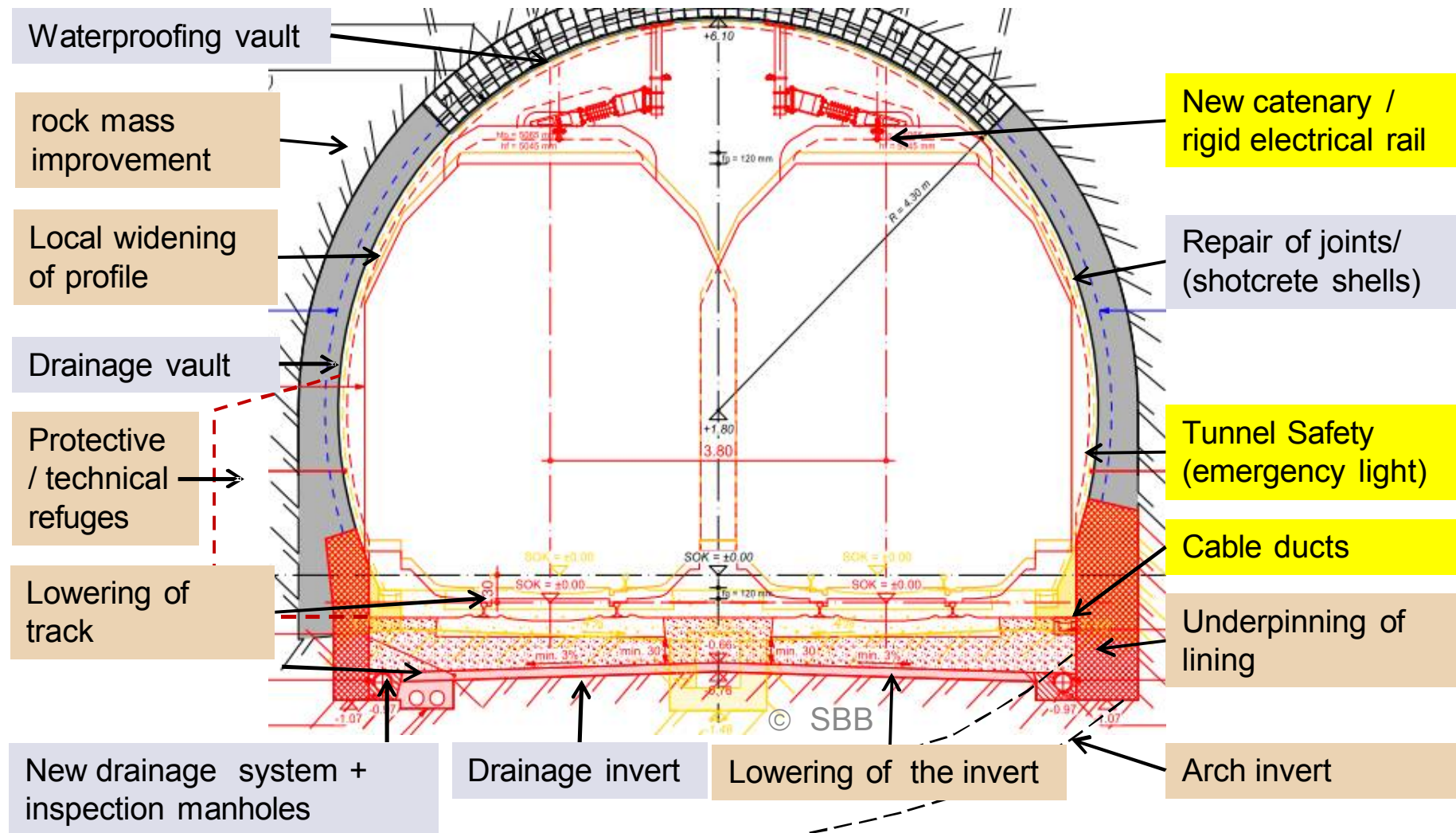


Minimising impact in case of fire due to waste / paper in cable-ducts / electrical boxes for rail technique: → protection with **barriers** / **cover panels** of the cable ascents

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Typical renewal + upgrading works

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Improving tunnel Safety

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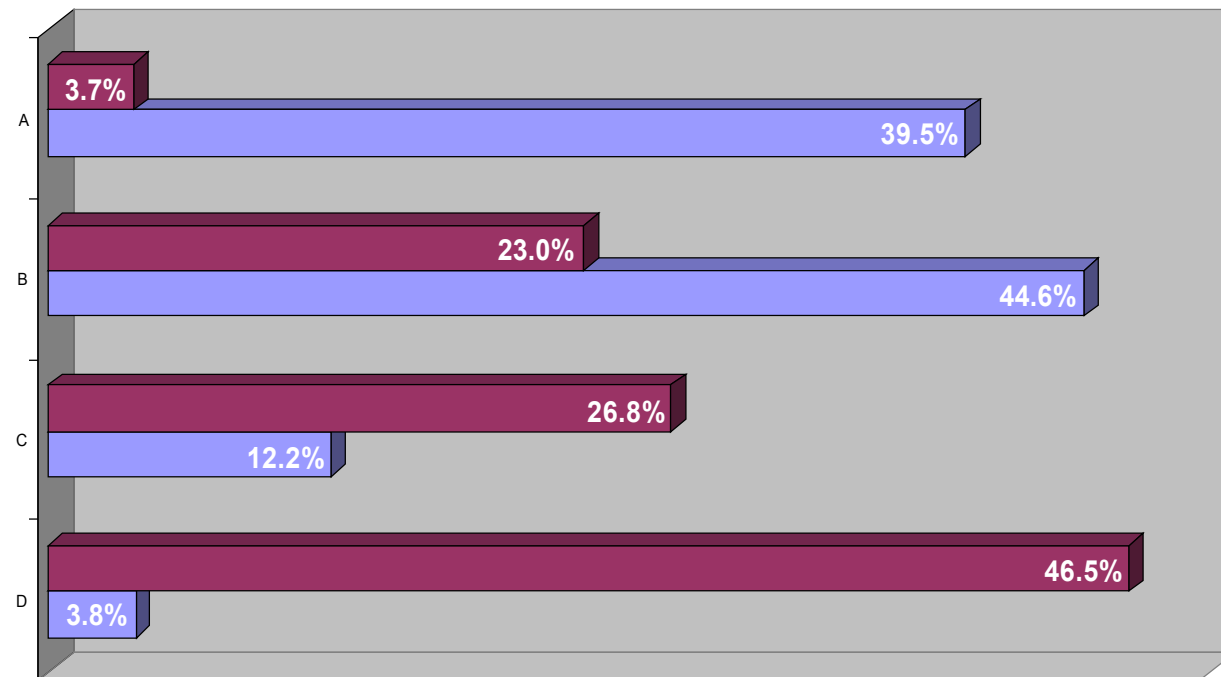
Risk categories in tunnels:

