BARTLETT SCHOOL OF PLANNING

UCL

PROJECT PROFILE

France

Millau Viaduct

Viaduc de Millau

omega centre

Centre for Mega Projects in Transport and Development

A global Centre of Excellence in Future Urban Transport
sponsored by Volvo Research and Educational Foundations (VREF)

This report was compiled by the French OMEGA Team, Ecole Nationales Ponts et Chaussees, Paris, France.

Please Note: This Project Profile has been prepared as part of the ongoing OMEGA Centre of Excellence work on Mega Urban Transport Projects. The information presented in the Profile is essentially a 'work in progress' and will be updated/amended as necessary as work proceeds. Readers are therefore advised to periodically check for any updates or revisions.

CONTENTS

List of figures

PROJECT TIMELINE AND DECISION-MAKING PROCESS

Dates	Project phase	Event's attributes
1987	Feasibility studies/ Research	Determining the possible routes - studies from the CETE d'Aix en Provence.
1988-1990	Feasibility studies/ Research	Conducting preliminary feasibility studies
1988	Feasibility studies/ Research	Establishment of an expert committee within the road administration. Four experts are appointed: P.Godin, M.Rat, M. Panet, M. Virlogeux
1989	Feasibility studies/ Research	Establishment of AIOA: the inter-departmental administration for the construction of bridges and civil engineering work. The AIOA is responsible for organizing and coordinating the delivery process of all bridges on the A75. At that time the Millau Viaduct was part of its competencies. Head of the AIOA: G. Gillet
1988-1989	Feasibility studies/ Research	Selecting the A75 route from four options.
28 June 1989	Feasibility studies/ Research	Choice of the 'median' option which bypasses Millau from the west. The choice complies with environmental requirements and supports Millau's development ambitions.
1990-1991	Feasibility studies/ Research	Selecting the route to cross the Tarn Valley from two solutions, the 'high' and the 'low'.
29 October 1991	Feasibility studies/ Research	Ministry decision to cross the Tarn via the high route. There are three reasons for this choice: the high route is the cheapest and the shortest, and offers better safety conditions for users than the low option.
1992	Feasibility studies/ Research	SETRA examines different Viaduct pre-projects to cross the Tarn via the high route.
1993/1994	Project design and conception	Constitution of an international committee to advise the Road Director. Seven architects and eight engineering consultancies.
1993	Project design and conception	Call for design proposals: determining and refining the structure of the bridge.
12 July 1993	Project design and conception	The Ministry approves the design of the preliminary project, which consists of a 2460m long and 270m high structure.
1994	Project design and conception	Selection of the project and decision to organize a competition to select the project.
	Public enquiry	First *DUP*: inter-ministry Decree conferring the status of 'public utility' on the bypass of Millau.
1994-1995	Project design and conception	Final studies of the project by five groups matching architects and engineering consultancies together.
1996	Project design and conception	Selection of the preferred project design: team Norman Foster-Segelerg. The cabled-stayed bridge won the competition. It consists of an improved version of the project initially proposed by Michel Virlogeux when he was working for SETRA.
1998	Procurement	Change of governance and introduction of the BFOT/concession arrangement. While the State had initiated the project with the intention to execute it, in 1998, Jean Claude Guayssot, Minister of Transport and

		Equipment took the decision to transfer responsibility for the project to the private sector.
1999/2000	Procurement	Organizing an international tender for a BFOT type of procurement, a concession where the private contractor is bound to finance, build and operate the designed infrastructure.
23 November 1999	Public enquiry	Second *DUP*: the first inter-ministry decree of 1994 is amended in order to comply with concession conditions and allow a toll system for the Millau Viaduct.
March 2001	Procurement	EIFFAGE won the bid for the delivery of the Millau Viaduct.
30 May 2001	Procurement	Signature of the concession contract.
8 October 2001	Procurement	The Council of State approves the project and the attribution of the contract to EIFFAGE via a Ministry Decree.
	Procurement	Decision to build the Viaduct in metal rather than concrete (beton).
10 October 2001	Project delivery/ construction	Beginning of the construction phase.
20 February 2002	Control of construction	Establishment of expert committee of the ACDC chaired by Jean Francois Coste.
14 December 2004	Project delivery/ construction	Opening of the Millau Viaduct and beginning of the operation phases a few days later.
Sources: Ministère de l'Equipement (2004) *Le Millau Viaduct, un ouvrage exceptionnel initie par le Ministère de l'Equipement.* Dossier de presse. http://www.environnement.gouv.fr/IMG/pdf/millau_cle148b14.pdf (17/02/2010) CEVM (Compagnie Eiffage du Viaduc de Millau) *Historique d'un projet né en 1987. Quelques étapes significatives d'un grand viaduc à Millau.* Unpublished document. Coste J-F (2009) *The Millau Viaduc,* Royal Aeronautical Society, 20 October 2009.		

A PROJECT INTRODUCTION

The Millau Viaduct is a seminal civil engineering structure on the Motorway A75, linking Clermont-Ferrand to Montpellier. It belongs to the same family as the Normandy Bridge: the family of bridges with multiple cable–stayed spans. Its civil engineering structure was originally designed by the same author, the French engineer Michel Virlogeux, before being improved and enhanced by the collaboration with Norman Foster & Partners, the British architectural practice.

Type of project and originality of the process

The Millau Viaduct is the fruit of a long process initiated in 1987, which ended in December 2004 with the delivery of the bridge. It presents different points of interest from the point of view of MUTPs.

> “The Millau Viaduct is not only considered as *an exceptional piece of work from the technical perspective* but also comprises several innovations in terms of processes and procedures from the choice of the route, the design, the evaluation prior to the BOT contract (a concession type) to the elaboration of the financing scheme and the negotiation process between the shortlisted private contractor and the public administration.”

