# Moncenisio, from Myth to history TELT – Tunnel Euralpin Lyon Turin and the collection of historic engravings on the Frejus tunnel

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ABSTRACT: TELT possesses a collection of original documents concerning the original Fréjus Rail Tunnel. By using them as a guideline, this paper reconstructs the history of the Fréjus tunnel, showing that it has plenty of lesson to teach us. The elements presented include: Cavour's closing statement during the parliamentary debate; The affair of the Fell Railroad, which warns us that new technologies have often an unforeseeable impact; The digging of the tunnel, whose completion was made possible by the development of the pneumatic perforator; The follow-on impact of the tunnel, which led to the digging of several other transalpine conections and which caught the eye of the public, leading to the construction of the so-called "Bogorama". As TELT digs the new Mount Cenis Base Tunnel, we can look back at the history of the first tunnel to cross the Alps as both an example and as a learning experience.

## 1 I THE TELT HISTORICAL COLLECTION AND THE SAGA OF THE FRÉJUS

To pass on the archaeology of underground excavations, collecting its traces and placing them at the disposal of enthusiasts and scholars alike. This is the duty that TELT – Tunnel Euralpin Lyon Turin, feels called up to accomplish. It has led TELT to put together a collection of engravings, dating back to the second half of the 19th Century, which reconstruct the history of the Fréjus Tunnel.

This collection, which TELT saved from dispersal, includes prints, both woodcuttings and original photos, taken from Italian, French and English newspapers of the time. The material is displayed in an exhibition room in TELT's Turin seat. There are five thematic sections: The Time before the Tunnel, the Fell Railroad, Excavation and Construction of the Tunnel, The Operating Line, Inauguration and Celebrations.

The collection is a mine of historical and technical information. It comprises 60 woodcuttings, 2 original photos, and a four-and-a-half-metres-long panel which displays the track of the railroad between Bussoleno and Modane. Furthermore, it also includes a series of original documents and books that make it possible to reconstruct the main political and technological developments of the excavation, such as the project for Germano Sommeiller's "perforating machine" and a table with the longitudinal sections of the tunnel.

The TELT offices, which are located in the Officine ferroviarie Grandi Riparazioni di Torino complex, have been designed as a Speaking Environment. The structure of the set-up and the use of infographics and images allow the visitor to discover many aspects of the Turin-Lyon line: from the history of the project to the geological composition of the Alps, from the characteristics of the Mont Cenis Base Tunnel to the excavation techniques used, to the connections with the TEN-T Network and the New Silk Road


Figure 1: A portion of the exhibition room in TELT's Turin headquarters

## 2 THE GREATEST OF ALL MODERN ENDEAVOURS

The Fréjus Tunnel was started in 1857 by the Kingdom of Sardinia, but it was the unified Italian state that inaugurated it on September 17, 1871, almost a year to the day after the taking of Rome. The original aim was improve communication between two territories belonging to the same state, but the transfer of the Savoy region to France in 1860 made the tunnel a cross-border connection instead. The excavation began with the miners painstakingly digging by hand the holes for the mining charges, but it was accomplished thanks to a massive use of mechanical drills. These examples offer a glimpse of the scope of the changes that involved the Fréjus Tunnel. Its excavation represented a massive engineering and financial challenge and its completion is a testament to the qualities of the Sardinian government of the time.

### 2.1 *A Bold Decision*

The first of the qualities demonstrated by the Savoy state was efficiency. Its Chamber approved the project for the Fréjus Tunnel on June 27, 1857 and the Senate gave its approval two days later, with a forecasted expense of 41.1 million liras. King Victor Emmanuel II signed the relative law on August 15 and digging began on August 31. Overall, once Parliament approved the project, it took little more than two months to start it, and the King was at work signing laws even during the holiday of Ferragosto. Any comparison with modern times can only be unfavourable to current proceedings, and this comparison becomes even more lopsided if one looks at the content of Cavour's closing argument during the debate at the Chamber.