A (< 100 m)

B (< 1'000 m)


C (> 1'000 m)

D (> 3'000 m)



Risk analysis:

- ➔ Length of tunnel
- ➔ + **Frequency** of trains

 Number of tunnels

 Length of tunnels

Legend

- ◆ Tunnels with self-rescue measures SRM
- ◆ Tunnels to be equipped with SRM (GBT: 2016, CBT 2018)
- ◆ Renewal existing illumination
- ◆ Mont d'Or (under responsibility SNCF)

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Upgrading Tunnel Safety

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Self rescue measures in 62 new or existing tunnels (150 from 252 km) (*Simplon: +2x 20 km*)



Retrofit / improvement tunnel Safety

Elements:

- Tunnel lightning incl. Alarming
- Walkway and handrail
- Signalization (escape signs)
- Improvement visibility of *existing* cross-passages / escape possibilities.



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Example Zimmerberg Base Tunnel

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rescue shaft

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Example of one rescue shaft at the Zimmerberg Base Tunnel near Zurich

- $H = 60 \text{ m}$
- Stairs + “Alimak”-elevator for fire service + rescue teams
- Enough «buffer space» for passengers
- Overpressure ventilation to prevent a «chimney effect»

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Upgrading Tunnel Safety

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Zimmerberg Base Tunnel (9.5 km)

- Improving Tunnel lightning
- better visibility of emergency exits



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Simplon Tunnel - History

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Example Simplon Tunnel

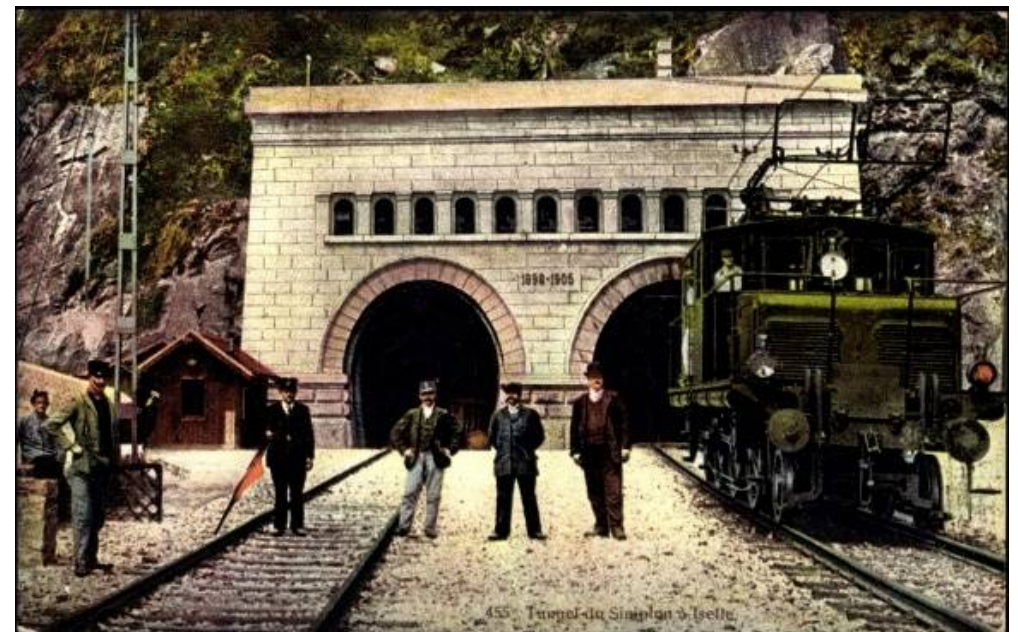
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Simplon Tunnel - History

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Key-data I / History:

- 2 parallel tubes, each 19.8 km long. Cross-over in the middle of the tunnel
- 1906 Inauguration of the 1st tube incl. cross-over, 2. tube 1922
- From beginning on with electrical traction 3-Phase DC 3kV, later change to 1-Phase AC 15kV 16.7 Hz

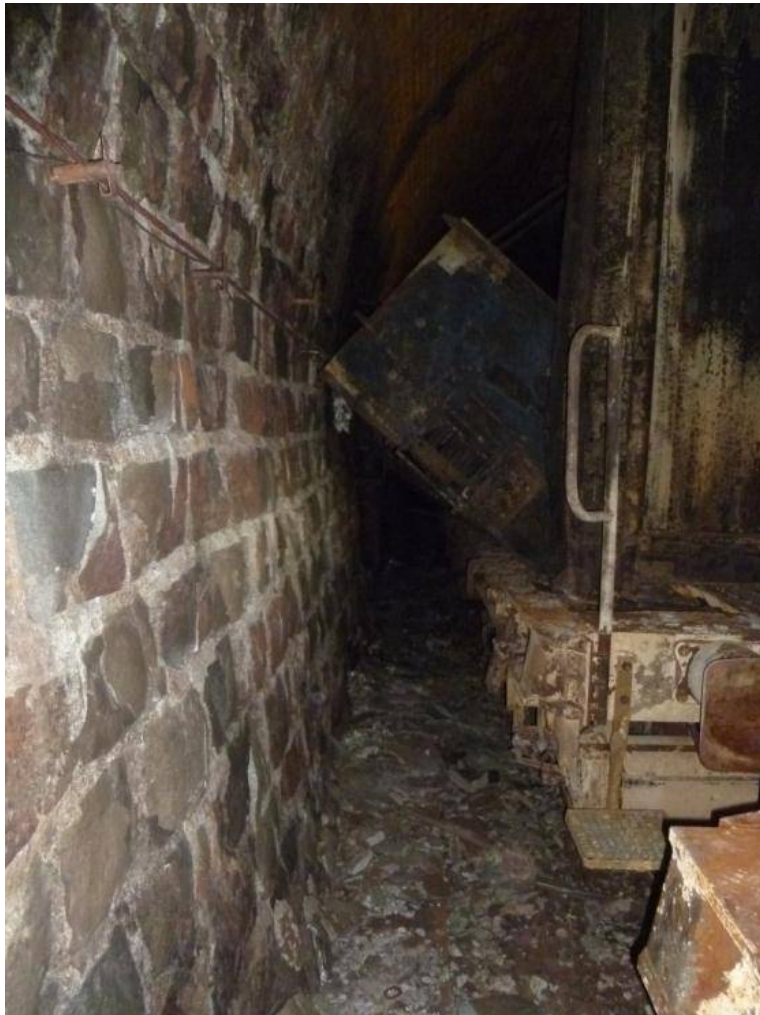


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Simplon Tunnel – fire June 9, 2011