Source: Translated from Coste, J. F. (2005)

One of its special features is linked to the process applied to this project: it has been, firstly, the subject of nearly twelve years of in-depth studies led by the Roads Directorate (*Direction des Routes*) of the Ministry of Transport and Construction (*Ministere de l’Equipement*); the technical services of the administration (Setra, AIOA DDE, etc.) then checked the feasibility of a single civil engineering structure crossing the Tarn river, and several architects and engineering offices were invited to enter a competition, to widen the search for possible alternative solutions. It was at the end of this search, under the lead of a panel of international experts, that the solution of a multiple cable-stayed span structure was decided upon.

The technical design is the product of Norman Foster & Partners, the British architectural practice, and SEGELERG-EEG-SERF. Yet, the design consists of an improved version of the early work of the French engineer Michel Virlogeux, who gave reality to Millau as a multiple cable-stayed span structure and who cooperated with Norman Foster during this phase.

Figure 1: Millau Viaduct

(Source: www.foxsaver.com/public/picture/542710490)

It is at the end of this stage that a pivotal decision occurred, with the decision in 1998 to build, finance, and operate under concession, rather than under the regime of public markets for civil engineering. After an international tender, launched in 2000, the concession contract was granted to the Compagnie Eiffage du Viaduct de Millau in 2001. This bid proposed two building solutions: one in concrete and one in steel; the contract was won on the basis of the second. This choice has many impacts on the design and build of this piece of work, as well as on site work and organization. The realization started in October 2001 (with the first stone laid on 14 December 2001) and finished in December 2004 with the inauguration ceremony for the Viaduct on 14 December 2004.

Subsequently, once again, this exceptional piece of work, for which the contractors implemented innovative techniques, has been subject to great attention by the Government services (in particular the Roads Directorate, with its mission of control and evaluation of the Millau Viaduct).

Current status and link with the parent project Motorway A75

Other special features of this project were the care given to territorial accessibility and to integration and environmental protection.

<u>Territorial accessibility</u>

From the point of view of territorial accessibility, the Millau Viaduct is linked with the parent project of the A75. At the end of 2004, when the Viaduct was opened for traffic, it constituted the central link in the chain of this motorway from Clermont-Ferrand to Beziers. With its opening, 90% of the itinerary was realized, i.e 310km of the A75. This motorway has been clearly planned for the purpose of regional development: opening up the Central Massif and the multiplicity of access in the crossed areas for the purpose of improving their accessibility. This motorway benefited also from the strong political will, of national figures such as M. Valery Giscard d'Estaing, ex-President of the Republic and deputy Mayor of Clermont-Ferrand, but also at the local level.

Free access to motorway versus toll on the Viaduct

The objective of accessibility also means free access to the motorway. The concept of the Millau Viaduct developed during the 1980s in the context of the A75 under the current policy framework for expanding the highway network in France. In contrast with the rest of the French national network (see below), the A75 is a free highway. Yet the Millau Viaduct is all the more unique in that it represents the only toll-infrastructure on the A75, a specificity explained by the choice of delivering the infrastructure under a concession/BFOT type of procurement.

Integration and environmental protection

The A75 has been also designed with special care for environmental protection: it is the first motorway which benefited from the application of the policies of '1% landscape and development' and 'villages stop' (*villages etapes*) launched by the government.

Beyond the objectives pursued for the A75, the Millau Viaduct has been also designed to solve the problem of the huge summer traffic jam in Millau. It is designed as a Millau bypass but with possible access to the city.

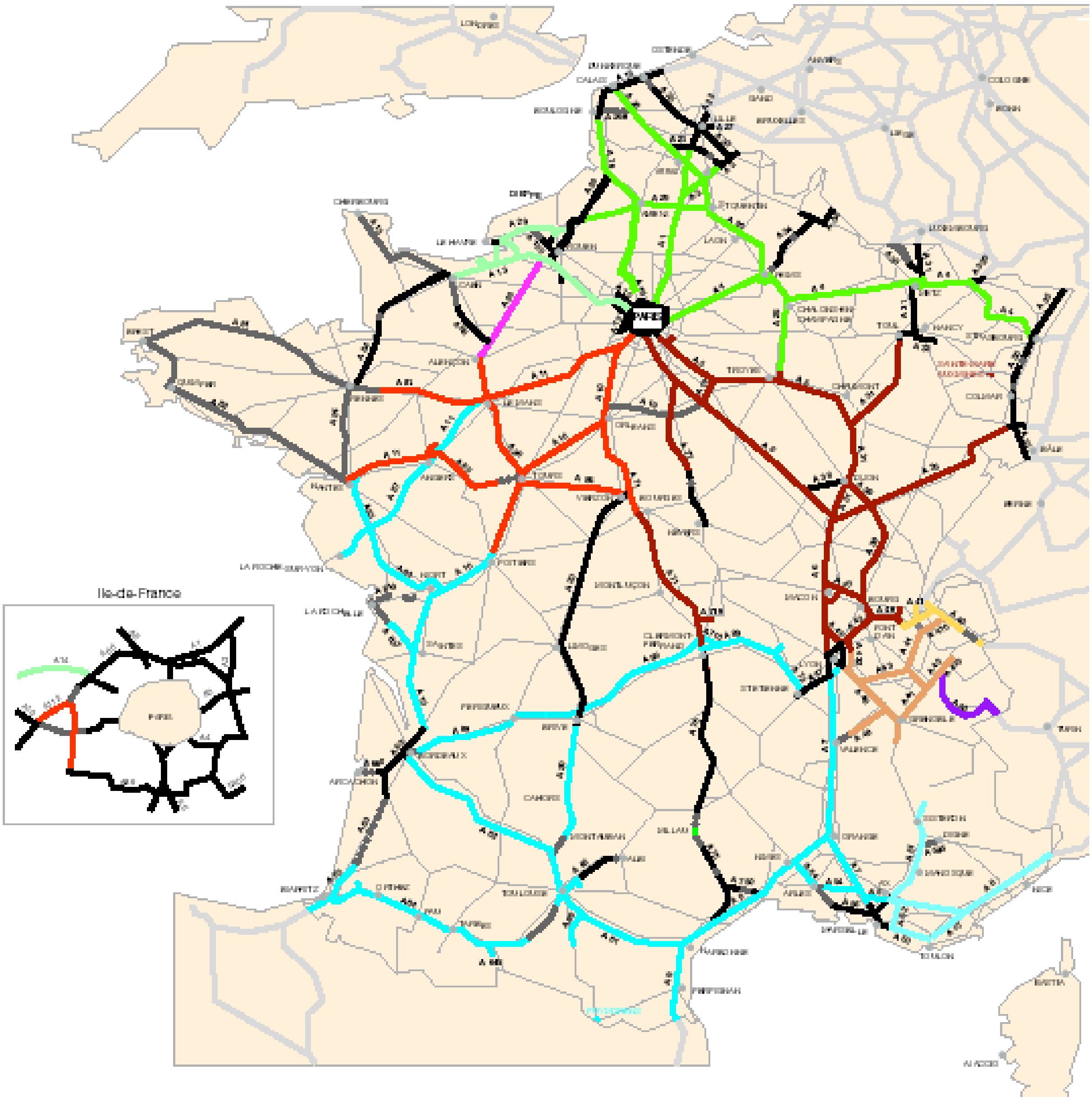
To summarize, the development of the A75 connecting Clermont-Ferrand to Beziers, particularly the Millau bypass, is integrated into a Road Policy aiming at:

- supporting spatial and territorial development;
- improving safety and security issues, and;
- paying particular attention to the protection of the environment.

In addition, the A75 had been subject to the traditional public enquiry and a form of participative process which involved local politicians and stakeholders, an odd practice at that time. The decision-making process was greatly influenced by such typical context, confirming the interesting character of the Millau Viaduct.

Source:

Figure 2: the French Highway Network (free highways in black)



Source: Coste (2009)

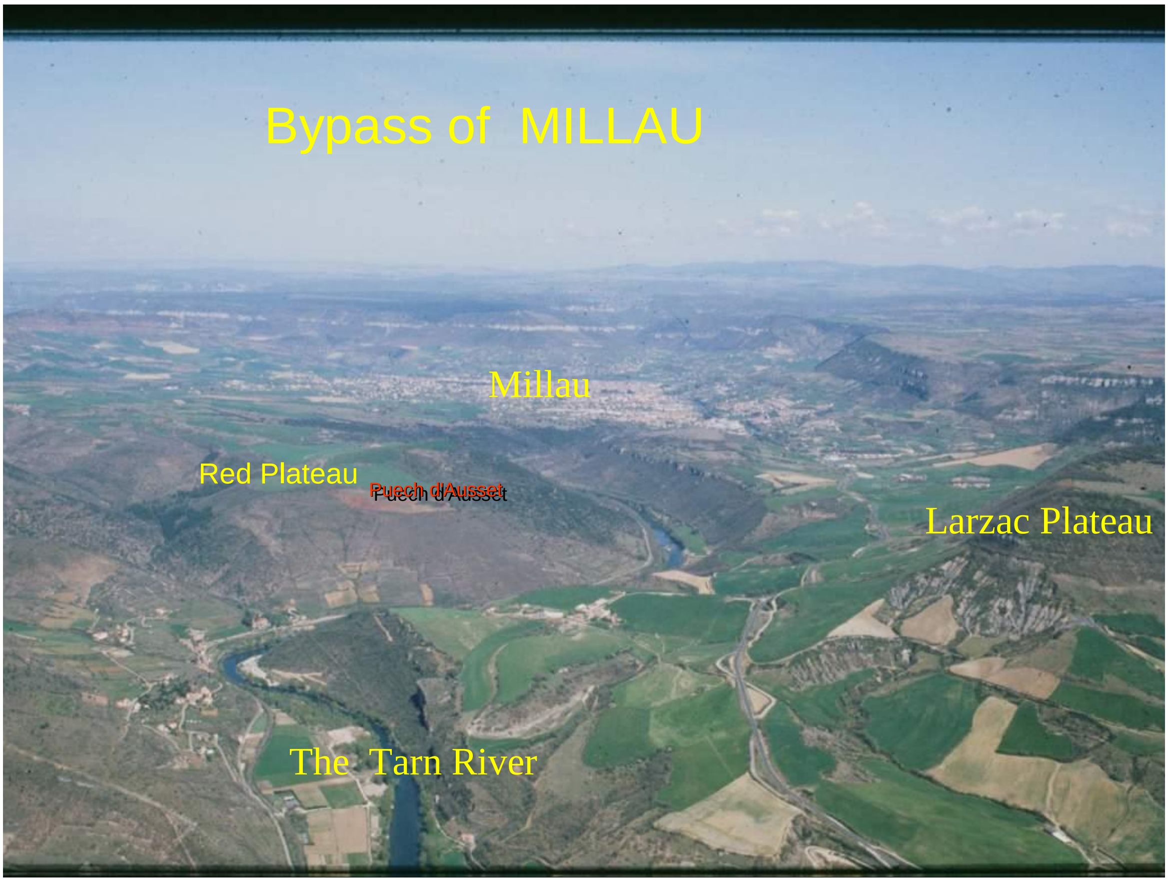
Spatial location of the Viaduct

Taking all these issues into account, the choice of spatial location for the Viaduct was not insignificant. The Viaduct, as we have seen, belongs to a ‘chain’ of civil engineering structures. It is also deeply linked to the dilemma met in the definition of the route, regarding both the bypass location and the crossing of the Tarn River. The location also contributed to explain the technical attributes, as will be seen below.

Briefly, the Millau Viaduct is the greatest bridge on the A75 highway, bypassing the Tarn Valley between the Causse Rouge in the north and the Causse de Larzac in the south. The bridge is located 5km west of the city of Millau and is the last part of the Clermont-Ferrand/Beziers highway link.

