RISK, CONTRACT MANAGEMENT AND FINANCING OF THE GOTTHARD BASE-TUNNEL

Davide Fabbri
MSc. civil engineer Swiss Federal Institute of Technology Zürich;
Company: Lombardi Engineering Ltd., via R. Simen 19, 6648 Minusio (Switzerland)

ABSTRACT

With the opening ceremony of the Gotthard base-tunnel on June 1st 2016 a new world record has been established: the commissioning of the world’s longest railway tunnel in the world. Many challenges have been achieved; many technical innovations have been developed for and considered into the project. Since December 11th 2016 the Gotthard base-tunnel is an integral part of the new timetable of the Swiss Federal Railways and it is full in operation. With a total length of 57 km and a cruising speed for passenger’s trains of 200 km/h, the Gotthard base-tunnel reduces the journey time through the Alps by 40 minutes, contributing significantly to break down the distance the south and the north of Europe.

After 25 years of design and more than 17 years of construction, it is the suitable time for a review of the interesting and intensive realisation phase of this project of the century. A look into successes and critical moments will allow for a remarkable learning process, identifying positive and more demanding experiences to be considered for future projects.

The presentation will highlight the management and the sharing of risks, the procurement strategy, the adopted contractual models, the contract and dispute management as well as the financing model. Those were some of the winning aspects for the construction of the Gotthard base-tunnel in accordance with the agreed level of quality, without exceeding the budget agreed and with full respect of the time schedule. Relevant suggestions and recommendations might be formulated as a valuable feedback of these aspects.

1. INTRODUCTION

With the opening ceremony of the Gotthard base-tunnel on June 1st 2016, a new world record has been established: the commissioning of the world’s longest railway tunnel in the world. Many challenges have been achieved; many technical innovations have been developed for and considered into the project. Since December 11th 2016 the Gotthard base-tunnel is an integral part of the new timetable of the Swiss Federal Railways and it is full in operation. With a total length of 57 km and a cruising speed for passenger’s trains of 200 km/h, the Gotthard base-tunnel reduces the journey time through the Alps by 40 minutes, significantly contributing to break down the distance between the south and the north of Europe.

After 25 years since the design commencement and more than 17 years of construction, it is the suitable time for a review of the interesting and intensive realisation phase of this project of the century, and to have a look into successes and critical moments will allow for a remarkable learning process, identifying positive and more demanding experiences to be considered for future projects. Not only from technical point of view, but – among other things – also as regards contractual aspects, project financing and risk management.

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2. NEW RAILWAY LINK THROUGH THE ALPS (NRLA), A LONG TERM MISSION

The Gotthard-Base tunnel, together with the 35 km long Lötschberg base-tunnel (in full operation since December 2007) are a masterpiece of the engineers, the miners, the consultants (see Figure 1), but they are also a product of the political involvement of the population through the direct democracy (the political model valid in Switzerland). The Swiss voters have voted by the means of many Swiss referenda about the New Railway Links through the Alps, about their alignments, about shifting the increasing traffic from road to rail, about protecting the Alps, about the LSVA (truck toll) and about the necessary contracts with the European Union. The vision of two base-tunnels under the Gotthard and the Lötschberg for rail traffic has been followed with steady coherence. The point was not to set world records, but rather to achieve content objectives, especially to improve national cohesion, to connect with the Gotthard base-tunnel the Italian-speaking region in the south to the German-speaking region in the north of Switzerland, and with the Lötschberg base-tunnel to bring the upper Valais, French-speaking Switzerland, and the central regions closer together. It was about sustainable transport policy. And it was also to make a significant contribution
to transport policy in Europe. The Swiss voters have given the lie to worldwide misgiving about direct democracy, which was not supposed to be able to plan in the long term because “the voters” cannot understand complex matters. The operation of both tunnels, but especially of the 57 km long Gotthard base-tunnel, could start on time and without financial overturns. [1]

3. GOTTHARD BASE-TUNNEL, BRIEF OVERVIEW OF THE PROJECT

The Gotthard base-tunnel is integral part of the so called Trans-European Networks-Transport (TEN-T) and is situated in the core-section of the Rhine-Alps Corridor (Rotterdam-Genoa). (see Figure 2).