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Fire of freight train in south tube II, between km 15.3 and 16.0:



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Simplon Tunnel – fire June 9, 2011

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Fire in south tube II, between km 15.3 and 16.0:

Fire on freight train, due shortage of electrical power



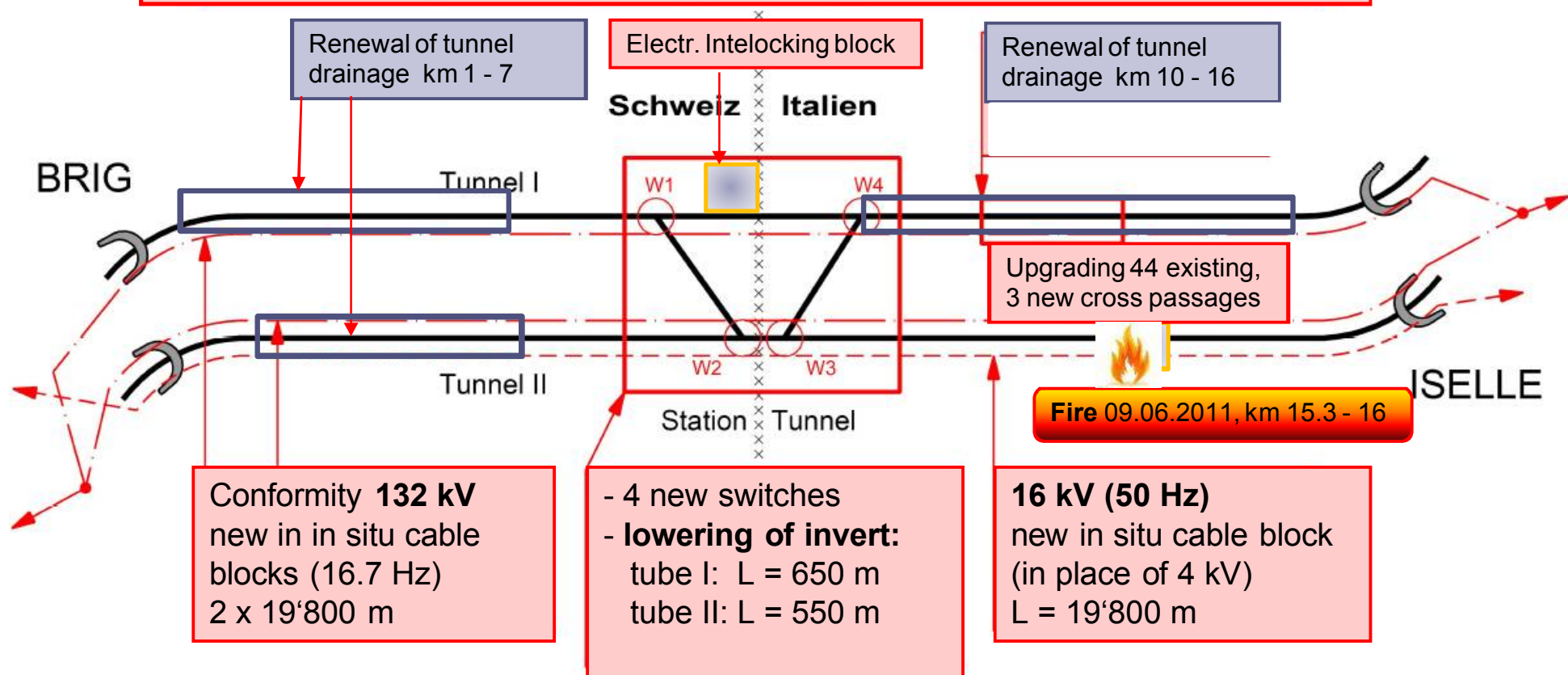
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Simplon Tunnel – upgrading Safety

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- **Self rescue measurements:** (lightning + power supply, signalisation walkway + handrail),
- upgrading existing **cross-passages** between tubes I + II,
- Further: **new switches, lowering of track, drainage, 132 KV + 50 Hz-power supply**

Self-Rescue measurements SRM (walkway, illumination, Handrail, escape signs.
Transformation of 44 existing and 3 new cross-passages. 2 x 19'800 m



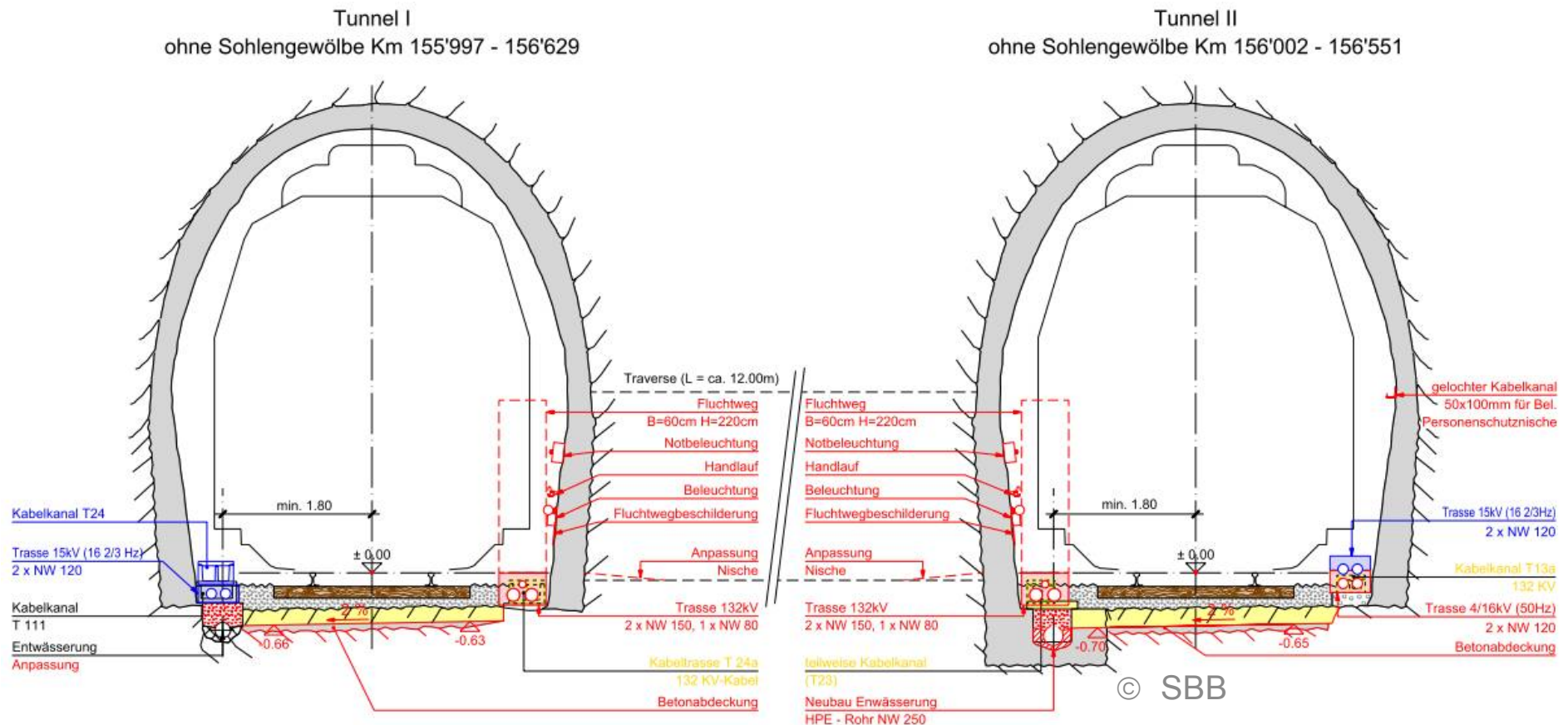
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Simplon Tunnel – renewal+upgrading safety