Source:

Figure 3: the site



Source: Coste (2009)

As seen above, the Millau Viaduct represented 'the missing link' of the A75 connecting Clermont-Ferrand to Bezier, one of the major highway axes for the planning of the Massif Central. As mentioned above, the A75 was the subject of a specific objective from the Government/the State: to provide a toll-free motorway. Actually, this objective was part of the Master Plan for National Roads (see the *Schemas Directeur des Routes Nationales* (SDRN) of 1988 and 1992), and relates to the continuity of the highway network (known as *LACRA*, a link ensuring the continuity of the highway network).

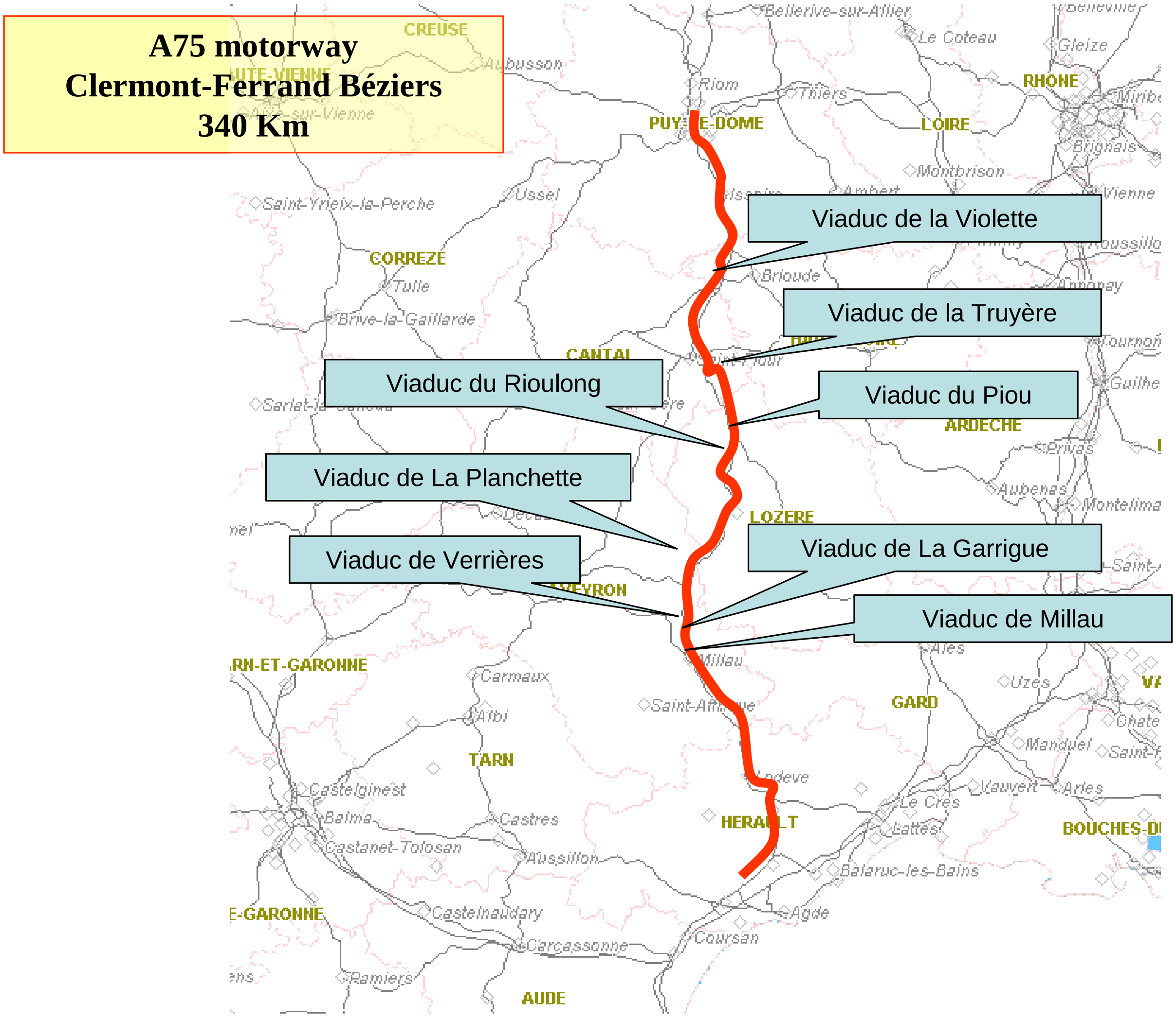
Source:

Highlands and bridges

The A75 is 340km long: 250km extends across highlands, of which the average height is 700m and the highest point, known as the Col des Issarets, is at 1.121km. The A75 required several bridge projects to cross the valleys. For this purpose, the Administration settled an organizational structure, the AIOA, under the direction of George Gillet in order to ensure *la maitrise d'ouvrage* (MOE), namely the implementation of the projects at local level. The term *MOE* stresses the role of the State in infrastructure delivery, that is its direct involvement in the construction phases and monitoring of technical aspects, via SETRA. Indeed, the bridges on the A75 present themselves as beautiful pieces of work: their designs suggest a series of successful collaborations between architects and engineers. The Millau Viaduct represents the most prominent example of such achievements but also the most challenging bridge from a technical and an institutional perspective. The latter point will be further developed in the next part of this document.

Source:

Figure 4: the viaducts of the A75



Source: Coste

Technical attributes and project challenges: from Normandy Bridge to Millau Viaduct

The choice of location and of design and civil engineering methods for the Millau Viaduct explain some of the technical challenges presented by this civil engineering structure.

Michel Virlogeux, civil engineering designer for the Millau Viaduct as well as for the Normandy Bridge, explained in our interview with him and in an article (M. Virlogeux 2001) the specific problems of bridges with multiple cable-stayed spans.

On the one hand they can be used for long spans, and rapid progress has been made in span length in recent years: “Cable-stayed bridges now compete with suspension bridges for spans between 700 and 1200, or even 1500m. The erection of the Normandy bridge was a major step in this field… (Nevertheless) the Normandy bridge is no longer the longest cable-stayed span in the world. Since May 1999, the world record belongs to the Tatara bridge, Japan, a very elegant structure”. As this author underlines, the cable stayed solutions can be both efficient and elegant. (Source).