In his opening statements, the Savoy Prime Minister had gone over the economic benefits that the completion of the tunnel was expected to produce, such as an increase in Piedmont's rice exports and the deviation towards Genoa of the trade with Genève currently going through Marseilles. MP Menabrea had then highlighted the geopolitical implications of establishing a direct rail connection with France. Once the Suez Canal, the digging of which would begin two years later in 1859, opened, the port of Brindisi could then become the European terminal of a commercial line towards India and China. To this respect, the TELT collection includes a poster with the 1891 winter schedule of the trans-European railway line that was indeed established after the opening of the Fréjus Tunnel. As the schedule shows, this line went from London to Brindisi and then Palermo, and it connected Paris with Rome in just thirty hours. This vision of using the ports of Southern Italy as terminals of trade with the East is far from being outmoded. To the contrary, it has gained prominence again in recent years, following the unveiling by Chinese president Xi of the project for establishing a new Silk Road, the so-called "Belt and Road Initiative", to strengthen trade links between Asia and Europe.

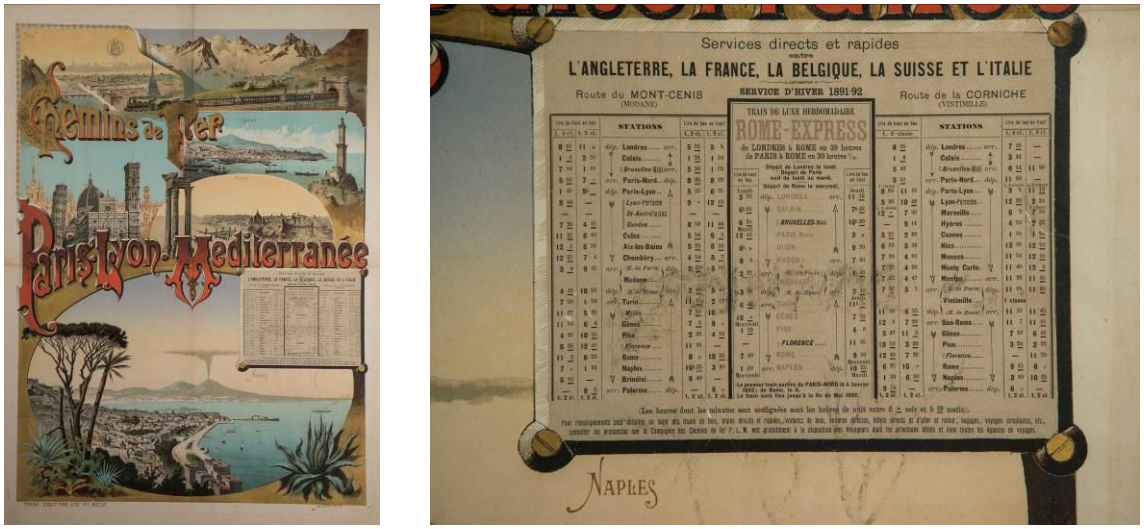


Figure 2: The illustrated schedule of the London to Palermo line

In his concluding remarks on the project, however, Cavour set aside all practical considerations in favour of a declaration of principle. It took the form of a rebuttal to the statement of MP Moia, his main opponent. Moia had declared himself not opposed to the project, but he had also highlighted its technical and financial risks and had suggested proceeding with the maximum possible level of caution. To this, Cavour replied that a policy based on half-hearted measures and on repeat studies commissioned only to postpone and delay decisions, a policy, therefore, which was not willing to assume responsibility for its choices, would end up blocking all initiatives, with disastrous consequences for the whole country. It is worth repeating the actual words of Cavour, because they have kept intact all their value in today's world:

*"Gentlemen, the endeavour that we propose here, it's not worth denying it, is a gigantic endeavour, its completion will however bring glory and benefit to the country. We have never hidden to you that we are convinced that this endeavour cannot be accomplished without overcoming huge, immense difficulties; we have never dissembled the scope of the responsibility, so much so that we are here asking for a confidence vote. But, if the difficulties to face are many, no less is the hope that we are capable of overcoming them.*

*Great endeavours are not accomplished, however, unless one condition is met, which is that those who are tasked with bringing these tasks to completion have a solid, absolute faith in their success. If this faith is not present, we must not attempt great things, neither in politics, nor in industry; if we did not have this faith, we would not have come here today to insist before you, placing on our head such a heavy burden. If we were hesitant men, if we let ourselves be scared by the thought of responsibility, we could adopt the system proposed by MP Moia, even tough, in the end, it could result fatal. As we are, however, unaccustomed to half measures, not used to proposing a timid, vacillating and perplexed politics, we could not accept his proposal, and we invite you to weight on your scales the only two rational systems: that of the execution, via a contract immediately established with the Laffitte Company, or of the deferment to other times of this brave attempt. […]*

*"I am convinced, gentlemen, that you will share our confidence. I hope that you will express a clear vote. If you share our faith, I call you to vote resolutely with us; […] if a doubt torments you that in the bowels of the mountain which we wish to cut open are hidden all manners of difficulties, obstacles and dangers, I call you to reject this law, but do not condemn us to adopt a middle line, which in this case would be fatal. […] I trust that you will always follow an open, decisive politics. If you adopted today the Moia proposal, you would inaugurate a new system, and I would lament it extremely, not just because we would lose this magnificent work, but because such an act would sign the death knell for the future political system that Parliament will be called on to follow. We had the choice of the way; we*

*have preferred that of resolve and daring; we cannot remain in the middle; it is for us a vital condition, an unavoidable alternative: to progress, or to die.*

*I hold firm faith that you will crown your work with the greatest of all modern endeavours, by deliberating the piercing of the Mont Cenis."*

This speech is a clear example of Cavour's political vision and it shows all his foresight in identifying the dangers of a political body that refuses to make decisions, which is one of the woes of our times. Along with efficiency, far-sightedness is indeed the most important quality shown by Savoy governments concerning the Mont Cenis Tunnel. It was not confined just to Cavour, as the project started long before he came to power. This quality was well expressed by MP Luigi Federico Menabrea's declaration of vote:

*"I believe in the Suez canal opening in a foreseeable future, because I am sure that Europe will come to understand that to survive, it is necessary to open up towards the indies and Chinese sea. This will balance the power of an opponent nation growing up really quickly to become a giant beyond the Atlantic. I am saying that the future of our country is ensured, that we will reach a prosperity level never seen before, because it will be the route for big part of transit and trade between Europe and Orient".*

## 2.2 *A Forward-looking Vision*

It was in the year 1844 that Belgian engineer Henry Maus was given the task of evaluating the possibility of establishing a transalpine rail connection between Savoy and Piedmont. At the time, there were only a few kilometres of railway lines in operation throughout the whole Italian Peninsula, and none of them were in the Kingdom of Sardinia. Nevertheless, King Carlo Alberto and his government were already aware of the importance that transalpine rail connections would have one day. Not just to bind together the domains of the Crown, but especially in order to place Piedmont solidly within the growing network of cross-European trade routes. The latter is a point that Cavour would make again during the parliamentary debate of 1857. The TELT Collection includes a copy of the final study presented by Maus in 1850. It also includes a rather curious document that shows the king's personal interest in the matter. It is an autographed letter by Count Avet, head of Carlo Alberto's chancellery, confirming the appointment with the king to Joseph-François Médail, a lowborn customs official. The appointment was to take place "Sunday, 27th of June [1841], between 10 a.m. and midday". It is a day, an hour, and a visitor's rank that are quite unusual for an audience with the king. The subject? Discussing the "Project of excavating the Alps between Bardonecchia and Modane" that Médail had sent to the king and his government the previous 20th of June.