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Key data II:

- Distance between tunnel axis only 17 m!
- F_{Air} = approx. 24 m². v_{max} 140 km/h, High speed trains-Züge up to 160 km/h
- Existing cross passages every today 350 – 700 m. New **max. 500 m**



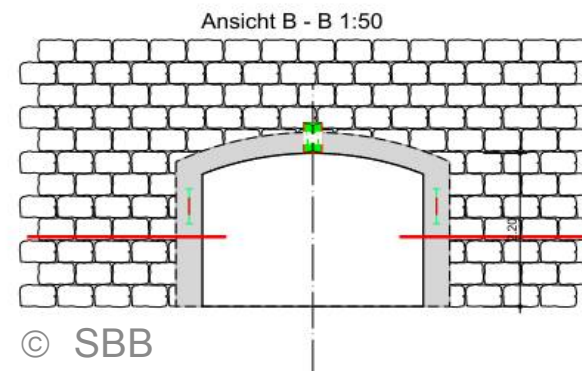
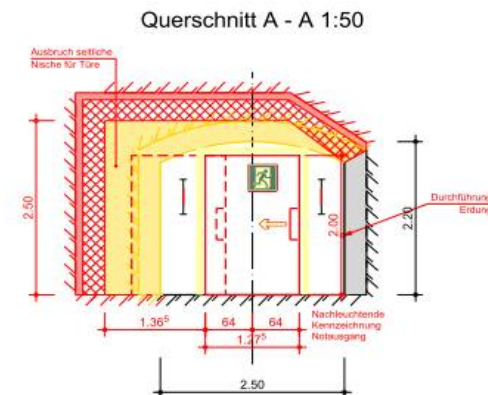
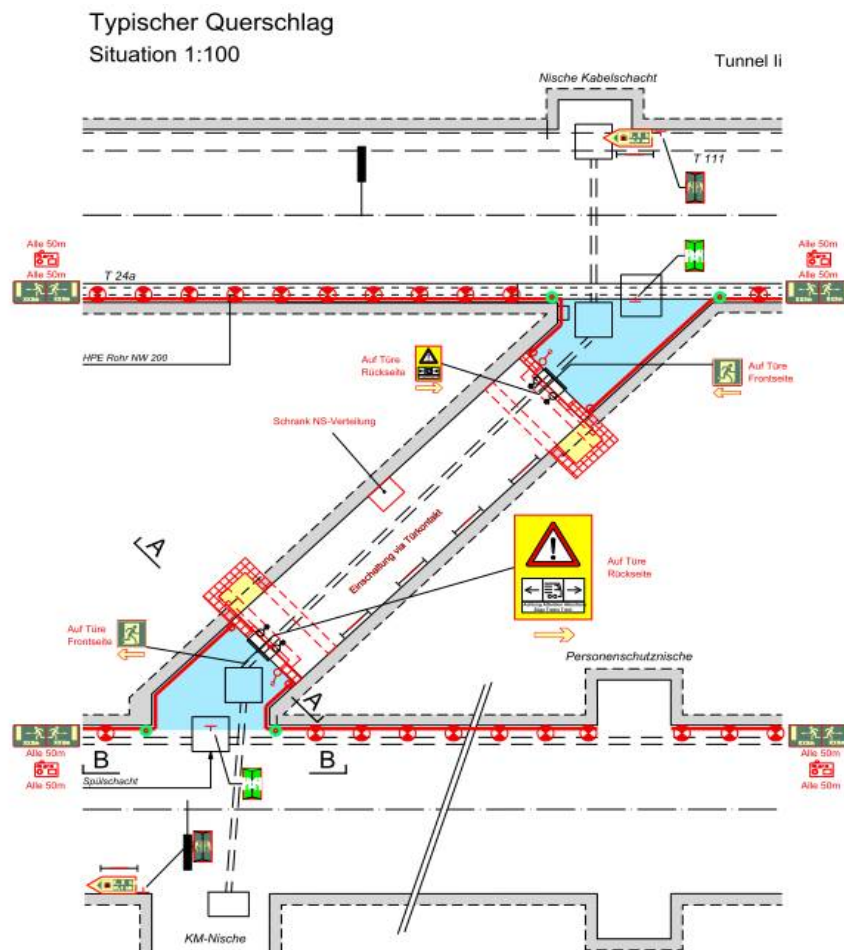
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Simplon Tunnel – renewal+upgrading Safety

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Typical situation cross-passages every Ø 500 m :

- Upgrading 44 existing, construction of 3 new cross passages
- New doors and illuminated escape-signalisation + illumination



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upgrading Tunnel Safety - Sempione

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→ Upgrading cross passages

- Signalisation:
 - Light 24 h
 - Green colour
- **Sliding doors**
- Fire resistance