The base tunnel stretches from Erstfeld in the north to Bodio in the south. It consists of two parallel single-track tubes with a diameter varying from approximately 8.80 up to 9.50 meters, which are linked by cross-passages approximately every 300 meters. At two positions, one-third and two-thirds along the base-tunnel are located multifunction stations for the diversion of trains via the crossovers to the other tube, for the installation of electro-mechanical installations, and for the stop of trains and the evacuation of passengers in an emergency case. (see Figure 3). Detailed and sophisticated evaluation demonstrated that this tunnel system was the most suitable for long alpine tunnels. To shorten construction time and for ventilation purposes, the tunnel has been driven from several sites simultaneously. To this purpose, the tunnel has been divided into five sections. Excavation took place from the portals as well as from three intermediate attacks in Amsteg, Sedrun and Faido.

Figure 2: Rhine-Alps Corridor (Rotterdam-Genoa)
Thanks to a design speed of 250 km/h for passenger trains and of 160 km/h for freight trains, a minimum radius of curves of 5,000 m and a maximum slope of the railway line of 12.5 % (6.76 ‰ in the base-tunnel) the new Alpine Link will allow a transit of 50-80 passenger trains per day and of 220-260 freight trains (750 m long) per day after the start of the operation, in December 2020, also of the 15 km long Ceneri base-tunnel. (See Figure 4). Compared to the situation before the opening of the new base-tunnels the capacity of freight transport on rail on this important north-south link will be doubled and the travelling time between northern and southern Switzerland will be reduced by about 40-60 minutes. (See Figure 5).

Figure 3: Scheme of the Gotthard base-tunnel (tunnel system)

Figure 4: Daily train-traffic through the Gotthard before and after the opening of the new link
4. ORGANISATION

A project realization, however large it may be, is by definition a temporary undertaking with a defined beginning and end. A temporary organisation for the specific task is beneficial, intended to fulfil the specified requirements (project aims) in order to create advantageous changes and added value. This principle also has been applied to the organisation of the AlpTransit Gotthard Ltd. (ATG).

Due to the unique size of the project for Swiss circumstances, the Swiss parliament passed a project-related legal framework, which formed the basis for the construction of the corridor of the New Railway Link through the Alps (NRLA).

According to this and in respect of the principle of the direct democracy, the entire stakeholders were involved. Therefore the following subjects were part of the project’s organisation, see also Figure 6:
- The Swiss Federation, sponsor of the project, charged among other, with the financing and the supervision of the NRLA
- The Swiss Federal Railways (SBB-CFF-FFS), sole shareholder of ATG and future operator of the new railway link;
- The consultants, contractors and suppliers having a contract with ATG;
- The community.

The chosen organisation, proved itself a good model, one of the factors for the success of the project allowing for a direct run, simplified contacts and links, management transparency thanks to the parliamentary control through the specific commission, a clearer and better governance and efficiency, thanks to a lean organization (facilitating the decision-making process).
5. PROJECT FINANCING AND COST MANAGEMENT

As a result of the intensive discussion, a new financing model was produced, which was the object of the popular vote of November 29th 1998. With a 63.5% “Yes” vote, the Fund for the financing of public transport infrastructure (FinöV) – with 30 billion Swiss Francs – was agreed by the Swiss people. Of the fund amount, 13.8 billion Swiss Francs (45% of the FinöV, price level 1998) were intended to finance “à fond perdu” (lost funding) the construction of the NRLA.

The contribution from the FinöV representing well 75% of the total required credit, only 25% of the investment had to be financed on the private capital market. This share of the investment would have to be paid back by the future operator, the Swiss Federal Railways, as in the former finance models. However a waiving of the payback of this share was decided in 2005.

The income from the FinöV fund should be supplied from the following sources:
- From the new performance-dependent heavy road vehicle tax (LSVA);
- From a share of the existing mineral oil tax;
- From an additional 0.1% on VAT.