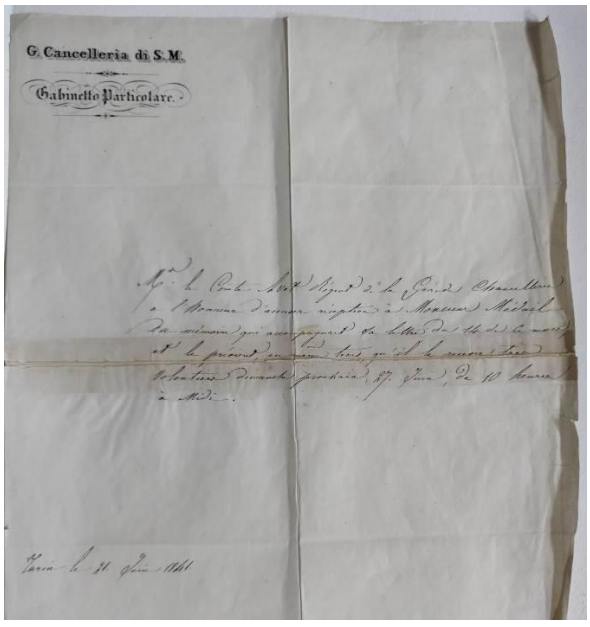


Figure 3: The letter confirming Médail's appointment with King Carlo Alberto

## 3 CROSSING THE MONT CERNIS

Médail's project did not lead to any actual initiative. It was too far ahead of its time, considering that the first operational railway in the Kingdom of Sardinia opened only in 1848, seven years after Médail had presented his project. This first line was the 8-km-long track between Turin and Moncalieri, itself just the first portion of the Turin-Genoa line. The whole line opened only in 1853, having to wait the completion, after an excavation entirely by hand, of the Giovi Tunnel. Meanwhile, people kept crossing the Mont Cenis in the same way they had followed in the past. The TELT Collection can help us to reconstruct how that took place, as it includes a series of original woodcuts from the middle of the 1860s, a period before the opening of the tunnel.

For centuries, the only way to cross the Mont Cenis was a narrow mule trail, sporting 33 hairpin turns on the Savoy side and 77 on the Piedmont side. The first major improvement was the construction, between 1803 and 1809, of an actual, 37-km-long road. The road was commissioned by Napoleon, who wished to be able to move his armies quickly between France and Italy. Napoleon, after all, had already lead two major campaigns in Northern Italy, in 1796 and 1800, and since 1805 he held, along with the crown of Emperor of France, also that of King of Italy. Furthermore, the renewal of hostilities with Austria in 1804 had increased the importance of the Italian theatre and the consequent need to possess a fast way to cross the Alps. The opening of the road allowed the Mont Cenis to be crossed by coach, drastically reducing both the travel time and the risks of the journey.

Woodcuts from the TELT collection show us the developments that followed the opening of the road. With the arrival of railways to both sides of the mountain, stopping at Saint-Michel-de-Maurienne and Susa respectively, by the mid-1800s it remained only the pass itself that had to be crossed by traditional means. At the time, travel between Paris and Turin took 35 hours, with three legs by rail interrupted by one by boat along the Lac du Bourget and one by coach to cross the Mont Cernis, with the latter including parts via sled in winter. Even with such a complex system, the arrival of the railway promoted a rapid increase in exchanges. During the year 1863 alone, the pass was crossed by over 40,000 travellers and 22,000 metric tons of cargo.