→ Orientation plan



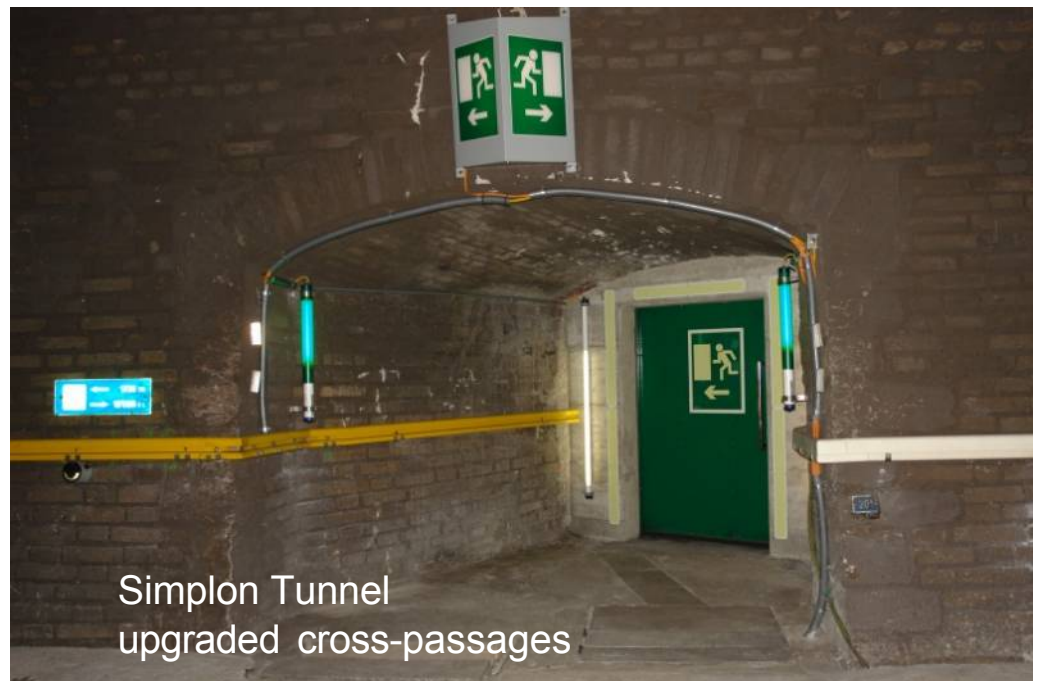
New tunnels:

- + *over pressure / ventilation*
- + *CCTV (video survey)*
- + *(Fire-water duct)*

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upgrading Tunnel Safety

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Tunnel Renewal + Safety @ SBB

Simplon Tunnel – renewal+upgrading Safety

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Before replacement of 40 km cable duct replacement of approx. 20 km drainage tubes with stronger, **high quality PP tubes** with larger \varnothing .
(150 cm² inlets /m')



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Tunnel Safety Gotthard Base Tunnel

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Example Gotthard Base Tunnel

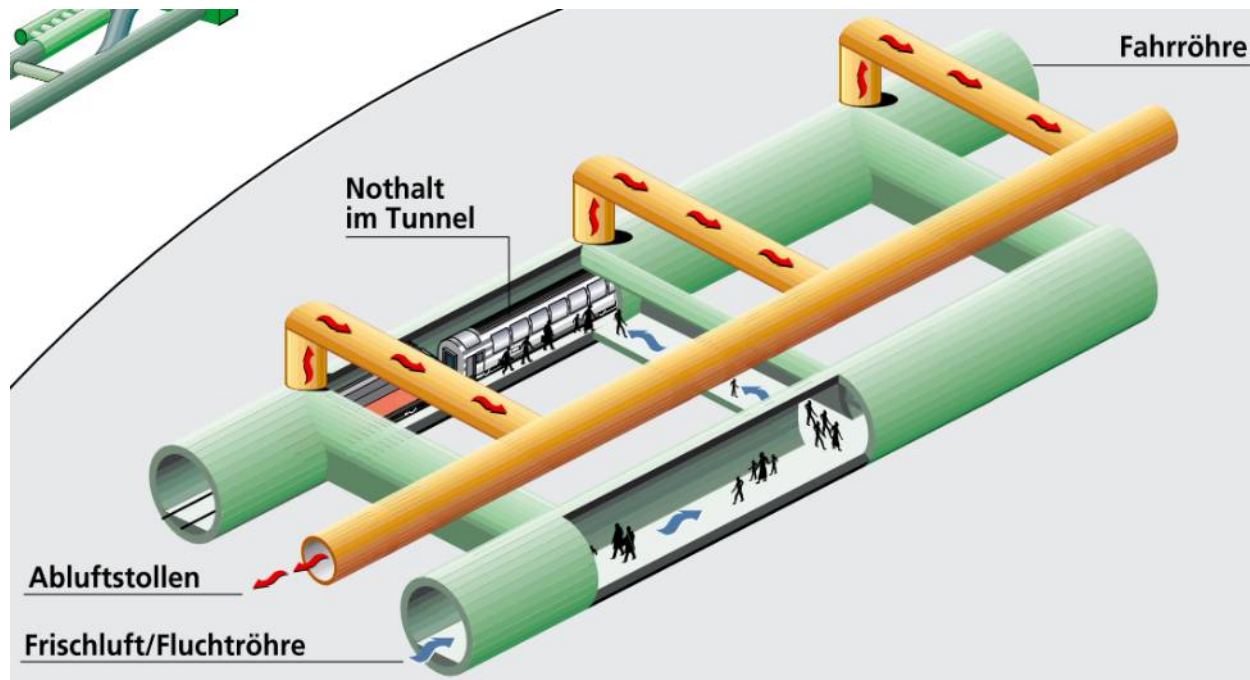
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Tunnel Safety Gotthard Base Tunnel

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Ventilation

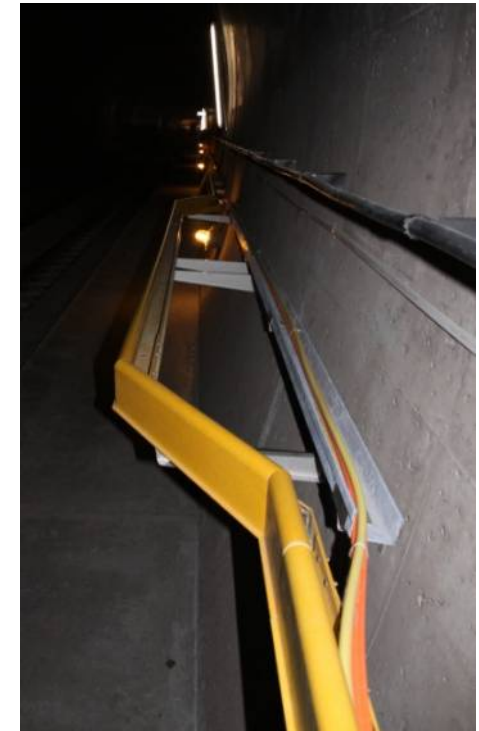
- in rescue station (MFS)
- in cross passages



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Tunnel Safety Gotthard Base Tunnel

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other safety installations / vehicles

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Other safety elements / installations @ SBB:

- Hot axle detectors
(usually approx. 2-3 km before main tunnel)
- Chemical detectors
- Offset load detectors
- Fire fighting train
«LRZ» 16 pcs,
all ETCS L2 compatible



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Conclusions

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- SBB tunnels are for >150 years safe constructions
- Tunnel Safety (self rescue) upgrading @SBB for approx. 18 years
- Safety improvements in longer tunnels according to TSI – SRT *technique and as simple as possible...*
- Tunnels must be maintained to ensure safe operation
- SBB-network with very high use 100 – **300 trains / track!**
--> **Access** + maintenance / Renewal under **heavy traffic** difficult
(closure of tracks / only in short work shifts)
- **Handling of groundwater** in tunnels **very important** for the lifetime (LCC) of tunnel structure + technical equipment
→ *Water must drain **permanent** without water-pressure under the invert or behind the lining !*

Final word

*Thank you for your
attention*



EXTRA



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Simplon Tunnel – 2012 – 2014, costs 160 Mio. CHF ITA-Cosuf Rome 22.06.2012



Cross-over:

Strong salt-formation on the lining surface due evaporation-enrichment.