On the other hand, they are confronted with some constraints. “The design of long span cable-stayed bridges is dominated by the resistance to turbulent wind dynamic effects and by aerodynamic stability. Streamlined box girders, inspired by the English suspension bridges and the Normandy Bridge, constitute the best technical solutions to these problems" (Virlogeux M. 2001, pp62-63). Another problem is that of cable vibrations: "Despite better understanding of the phenomena that produce such vibrations, one cannot consider the problem solved, as some points are still controversial. On the other hand, it is known how to master cable vibrations by different types of countermeasures" (Virlogeux M. idem). Different solutions can be found to these constraints. "The best solution and the most elegant, is to distribute rigidity between the different structural members (the deck, piers and pylons) in order to balance bending effects produced by asymmetric live loads and to limit deflections." (Virlogeux M. idem p.70).

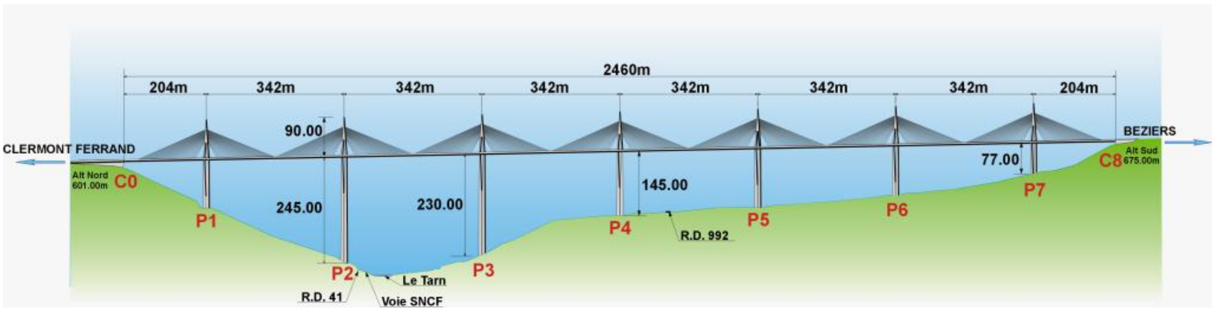
According to these previous considerations, the Millau Viaduct could seem very ambitious: it is about 2.5km long, with the road passing 270m above the River Tarn.

It is made of steel with a maximum height of 343m at the top of the pylons. A multiple cable-stayed span structure was selected due to aesthetic considerations, giving prominence to a very light deck and piers soaring up towards the sky. However, the Viaduct comprises seven piers, that is only seven points to lean on. Going further, the Viaduct constitutes an exceptional bridge with the following characteristics:

- a length of 2,460m comprising:
  - six spans of 342m length;
  - two side spans of 204m length.
- seven piers, P1 to P7:
  - the highest, named P2, measures 245m and is 270m above the Tarn River.
- two Abutments (C0 and C8).
- it required 85,000 m^3 of concrete.
- the steel deck is:
  - 32.05m large, entailing:
    - a 2x2 lane highway with a three metre shoulder;
    - wind screens to protect the vehicles;
  - 4.20m thick;
  - and weighs 36,000 tonnes, four times the weight of the Eiffel Tower.

Source: Coste (2009)

Figure 5: technical attributes of the Millau Viaduct



Source: Coste (2009)

B BACKGROUND TO PROJECT

Principal project objectives

In the domain of accessibility and economic development, the Millau Viaduct has three objectives:

- To promote economic development and tourism in the crossed regions;
- To constitute a major axis at the national level;
- To offer an international communication axis from the north west of Europe towards Spain and the Mediterranean regions.

According to Jean Guenard, chairman of Companie Eiffage du Viaduc de Millau and Director of Eiffage TP, in 2005 "the Viaduct constitutes the ultimate point addressing the missing link in the A75. Then, this major axis which first aimed at opening up the Massif Central will become a structuring European vector to avoid the bottleneck of the Rhodanien axis."

Source: Guenard, J (le journal du Viaduc 2005)

Linking Paris to the Mediterranean Coast in less than six hours, the new A75 constitutes both an alternative to the Rhone Valley route and an opportunity to provide access to the territories of the Massif Central. Subsequently, for the Mayor of Millau, Jacques Godfrain, the Viaduct consists of a catalyst for economic growth and development, carrying the potential to turn the city into a tourist destination in its own right. In this context, Jacques Godfrain mentioned the cultural heritage of the city and its surroundings, and the need to highlight it. In this regard, the Viaduct is not only viewed as a sight in itself (it was not expected that the Viaduct would attract visitors and tourism on its own), but also offers the opportunity to present the traditional activities of the region such as its Gallo Roman archaeology (*la Graufesenque*), the Sylvanes Abbaye; the Levezou lakes, the great Causses, and the Gorges of the Tarn. Nevertheless, the lack of transport and communication links is identified as a barrier to local development, a situation that contrasts with its past. Throughout the 19th century, Millau was famous for its traditional industries and glove factories. More recently, the city was labelled 'City of Art' in 2002 for its excellence in handcrafts, a potential to be further developed thanks to activities such as pottery, ironworks, cabinet-making, cutlery works and culinary arts. Indeed, Millau has always offered a dense economic fabric. Yet, insufficient accessibility is slowing down innovative industries in the domain of printing works, software and multimedia, the food industry and logistics (see interviews with Godfrain). Even if transport infrastructure cannot generate new economic dynamics alone, the Viaduct has encouraged the emergence of new themes for urban development as hotel businesses and glove factories create opportunities for additional services, such as activities and leisure. Finally, the Viaduct would constitute an icon for the region of the Aveyron: does the Viaduct mean to Millau what the Eiffel Tower means to France?