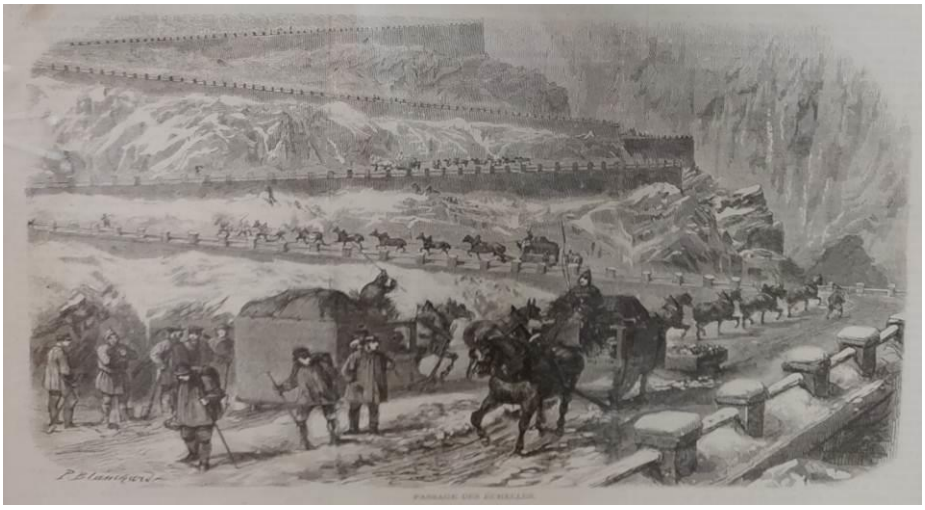

Figure 4: The crossing of the Mount Cenis in winter according to an 1865 French woodblock print

## 4 THE FELL RAILROAD

The last main innovation before the opening of the tunnel was the so-called Fell Railroad, whose history is also told by the TELT Collection. This line, inaugurated in 1868, ran parallel to the Napoleonic road. In order to be able cross the steepest slopes, it utilised a three-rail system, a predecessor to the modern rack railway, patented by British engineer John Barraclaugh Fell. The Fell Railway is important for a series of reasons. The first is eminently practical: while it

operated, it cut down the time needed to cross the Mont Cenis from sixteen to just four hours. Its importance, however, is mainly due to its economic and industrial relevance. The construction of the line was proposed in 1861 by a group of English investors that included Fell himself. At the time, the Fréjus excavation had already been going on for four years. In fact, the line was designed as a temporary measure, with the idea that it would cease its operations once the tunnel was finished. In the estimates of Mr Fell and his partners, completion of the Mont Cenis tunnel would take enough time to allow their line to turn a profit in the meantime.

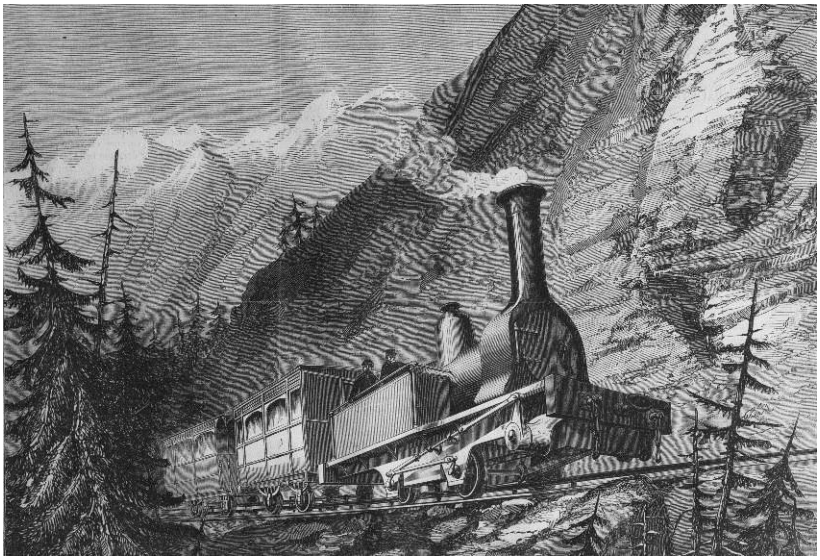

Figure 5: The Fell railroad in operation. Clearly visible is the third track specific of the Fell system