Water can be aggressive for any metallic component

Tunnel Renewal + Safety @ SBB Tunnels du Mormont



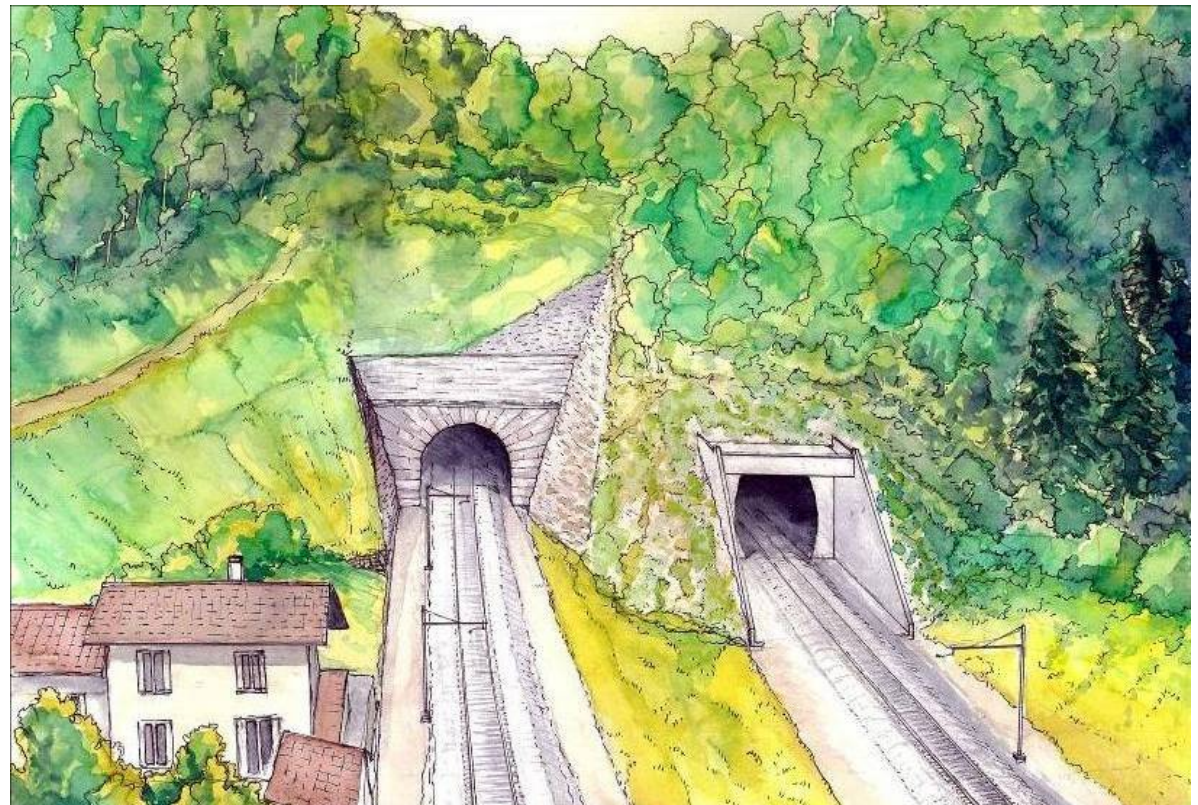
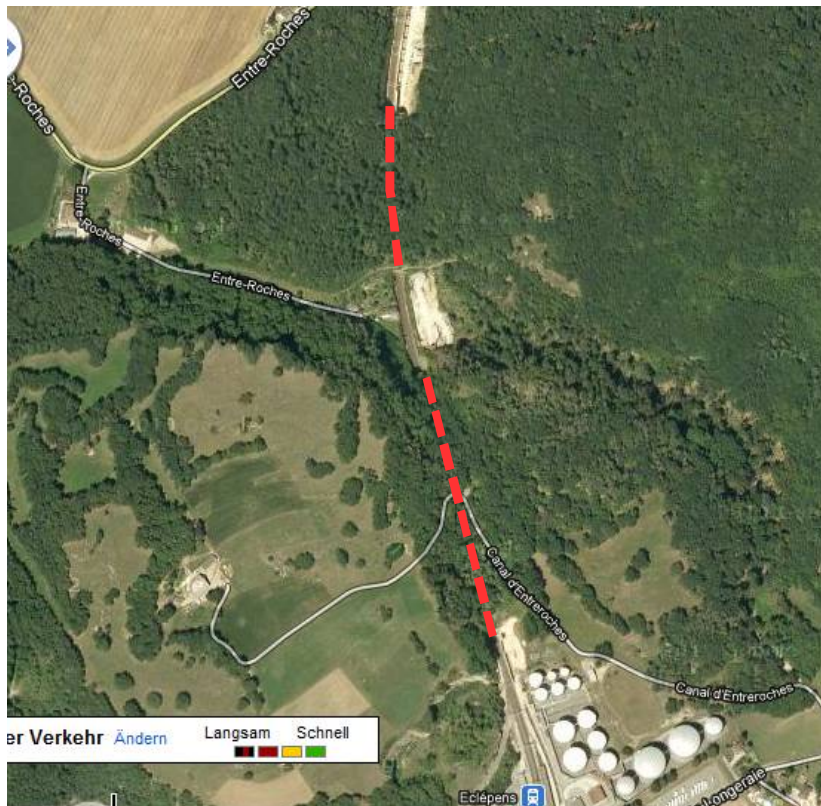
Example Tunnels du Mormont

Tunnel Renewal + Safety @ SBB

Tunnels du Mormont

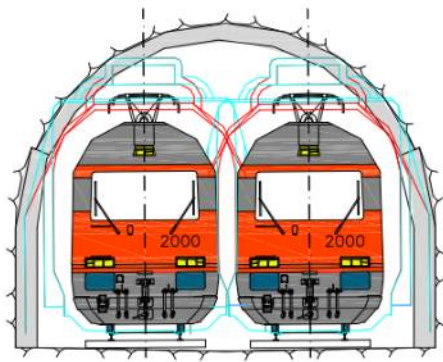
- 1855** Inauguration 2 Tunnels, L = 183 and 301 m,
Line between Lausanne – Yverdon)
- 1925** Electrification 15 kV 16.7 Hz, (incl. 1st lowering of the vault)
- 2008-10** Construction of the parallel tube, transformation existing 2-track tube into a 1-track tunnel.