Project story line

The first studies for the Millau Viaduct began in 1987 when the Normandy Bridge, another cable-stayed bridge conceived by the same structural engineer, was about to be constructed. The conception of the Viaduct drew upon this previous experience, together with ten years of studies within the Administration. Here it is worth remembering that, initially, the Millau Viaduct was treated as any A75 infrastructure under the authority of the National Road Administration.

Concurrent with the development of the project, the National Road Administration in charge of developing the project went through internal changes. In 1989-1990 Jean Berthier, the head of the Road Directory, who decided the actual route of the Viaduct, left the administration. He was succeeded by Christian Leyrit, who supervised the whole delivery of the Millau Viaduct from conception to opening. Patrick Gandil replaced Christian Leyrit for the operation phases. Among other decisions, Christian Leyrit took responsibility for selecting the design of the Millau Viaduct via an international competition comprising several teams of engineers, architects and representatives of local governments. Yet such a decision constitutes an important turning point in the design of bridges in France, especially compared to the Normandy Bridge, which was designed within the Administration by SETRA, a public consulting and engineering office under the direct authority of the Roads Directorate. In other words, it was not very common to subject SETRA's expertise and projects to external opinions and experts. Indeed, the Millau Viaduct represents the first time that the design of a project would depend on a competition, a decision greatly justified by the scale of the project and its ambitious character.

Subsequently, SETRA and the Roads Directorate defined five 'best options' for the future Millau Viaduct and then invited five integrated engineer-architect teams to compete by elaborating on each option. These five options emerged from a 'brainstorming' process organised within SETRA and calling on international experts. The competition was launched in 1995 and led to the selection of the project of the British architect Sir Norman Foster in 1996. The project is derived from the cable-stayed solution originally proposed by Michel Virlogeux, who had also designed the Normandy Bridge when he worked for SETRA. However, this design did not prescribe the construction method, namely whether to build the bridge in steel or concrete. While both solutions were possible, at that time, the Millau Viaduct was intended to be in concrete, not in steel. Later, when the project entered the realisation phase, the decision to adopt the steel solution became a crucial factor in respect of avoiding construction delays and a preoccupation which cannot be isolated from the Viaduct's key enabling mechanism: the decision to entrust the private sector with the financing and delivery of the project.

Source: Compiled by the author.

Main actors (outside of the designers)

- The French State: the conceding authority, with its different missions of experts.

- The *Arrondissement Interdepartemental des Ouvrages d'Art (AIOA)* was given responsibility for monitoring the project by the State. It reports to the Infrastructure Directorate of the Aveyron, which manages the construction works of the A75.

- The local government authorities: The commune of Millau and the *Grands Causses* Grouping of Communes.

- EIFFAGE: The third largest construction group in France:
  - CEVM: The concessionary structure, a subsidiary of EIFFAGE;
  - EIFFAGE TP;
  - SETEC: an independent engineering office responsible for the *MOE* (*Maitrise d'oeuvre*).

Source: Ministry of the Equipment
http://www0.planete-tp.equipement.gouv.fr/en/IMG/pdf/6_cle6a166b-8.pdf

Key enabling mechanism

The decision to procure the Millau Viaduct under a concession/BFOT scheme was made in 1998 by the Communist Minister of Transport, Jean-Claude Gayssot. The decision relates to the lack of public funds available to provide the A75 missing link, namely the Viaduct, which represented an investment of approximately 2 milliards of francs (about EUR 400m). Again, in the initial planning stage, the link was conceived of as a free highway without any toll. As the public budget could not accommodate such expense the only way to avoid postponing the project delivery – and its economic benefits – was to find a source of alternative funding. That is why the Millau Viaduct came to rely exclusively on private finance. More precisely, the initial investment relied on the corporate funds of the Compagnie Eiffage which then re-negotiated a loan from the banks at a lower interest rate, once the construction risks disappeared (Coste, 2006).

Source:

The tendering process was launched according to European Law in November 1999. In 2000, the Compagnie Eiffage won the bid. Unlike his competitors organised in consortia, M. Jean-Francois Roverato, the CoE of Eiffage, bid alone with subsidiary companies. Among other constraints, an organisational structure similar to the traditional French *Maitre d'Ouvrage (MOA)* and *Maitre d'Oeuvre (MOE)* structure was required. Within the concessionaire organisation, the client role (*MOA*) was taken by CEVM, the future operator of the infrastructure, and the contractor role (*MOE*) by SETEC. Reciprocally, the role of the Administration, namely the state, has changed over the delivery of the Viaduct and is confined to the control of the process.

Source: Contrat de concession?

Project outcome

From the procurement and delivery perspective, it could be mentioned that in such a large scale project, increasing costs and delays over the construction phases are the norm rather than the exception (among many others see Miller & Lassard, 2000;[1] Flyvberg, et al, 2003[2]). However, in the specific case of the Millau Viaduct, the project was delivered on time and within budget, that is three months in advance of the initial plan. From this perspective, the project constitutes a success all the more exemplary because it relied on a concession scheme.

This procurement choice could be viewed as a specific contractual form of Public-Private Partnership (PPP) arrangements, which raise the issue of the allocation and management of risks and uncertainty between the state, as the public client, and Eiffage, the contractor. Indeed in France such arrangements raise a general issue concerning the conception, design and construction of such infrastructure: how to avoid the multiplication of competitive tenders favouring economical but trivial structures, easy to build and without risks? The constraints of the market and financing concerns could rule out original solutions and limit

[1] Miller R, Lessard, DR (2000) *The Strategic Management of Large Engineering Projects: Shaping Institutions, risks and governance.* MIT Press.
[2] Flyvbjerg B, Bruzelius N, Rothengatter W, (2003). *Megaprojects and Risk: An Anatomy of Ambition.* Cambridge University Press

the scope of architectural ambitions. This is an important question in a country where the image of the construction sector relies on the excellence of national projects: arguing that the French system should find appropriate political and administrative means for perpetuating its tradition of elegance and efficiency. Regarding the Millau Viaduct, the concession led to an exceptional Viaduct based on:

- Commitments from all parties;
- Consideration for local/regional issues;
- Integration of the financial risks by EIFFAGE;
- A short and clear decision chain;
- An integrated contractor (*MOE*) made of autonomous units (in contrast to a consortium of different firms).