The lifetime of the fund – that is, the time period until all debts would be repaid – was estimated in 1998 as 23 years (1997 to 2020; in meantime extended in 2010 to 2027). Since the fund would be empty at the beginning, but the construction works on the two NRLA links would increase rapidly, a Federal loan of 4.1 billion Swiss Francs was provided by the Swiss Federal Government (extended in 2010 to 10.1 billion Swiss Francs according to the evolution of expenses vs. incomes in the first years).

The project financing model, assuring from the beginning a clear and sure financing of the whole project, independently from the current state budget and from possible political changes, avoiding possible delays or stops in the construction phase as a consequence of a possible lack of financial resources or of political consensus was one of the fundamental elements of the success of the Gotthard project.

ATG as the constructor essentially had to operate two control circuits:
- Project and cost management vis-à-vis the federal government as the project sponsor
- Project and cost management vis-à-vis their contractors.

The order placed by the Swiss Federal Government with ATG was regulated in the contract agreed between these two parties. The cost management process was generally set up with regard to the optimal achievement of the NRLA Controlling Instructions (NCI), defining the decisive control figures, the type and frequency of reporting (every 6 months) and the handling of alterations being laid down correspondingly. In each status report, the reporting and reciprocally comparison of Cost reference basis (original and current), Cost situation (awards, paid invoices, extra/reduced costs for construction, inflation, final invoices) and Cost forecast (credit approvals, residual costs, presumed final costs, extra/reduced costs) had to be included.
A management system for engineering changes was to be consistently updated to ensure that all project modifications could be processed and documented transparently and understandably. The responsibilities for the approvals were clearly specified in order to permit the necessary decisions to be formed at the right time for the right stage. Performance variations with effects on costs and deadlines could generally only be implemented after the targets had been adapted. If a performance variation had to be implemented immediately for scheduling reasons, then it was to be notified to the Swiss Federal Office of Transportation (FOT) in an incident report. After the approval of a change request by the FOT, ATG could apply for an adaptation of the project basis. [3]

In 2008, according to the in the meantime by the FOT approved changes, an adaptation of the cost reference basis for the Gotthard link (Gotthard and Ceneri base-tunnel, including surface railway sections) as per Figure 8 has been decided by the Swiss Federal Government. The major issues leading to the update of the cost reference basis were related to upgrade of the project according to Safety and state-of-the-art technology (do not forget, that the project realisation spans over 2 decades), to extra costs for Geology (situations with worse geological and geotechnical conditions as expected most impactful as situations with more favourable geological and geotechnical conditions as expected) and to increase of costs due to contract award and construction.

**Swiss Government Decision on Amendment of the NRLA Total Credit (Alp Transit Financing Decision) of September 16, 2008**

**Art. 1**

For the realisation of the New Rail Link through the Alps, a total credit of 19 100 billion Swiss francs including reserves (price level 1998 according to NRLA inflation index and project status 2007, without inflation, value added tax and construction interest) is approved and divided into the following committed credits:

<table>
<thead>
<tr>
<th>Investments in CHF million</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Project management</td>
</tr>
<tr>
<td>b. Lütschberg route</td>
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<tr>
<td>c. Gotthard route</td>
</tr>
<tr>
<td>d. Upgrade Sursesha</td>
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<tr>
<td>e. Link to Eastern Switzerland</td>
</tr>
<tr>
<td>f. Upgrade St. Galen–Arth–Goldau</td>
</tr>
<tr>
<td>g. Other upgrades, Lütschberg route</td>
</tr>
<tr>
<td>h. Other upgrades, Gotthard route</td>
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<tr>
<td>i. Reserves</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
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Figure 8: Update of the cost reference basis (inflation, VAT and interest costs excluded)

The evolution of the probable final costs and of the potential risks with financial impact has been monitored by ATG on a quarterly basis and reported to the control authority every six months. Figure 9 shows that the final costs will be lower than the credit of 13,157 billion Swiss Francs.