Approx. 250 trains / day + freight traffic to oil refinery + cement factory.



Tunnel Renewal + Safety @ SBB Tunnels du Mormont

Construction phases and track closures for renewing of the old tunnel

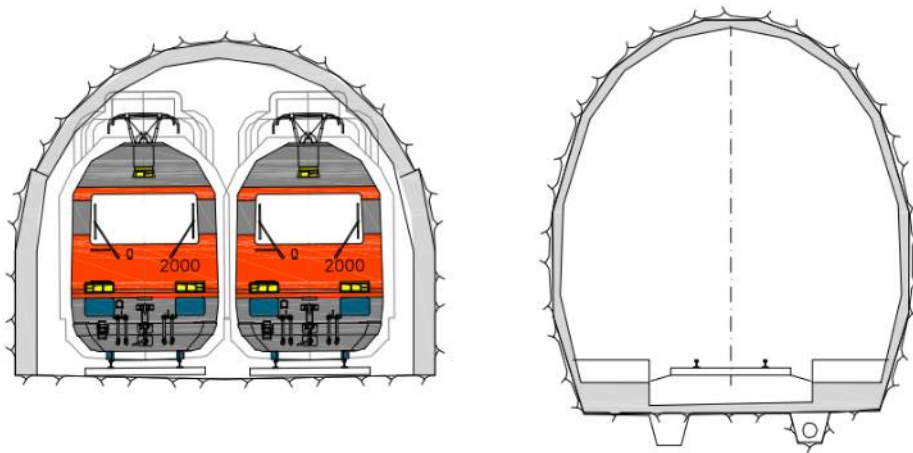


Original state



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Construction phases and track closures for renewing of the old tunnel

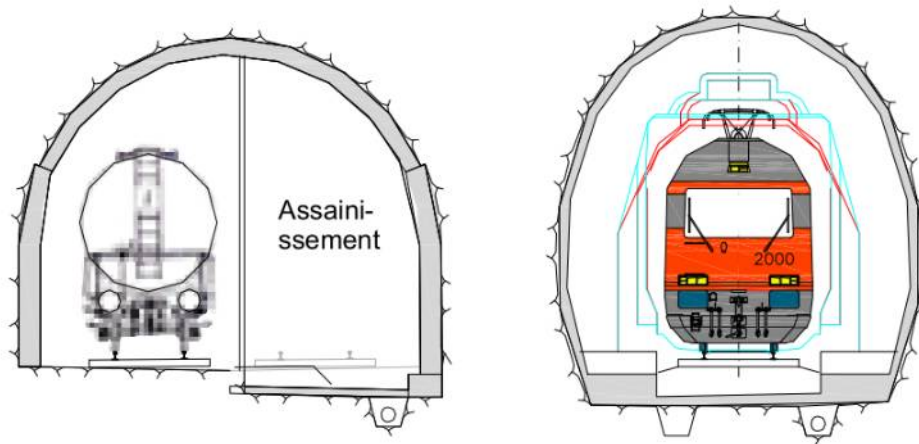


Construction parallel tube



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Construction phases and track closures for renewing of the old tunnel

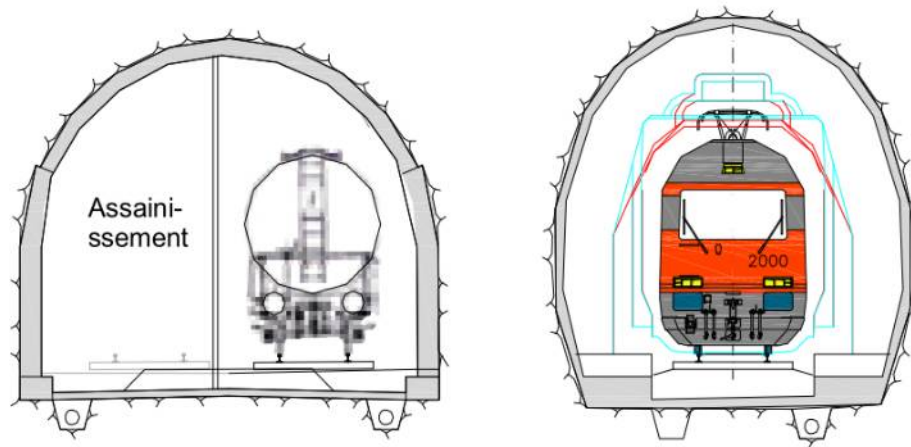


Track change, transformation first
half in existing tunnel
(*freight traffic to local plant ensured*)



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Construction phases and track closures for renewing of the old tunnel

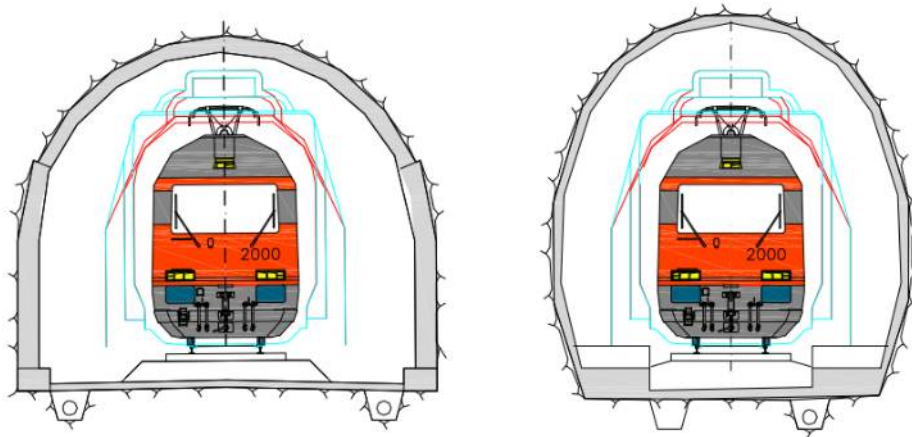


transformation second helft in
existing tunnel
(*freight traffic to local plant ensured*)



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Construction phases and track closures for renewing of the old tunnel