Source: J. Guenard

Local economic development

The state required 1% of the project budget to be allocated to the economic development of the region. For this purpose, in 1990 a 'joint association' for economic and tourism development was created, having as its objective coordination of the initiatives of territorial communities along the A75. The overall plan was financed from the FNADT (the National Fund for Territorial Development and Planning). The process was led to a large extent by Bernard Seillier, Senator of the Aveyron department and Mayor of Severac le Chateaux.

Source: Coste (2005)

Among others, these initiatives materialized in:

- the creation of two industrial development sites in Severac le Chateau and la Cavalerie on the Larzac;

- The equal re-allocation of 80% of the professional taxes generated by these two developments among the communities in order to avoid inequalities between local communities.

Source: Le journal du Viaduc n.6

Also the Millau Viaduct became a tourist attraction in itself and a potential source of revenue, the magnitude of which was unexpected and unplanned by either the concessionaire or local authorities.

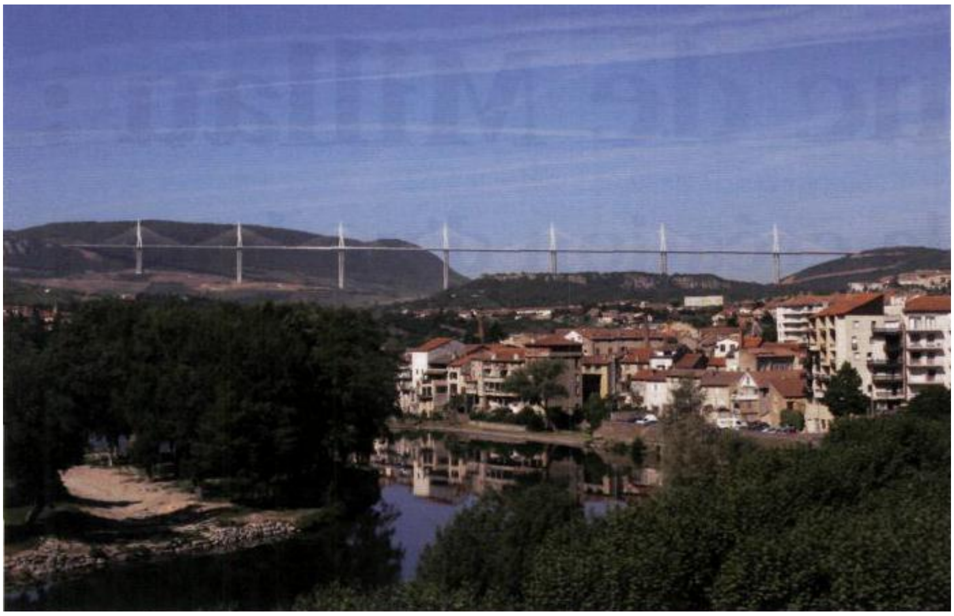
The concession offer also paid particular attention to landscape considerations and included expenses for the restitution of the access roads built for the construction. These measures prevented the urbanisation of such a special natural site and limited the disturbance of:

- the natural milieu and biodiversity;
- housing heritage;
- agriculture.

The second point refers to the restoration of traditional farmhouses such as the Farm of Brocuéjouls and its development for tourist purposes.

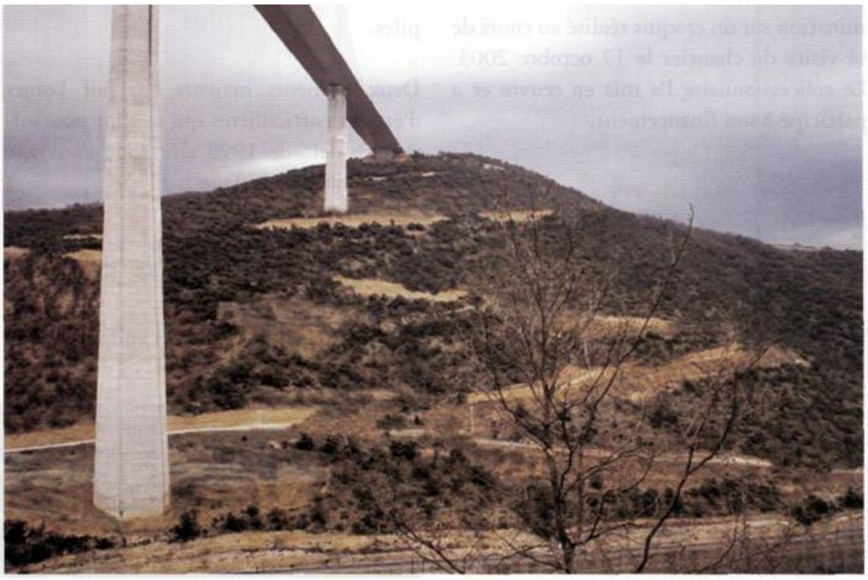
Source: Offre de concession d’Eiffage- extraits concernant les concepts paysagers et la restauration du milieu vegetal.

Figure 6: view of the Viaduct from the town of Millau



Source: PCM (2005)

Figure 7: access road reforestation



Source: PCM (2005)

Still, it is important to stress that the cooperation between the concessionaire, the state and the local authorities persists beyond the delivery of the project: for example in the case of extreme weather conditions such as snow fall, the actors have to organize themselves in close collaboration to provide – and fund – the required safety measures. Yet to some extent the concessionaire EIFFAGE became an important actor in the life of the local communities.

Besides the indisputable evidence of the positive effects of the Viaduct on local economic development some deplore insufficient leadership from the state at the local level, as greater benefits could have accrued if the process had been further monitored and managed.