A series of delays, however, prevented the Fell Railroad from opening before 1868, while the resolution of the problems that had plagued the Sommeiller pneumatic system allowed the conclusion of the excavation of the Fréjus Tunnel by mid-1871. Therefore, the Fell Railroad was forced to close down after just three years of activity. While it had, during its operation, transported over 100,000 passengers, the result was a net loss for its investors. This story is an example of the sometimes unforeseeable consequences produced by technological change. It can also serve as a warning, which is still valid today, on the need to evaluate carefully those projections that go beyond the short term. Predictions, as the saying goes, are always difficult to make, especially when they concern the future. We can also add that they become increasingly uncertain the more you go beyond the present. Especially, as was the case for Fell, if you are dealing with technologies that have not yet had the time to demonstrate their full disruptive potential. We will come back again to this point in the course of this paper.

## 5 DOUBTS ABOUT THE TUNNEL

In defence of Fell, there were actually several reasons to believe that the excavation of the Fréjus Tunnel would have taken a very long time, and even to doubt its eventual completion. It was the first attempt to dig a tunnel through the Alps. The only applicable reference was the Giovi tunnel, dug as part of the construction of the Turin-Genoa line, which ran through the much smaller Apennines. This tunnel was three kilometres long and it ran at a height of 360 metres over sea level. It had taken eight years to dig and, when it opened in 1853, it had been the longest tunnel ever completed. The proposed Fréjus tunnel was over 12 kilometres long, four times the Giovi, and it had to be dug through a tall mountain, where information on the types of soil to face was very scarce. Furthermore, there were many doubts concerning the ability of the buyer, i.e. the Kingdom of Sardinia, to finance the project. Those were the same years of the Risorgimento, the process of unification of Italy. At the beginning of the dig, the Savoy coffers showed a debt of 680 million liras. This was due to the First War of Independence of 1848 and

to the Sardinian participation to the Crimean War in 1854-56. The start of the Second War of Independence then left only 500,000 liras available to the Fréjus project for the whole year of 1859, further delaying the works.

After considering the technical and financial challenges facing the Fréjus project, it can be understood why Fell was by far not the only one who had doubts about the completion of the tunnel. Another sceptic was the French state. When France acquired the Savoy region, it accepted with an accord signed in 1862 to finance a portion of the endeavour. The accord stipulated that France was to pay 19 million liras, but only if the tunnel was completed within the following twenty-five (!) years. It also included an incentive mechanism according to which, if the tunnel opened before the deadline of 1887, the French would pay an additional 500,000 liras for each year saved, or 600,000 for each year before 1877. Since the tunnel was completed already in 1871, France ended up paying 26,100,000 liras, which corresponds to more than a third of the total cost of the dig, estimated at 70 million by an 1873 study. It is worth recalling that the law of 1857 that established the project had foreseen an expense of 41.1 million. Cost overruns for big projects were, indeed, as common at the time as they are today. The Suez Canal, which was dug at the same time as the Fréjus tunnel, ended up costing more than twice what was originally envisaged.

## 6 THE SOMMEILLER SYSTEM

Completion of the Fréjus Tunnel in just fourteen years, long before the estimates of Fell and of the French, was made possible by an important technological innovation: the Sommeiller pneumatic perforator. Up until that moment, the traditional digging method was for the miners to prepare by hand, one by one, the holes where to place the explosive charges. Following this method, during the first year, digging through relatively easy rock, the excavation advanced by about four hundred metres. Such a speed would have required thirty years to dig through the more than twelve kilometres of the tunnel. During the preparatory phase of the project, a perforating machine made by the British inventor Bartlett had been tested as an alternative. This machine used steam to move a mechanical drill and it produced good results during the essays. However, the problems connected with safely bringing steam power to a machine destined to be placed up to six kilometres inside a mountain could not be easily solved. A government committee then tested in Genoa in 1856 a modified version of the Bartlett machine, which used compressed air in conjunction with steam, but this version was judged too complex and difficult to handle. It was Savoyard engineer Sommeiller who found a solution. He developed a simplified version of the Bartlett perforator that used only compressed air. This innovation permitted to solve two key problems at the same time. First of all, the possibility of carrying the compressed air via a network of tubes allowed the power generators, in this case the compressors, to be kept in fixed buildings placed outside the galleries. These compressors could then be powered very cheaply using the hydraulic power of mountain torrents. Furthermore, the ample availability of air allowed to safely remove the fumes generated by the explosion of the mining charges by forcing the atmospheric circulation within the galleries.