Referred to the Gotthard base-tunnel only, the increase of the credit from original 6.323 billion Swiss Francs to 9.861 billion Swiss Francs (part of the above mentioned 13.157 billion Swiss Francs), corresponding to +53% without inflation, was not unexpected, but was nonetheless impressive. Almost the half of the extra costs derive from variations arising from orders issued by the Swiss Federal Office of Transportation (FOT) for consistently respecting the principle to deliver a tunnel with state-of-the-art Safety and technology. The extra costs from ground risks, which could not be directly influenced, only made up 9% and thus only a sixth of the total increase.
6. THE SWISS STANDARDS SIA FOR TUNNELLING

To better understand the content of the following chapters of this paper, it is appropriate to have a brief overview of the Swiss Standards SIA (Swiss Society of engineers and architects), developed for underground works, upgraded in 2004/2007 also summoning the experiences acquired in the design and construction of the NRLA [6].

The following Codes SIA for underground works, available in 4 languages (German, French, Italian and English), were endorsed by Working Group 3 “Contractual practice” of ITA-AITES in 2015 [4] according to “The ITA Contractual Framework Checklist for Subsurface Construction Contracts” [5]:


The responsibilities of the contractual parties during the execution, the provisions regarding payment, the determination of quantities, the general conditions to apply for variations, adjustments of deadlines and the allocation of risks and so on are clearly stated in the above mentioned Codes SIA. Those Standards, reflecting the Swiss mentality for the construction of underground structures, greatly affect, inter alia, risk management aspects and the contract model.
7. CONTRACTUAL MODEL, RISK ALLOCATION AND RISK MANAGEMENT, CONTRACT AND DISPUTES MANAGEMENT

The contractual model adopted for the realisation of a large underground work significantly affects the project's organisation, the development of the design, the bid procedure and finally the implementation of the construction contract itself during the entire construction phase.
A reasonable risk allocation is important in order to allow the contractor, at bidding stage, to make an appropriate calculation of the offered unit prices as well as to establish the bid strategy and for building the relationship between client and contractor after award and contract’s signature.

The analysis of the experience acquired in various continents, conducted by the working group Nr. 3 of ITA-AITES (International Tunnelling and underground space Association) actually shows that only a suitable and balanced risk sharing allows the client for the optimization (minimisation) of the construction costs.

Mechanisms for the management of conflicts are essential for dealing in a professional manner the difficulties and the changed conditions that inevitably characterize the realization of works of this scale.

In the specific case of the Gotthard base-tunnel, the design (at all stages, except the detailed design of MEP (Mechanical, Electrical, Plumbing) and the detailed design for the for the turnkey project of the railway infrastructure), as well as the general and the local construction supervision were run by the client, AlpTransit Gotthard Ltd, and its consultants. Contractors were generally only commissioned, so to speak, to carry out the construction works defined by the client’s designers.

The civil engineering activities and the services related to the provision and commissioning of MEP were contracted according to the "classic model" applied in Switzerland for underground works, defined by the standards SIA (Swiss Society of Engineers and Architects), where the designer acts as a direct agent of the client.

According to this standard, among other aspects, the remuneration of the contractor bases on unit prices and actually adopted quantities and an adjustment of the deadlines is granted in consideration of variations (arising from risks under client's responsibility like the risk allocation related to the geology), while the risks are attributed to the contractor when related to the production process and the achievement of the declared performance as offered (see extract from Standard SIA 118/198 (2007) [6] in Figure 11, displaying the allocation of general risks as well as details about the allocation of risks for Drill & Blast (conventional tunnelling) and for TBM in Hard Rock). The Code SIA 118/198 (2007) also defines the risk allocation for mechanically assisted tunnelling in rock mass, in soft ground and for tunnelling by shield TBM in soft ground. The conflict management process was designed to act through progressive levels, starting from the lowest level, that of the "construction site", hierarchically increasing the involved figures reaching, for the few cases where it was not possible to find a consensual solution, the level of the advisory Arbitration Commission, agreed upon in advance between the parties. Thanks to this mechanism for the management of disputes and the willingness to dialogue, no dispute has ever come to court!

The management of geology-related risks and chances (because geology can be worse as predicted but even better) by the client and its consultants, together with the unit prices remuneration mechanisms, was a key aspect for the success in the construction of the Gotthard base-tunnel. The following two examples will clearly explain by large underground works like especially by long and deep tunnels in mostly unknown geological conditions because of limited exploratory drillings and experience from former comparable works, the importance of the client’s right to choose the appropriate solution in case of unexpected faults or in case of delay with respect to deadlines contractually set and publicly disclosed.