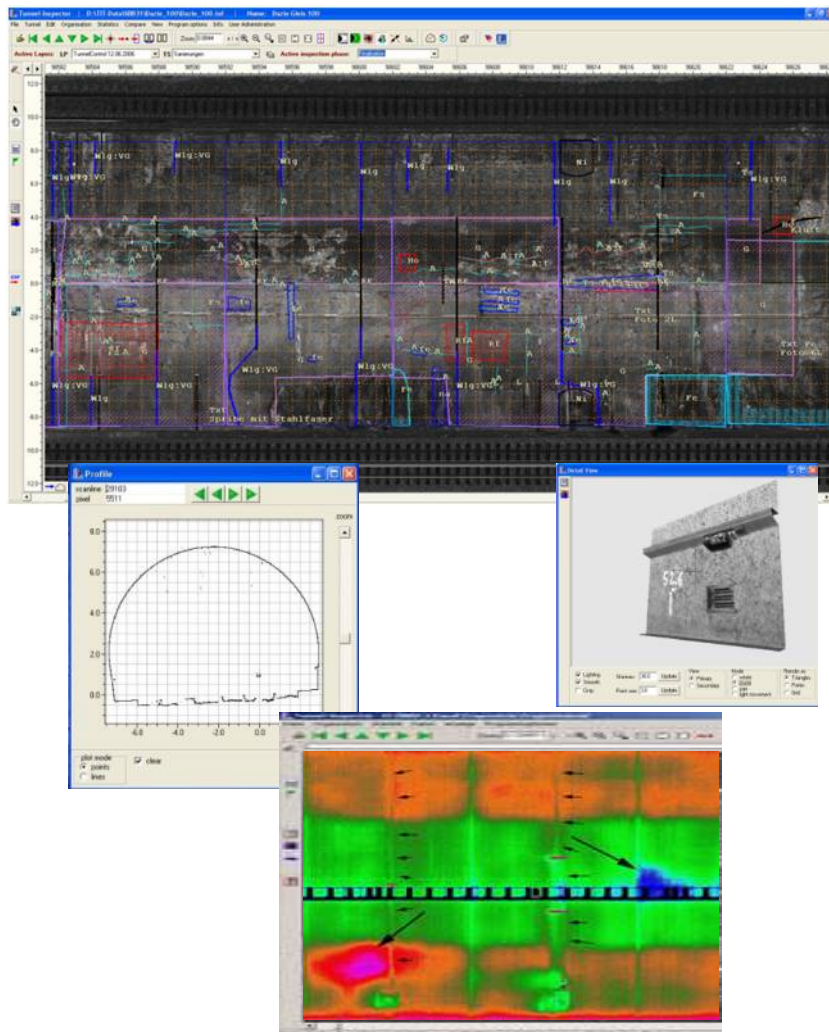


Final state



Tunnel maintenance and renewal @ SBB

Tunnel inspection tools

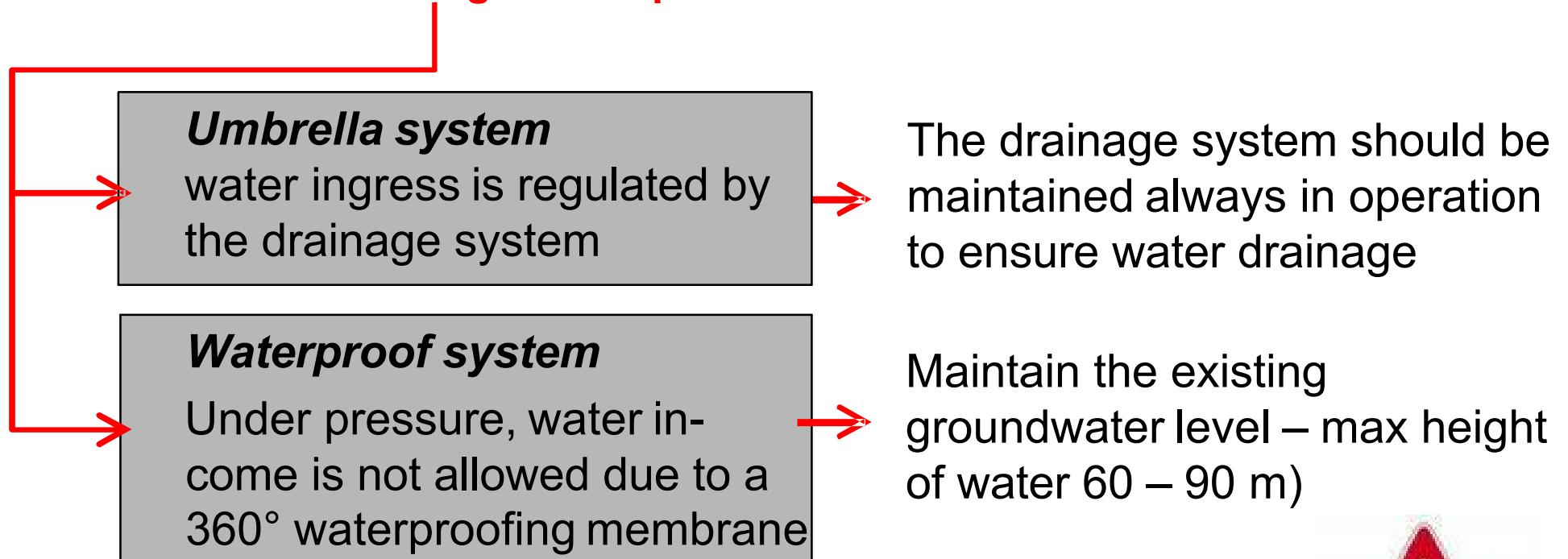


- All mapped items are assigned to an appropriate layer
- The inspection map provides a clear image of the conditions of the tunnel
- Comparing the results with former inspections drawings and/or scans allows to better assess the evolution rate of observed damages
- Thermal data may help for detecting water infiltrations and/or cavities

Tunnel maintenance and renewal @ SBB

Drainage concept

2 Drainage Concepts for tunnels:



→ **An intermediate concept can't be allowed:** «*Let's hope*»
e.g. injections to avoid water inflow ⇒ could result in filling cavities and pipes of the existing drainage systems!



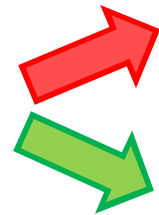
Tunnel maintenance and renewal @ SBB

Drainage Calcite deposits

drained concept → water + contact to concrete = Risk of **calcites** in drainage

Calcites must be removed, otherwise tube loaded, then water flow blocked:
→ **water pressure!**

Removing calcites



Mechanically: regular, “stress” for pipes
Track Closure, costs

Physically: permanent,
deposits are hindered, no / or few soft deposits.

→ Maintenance + costs drastically reduced

Hardness-stabilizing: Dosage-System, see: www.mcwegmueller.com



19th June 2009



3rd August 2009



24th Oct. 2011

Final word



Thank you for your attention