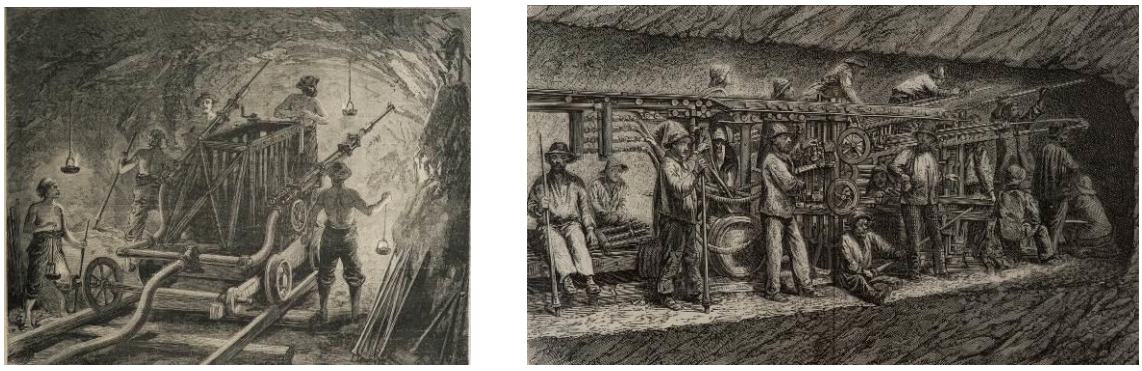

Figure 6: An early model of the Sommeiller Perforator (left) and its final version (right)

The first years, as it is the case with all innovative technologies were not easy for the Sommeiller perforator. The images in the TELT collection show us the evolution of the models used during the excavation. The original compressors proved prone to failures and they had to be re-designed completely. Even more difficult was finding a correct design for the drill heads, which tended to break down or wear out very fast. In the sole year of 1862, the workers ran through more than 72,500 different drill heads. The best shape, it was found out, adopted a point squared like a "z". These and other teething problems were faced and gradually solved one after another and the digging speed progressed accordingly year after year until, by 1870, it was four times that of the original manual dig.

Besides allowing the tunnel to be completed much faster than it would otherwise have been possible, the use of compressed air in the Fréjus tunnel had many other repercussions. Some are easily imagined, such as the creation of a new whole sector, that of pneumatic excavation. Indeed, Belgium started a feasibility study concerning the use of pneumatic perforators in its coalmines already in 1863, when the Sommeiller machines were just beginning to show their worth. Other repercussions, and with this we come back to the subject of the unforeseen disruptive effect of new technologies, were less obvious. The most important is probably the one that concerned the rail sector: it was by reading an article on the machines used in the excavation of the Fréjus Tunnel that American inventor George Westinghouse got the inspiration of using compressed air to power a distributed breaking system affecting all wagons of a train. This system is, with all the improvements brought by more than a century of use, the one that we still use today.