1 The construction contracts for the main civil works of the Gotthard base-tunnel were referring to the Code SIA 198 (1993), appendix 5, conceptually in line with the subsequent update, implemented in the Code SIA 118/198 (2007).
8.7 Allocation of risks

8.7.1 Risks in underground construction work

8.7.1.1 Special risks exist in connection with tunnelling resulting from the properties of the rock mass, irrespective of a fault on the part of the contractor. It is therefore recommended that these risks be allocated in the works contract.

8.7.1.2 Unless otherwise agreed, the following allocation of risks to the principal or to the contractor applies. The principal risks, which can exist in tunnelling depending on the individual case, are listed.

8.7.2 General risks

8.7.2.1 The following belong to the risk sphere of the principal:
- Rock characteristics different from the tender documents, to the extent that the deviation lies outside the contractual limits
- Presence of gas
- Encountering contaminated ground
- Effects on existing structures within the area of influence of the cavity which occur despite proper execution of the work
- Major collapses due to geological conditions and exceptional inflow of water
- Encountering archaeological remains,

8.7.2.2 The following belong to the risk sphere of the contractor:
- Rock characteristics different from the tender documents, to the extent that the deviation lies within the contractual limits
- Contractually defined services.

8.7.3 Drill & blast tunnelling in rock (D&B)

8.7.3.1 The following belong to the risk sphere of the principal:
- Deformations of the cross-section of the cavity greater than contractually provided for, and their consequences: reworking of the profile, modifying the formwork to reduced cross-section,

8.7.3.2 The following belong to the risk sphere of the contractor:
- Problems with the operation of the drilling, loading or conveying system, e.g. as a result of the adhesion of the excavated material or large blocks of material,
- Obstruction caused through the inflow of water into blasting holes.

8.7.4 Tunnelling with tunnel boring machine in rock (TBM)

8.7.4.1 The following belong to the risk sphere of the principal:
- Deformations of the cross-section of the cavity greater than contractually provided for, and their consequences: jamming in place of the tunnelling machine, sinking in of invert segments which have already been installed, modifying the formwork to reduced diameter, widening of tunnel cross-sections, which have already been bored, reboring the tunnelling machine to a larger diameter
- Rock characteristics lying outside of the limit values stated in the works contract and the consequences of this: significantly less favourable muckability, rock falls to provide the necessary grip for the gripper pads, load-bearing capacity of the invert inadequate (tunneling machine cannot maintain its intended position without exceptional measures)
- More difficult tunnelling in loose rock or in rock broken into loose material (e.g. locally unstable face),

8.7.4.2 The following belong to the risk sphere of the contractor:
- Poor muckability due to very different hard and soft sections of rock in the same excavated cross-section
- Problems with the operation of the boring, loading or conveying system, e.g. as a result of the adheriveness of the excavated materials or large blocks of material.

Figure 11: Allocation of risks, extract from Code SIA 118/198 (copyright), pages 31+32
Gotthard base-tunnel, real case 1: Unexpected mayor fault in the multifunctional station of Faido

The unexpected presence of a major fault zone, almost parallel to the alignment of the main tunnels and in correspondence with the planned excavations of the largest tunnel sections (see Figure 12, upper part), namely the transversal cavern and the bifurcations of the northern cross over tunnel, required the involved engineers to adopt a major variation of the scheme of the multifunctional station under a very short timeline because the excavation was in full progress. That significant modification had to be established limiting as much as possible the increase of the construction's costs and minimizing the impact on the overall construction schedule of the entire Gotthard base-tunnel.

The cross overs from the one tunnel to the other (diagonal connections) include bifurcation caverns with the largest tunnel section in the project (up to 230 m²). In the original layout (see Figure 12, lower part, upper scheme) these were affected by this unfavourable geological condition. In order to optimise the solution of this situation, the scheme was modified by moving to the south both cross overs and the emergency stop along the western tunnel, in more favourable geological conditions (see Figure 12, lower part, lower scheme) instead to apply extreme supports. This modification has been combined with an important upgrade of the scheme for safety’s reasons, with the integration of the additional exhaust air extraction gallery systems (see Figure 12, lower part, in green).

