

NATURAL HAZARDS ALONG THE GOTTHARD RAILWAY

RISK ASSESSMENT TOWARDS SAFETY IN OPERATION

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Approximately 500 km of the Swiss SBB AG's railway network (3000 km) are substantially threatened by natural hazards, such as snow avalanches, landslides, debris flows, torrents and rockfall. The Gotthard line section has been in operation for 125 years and ever since, the safe operation of this line has been very challenging, because of the above described ubiquitous natural hazards.

Almost the entire openly led railroad line is registered on hazard maps. Fig. 1 displays a track section of the Wassen region, 850 - 950 m a.s.l. The degree of brightness indicates the probability of a track burying caused by rockfall, snow avalanches, or flood:

- ◆ dark: average recurrence interval: < 30 years
- ◆ medium: average recurrence interval: 30 – 100 years
- ◆ light: average recurrence interval: 100 – 300 years

Unmarked track sections are essentially tunnels or bridges.

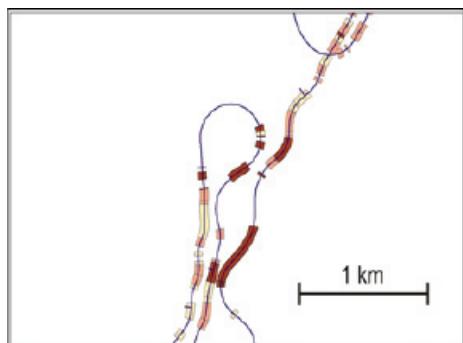


Fig. 1: Potentially endangered track sections in the Wassen region

Despite omnipresent potential natural hazards a high level of security and availability of these tracks can, with various kinds of measures, be maintained. At the time, when the route was designed in the 19th century, already, with all the hazards in mind, the less endangered valley side was selected. Highly endangered sections were bypassed by tunnels or crossed by bridges. At that time, only a few protective structures were built. A branch of service was installed, in order to monitor and maintain rock walls, slope cuttings and screes. Additionally, approx. 3000 hectares of forest offer protection against natural hazards. Because the importance of protection forests has been well known

in the Canton Uri for a long time, the forests have been preserved for centuries from exhaustive exploitation. It is owed to this fact, that projecting a transalpine railroad was even an option.

Since 1882 however, more and more protective structures have been built. Hazardous events such as deposition of snow or rocks on the tracks and subsequent traffic interruptions have repeatedly shown the need for action. After the electrification and the increasing train frequency the track and the whole system became more vulnerable to disturbances. Mainly because of the great losses arising from such events new protective structures were built. The increasing road traffic, the construction of the Gotthard motorway and thus the increased competition between road and rail forced the SBB to invest more into safety and reliability of the Gotthard route e. g. by protecting hazard areas by implementing extended preventive measures. In order to stay competitive since 1975, the following new protective structures were built:

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- ◆ 829 m new avalanche galleries
- ◆ ca. 2 km rockfall barrier systems
- ◆ ca. 800 m walls and dams
- ◆ dozens of rock reinforcements and supports
- ◆ Replacement of already existing protective structures.

With these measures the protection from natural hazards could be improved on 10% of the track distances. But does all this lead to an optimal risk reduction? After one hundred years of experience, it is quite safe to assume, that the preventive measures against the "frequent hazards" (recurrence intervals < 30 years) are sufficient. The probability, that such a "frequent" event occurred in the last 125 years, amounts to 99%. "Rare" events (recurrence intervals 30-100 years) theoretically arose once with a probability of 72 %, "very rare" events (recurrence intervals 100-300 years)

arose once with a probability of 34 % only. But even if the most dangerous spots can, in the future, be secured, substantial dangers will still remain on long track sections. What can be done about this situation in the future? Is it a solution to just concentrate on protecting the well-known threatened spots, following the same concept as up to now? Or should the safety of the whole Gotthard line section be examined through a risk analysis?

For the mountainous reach Erstfeld-Goeschenen, a cost effectiveness calculation was done including the substantial reduction of importance of this track within the next approx. 10 years (start of operation of the base tunnel). The calculated costs equal CHF 6 millions for each option. After all, the concentration on two cost-intensive measures (see fig. 2) did not prove to be very cost effective. Therefore the second option, where the safety can be improved by implementing lower-cost measures at 20 different places (determined through the risk analysis) along the whole reach, was favoured.

Despite of all these measures residual risks will always remain. As it is not possible to exclude all dangers from natural processes, all one can do is limit the potential damage as much as possible. Therefore, these additional measures are currently necessary:

- ◆ monitoring and "maintenance" of rock flanks, of known landslide areas and of torrents;
- ◆ temporal track guarding in critical meteorological situations, particularly in case of voluminous snowfall
- ◆ detecting all natural incidents, in order to better assess the magnitude and frequency of the dangerous processes.

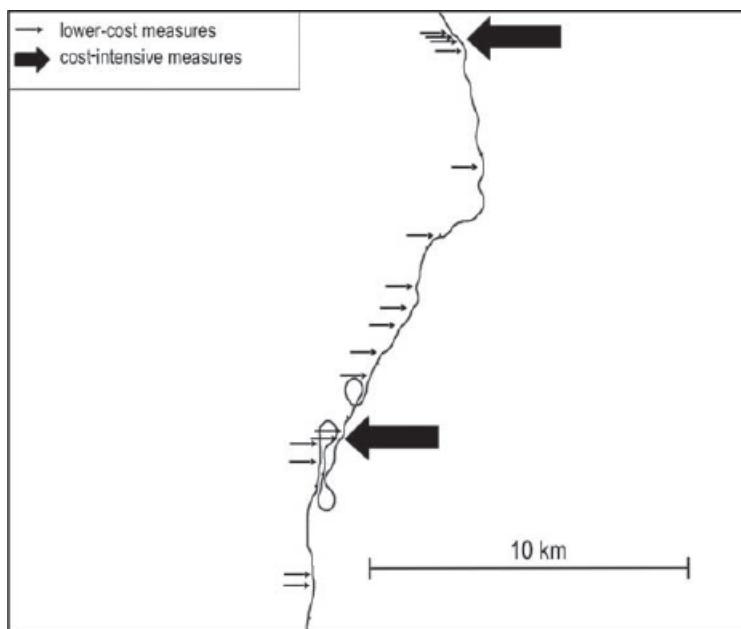


Fig. 2: Optimal improvement of protection against natural hazards by implementing the results of the risk analysis