## 7 THE IMPACT OF THE FRÉJUS TUNNEL

### 7.1 *The First of its Kind*

The first, and most important, effect of the completion of the Fréjus Tunnel was to demonstrate that it was actually possible to dig galleries through the Alps. This led to the excavation of several additional transalpine tunnels in the following years. Indeed, works for the Gotthard Tunnel started already in 1872, just one year after the opening of the Fréjus. Furthermore, the story of the project showed that it was possible to accomplish these works with a minimal loss of human life. During the thirteen years that it took to dig through the Fréjus, the construction suffered a total of 48 deaths. It is for sure quite a high number, but it is still low if compared, for example, with the 177 official deaths during the ten years of the Gotthard dig, which in addition do not include deaths for sickness or malnutrition. Furthermore, of the 48 Fréjus deaths, eight were due to fights, one was a suicide and four were due to the explosion, probably caused on purpose, of the Fourneaux powder magazine. The main killer, however, was the epidemic of cholera that developed on the Italian side in 1865, which killed 18 diggers and caused further 60 deaths in the nearby city of Bardonecchia. The deaths directly liked to work site accidents were therefore, on average, less than two per year, which is, no matter how one looks at it, a very low number, especially if one considers the technological level of the time. Such a reduction in the total amount of deaths constitutes an undeniable merit of the management of the Fréjus excavation.

### 7.2 *The Bogorama*

The impact of the Fréjus Tunnel was not limited to technical circles. Just like the other great works of the century, it attracted the interest of the press, of artists, and of the general public as well. At the beginning of the year 1870, the two halves of the tunnel were still separated by a kilometre and a half of rock, but the dig was by that time advancing rapidly and the people of nearby Turin started talking about the forthcoming inauguration of the tunnel. After all, such ideas were part of the spirit of the time, as the main news then was the completion of another great work that had a big impact on Italian commerce: the Suez Canal. Even the great Italian opera writer Giuseppe Verdi had been asked to contribute to the inauguration ceremony of the Canal, which took place with great pomp on November 17, 1869. Verdi wrote for the occasion the *Aida*, even though some technical delays eventually forced its replacement with the *Rigoletto*. It should not surprise therefore that the free spirits of Turin's Artists' Society took

advantage of the 1870 carnival to build in Piazza Castello a stand that was a tribute to the two inaugurations of the year: one, Suez, which had just happened, and the other, the Fréjus, which was expected to happen shortly. The structure, of which the TELT collection includes an original albumen print photo, was a gigantic pharaoh's head, whose mouth gave access to a pavilion containing a single, 120-metres-long painting. The painting represented the vistas encountered during an imaginary voyage from Bardonecchia to Suez. The front of the mask showed the writing "Bardoneccio – Suez – Bogorama", referring to the two ends of the voyage and to the "Great Bogo" goliardic- chivalric order, founded years before by the same members of the Artists' Society. The Bogorama, as the whole work was called, had a large success with the public and it remained in Piazza Castello until Lent, but it then suffered a sad ending. It was bought by a Frenchman who wanted to replicate in Paris the success that the Bogorama had incurred in Turin, but it was destroyed instead in one of the fires caused by the constitution and then suppression of the 1871 Commune. The photo in the TELT collection is therefore the only picture we have left of the Bogorama, which in turn is a signal of the interest with which the public followed the progress of the Fréjus Tunnel.


Figure 7: The Bogorama

## 8 CONCLUSIONS

The Fréjus Tunnel was the first alpine tunnel ever dug. The Mont Cenis Base Tunnel that TELT is digging 800 metres below it comes, instead, last among the various alpine base tunnels. Because of this, however, it can benefit from the best practices, both technical and managerial, developed during the construction of the other seven next-generation alpine tunnels.

This is not, however, enough. The ambition of TELT is to be a pathfinder in employing cutting-edge technologies, just as the technicians and engineers who were protagonist of the Fréjus endeavour did during their time. It is a path that the Franco-Italian company is following through high-profile technical and scientific partnerships with institutions such as the Turin Polytechnic and the University of Bologna in Italy or the Ecole Nationale des Ponts et des Chaussées and the Centre Etudes Tunnel Universitaires in France. TELT also aims to set the highest standards for governance, with the benchmarking of great works and by applying, for the first time in Europe, the anti-Mafia legislation to the whole of the project, independently from the nationality of the individual sites.

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