This first example clearly highlights how important the control over the detailed design and the management of geological risk was in the client’s hands. The remuneration of the performed works with unit prices allowed to manage the changes of sequences and of quantities, while a remuneration on a time and material basis (per labour), allowed to manage those particular situations, for which the definition of unit prices was impossible or not fair.

Client’s detailed design and client’s management of the geological risk allowed him to make important decisions in a short time, avoiding any stop of the works without renegotiating the conditions of the entire framework agreement, but merely adapting deadlines and remuneration amount, therefore optimising schedule and costs.

![Figure 12: Unexpected major fault in the multifunctional station of Faido & adopted measures](image-url)
Gotthard base-tunnel, real case 2: Measures taken to recover a delay of 1 year

The challenges to overcome were not only of technical matter. The realization of a base-tunnel requires coping with risks of geological, administrative and legal nature that may result in important delays of the project. The general schedule of works is characterized by numerous interdependencies, for example between the civil engineering works and the equipment (MEP) as well as the Railway technology, and this may have repercussions delaying the scheduled commissioning dates.

In the particular case, an accumulation of delays anticipated in 2008 would have shifted the start-up of the base tunnel in December 2017, one year later than expected and as publicly announced. Figure 13 helps understanding the situation: after the contract signature for the main lots of the civil engineering works, the date of commissioning of the base-tunnel had been updated and fixed in December 2016 as a consequence of the geological unforeseen conditions in the southern part and of the difficulties arising in the years 2003-2004 for the start of work at the north portal. Further geological problems arising in the southern part compromised the achievement of this announced milestone. However, the client expressed its clear intention to remedy this negative evolution.

Figure 13: Forecast for the start of commercial operation of the Gotthard base-tunnel

After analysis and weighing of risks and opportunities, the client decided to change the limit between the main lots of Sedrun and Faido / Bodio. This eventually was foreseen in the two contracts (already an integral part of tender documents). Unit prices were therefore already been offered in the bid phase (under competition) and defined by contract in order to manage and compensate a possible extension or reduction of the excavated extensions of up to a maximum of 1 km. Since the activation of the optional displacement of the limit between lots of 1 km was not enough, the client has negotiated with the contractors a further modification of the limit of the lots. This was possible as the basic concept for this limit modification was already foreseen. As a consequence of the relevant negotiations, guided by consensus, contractual complements were signed.

Figure 14, on the left, highlights the delay from the lot Faido / Bodio and the need to take additional countermeasures, in order to prevent a final tunnel breakthrough postponed of six months.
The amendment to the boundary of the lots of Sedrun and Faido / Bodio, by itself, was not sufficient, however, to regain all the accumulated additional delay. Therefore the client proceeded to make a proposal to all the other parties involved, namely the total contractor of the Railway technology and the designers, in order to achieve an acceleration of the work and activities. In return they were promised cash rewards if successful. The initiative, called "Project Capricorn" represents an outstanding example of win-win situation, with dialogue between the parties in order to reach a common goal based on discussion and confrontation but avoiding conflict.

Figure 14: Project “Capricorn” → modification of the limit of the main lots Faido and Sedrun

Also in this second real case, the contractual model adopted and the effective risk and conflict management showed their appropriateness. Figure 14, on the right shows the result achieved with the "Project Capricorn".

8. CONCLUSIONS

In conclusion, the success should be underlined of a fair and flexible contract model, which allowed handling all contingencies and all design changes during 25 years of design and 17 years of construction as well as the success of an efficient Project financing model and of an adequate Project organization.

It is worth highlighting the importance of open dialogue between the parties and the principle that searching and identifying a mutually agreed solution should be the first step in case of problems, while the discussion about liability and contractual consequences only should come in the next one.

Last but not least, the Swiss standards SIA have proved their fitness for the design and construction of large underground structures, profiting themselves of the experience gathered during the realisation of this outstanding project in part of their last revisions.

9. REFERENCES

[1] Leuenberger Moritz, ““In the year of the Tunnel”, Swiss Tunnel Congress 2016 (proceedings), Swiss Tunnelling Society, 2016, ISBN: 978-3-033-05486-8