Source: personal interviews with actors.

C MAIN CHARACTERISTICS OF THE PROJECT

To introduce the Millau Viaduct, M. Virlogieux emphasized three points concerning the project:

- The project is part of the last highway project to be procured by the Government;
- The specificity of the project relates to the attention paid to the landscape and other aesthetic considerations (M. Marcef, landscape architect);
- The design of the project required an unusual period of ten years of research and studies prior to the construction phase (to see if it is correct).

Virlogieux's perspective relies on the following metaphor: "The efforts droved the form of the bridge, not (la fantaisie)…" putting a specific emphasis on the technical challenges raised by the design of such large scale infrastructure, namely the need to take into consideration the wind (Universite de tous les savoirs).

The choice of the route: integrating local and environmental interests (1988-1990)

The deep valley of the Tarn River lies within the Causses which constitute a natural barrier particularly difficult to cross for a highway. From 1988, engineers and geologists looked at a way to reach Millau, whilst ensuring the feasibility of the project. Four options were considered from 1988 to 1989:

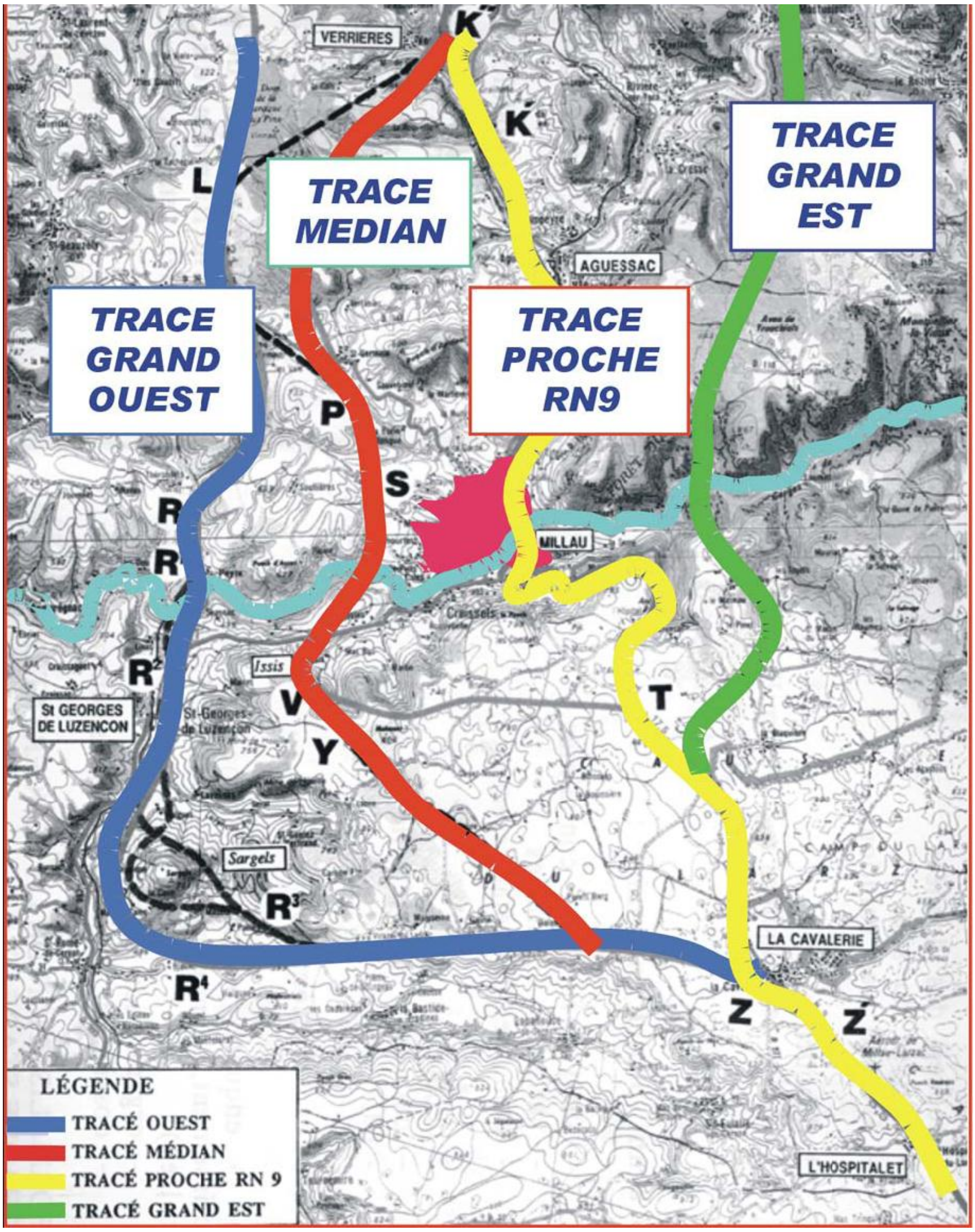
1 *Great East*: this option comprised two suspension bridges of 800m and 1km span to cross the Tarn and the Dourbie Valley. However, this option did not provide access to Millau and residents mobilized for the protection of the Dourbie within an association called 'Saving the Dourbie Valley from the A75', so it did not receive any political support from local governments.

2 *RN9:* The second option consisted of approaching Millau from the north by its east boundary to cross the Tarn and then join the Larzac by going south. It provides good access to Millau but implied several technical constraints and posed important safety issues; the abrupt downhill gradient was deemed dangerous for freight traffic, having a strong impact on the urban environment.

3 *Great West:* this option was the longest (12km longer) compared to the others. It passed through the Cernon Valley and the traditional villages of Peyres and St Georges Luzencon with four bridges. Indeed, it did not provide access to Millau and also generated opposition from the villages.

4 *Median* option starts from the St Germain villages in the north, crossing the Tarn to join the Franc and then goes up towards the Larzarc. Though it bypassed Millau, this solution was welcomed by local government and the mayor because it provides an easy link to the city and reduces the negative impacts of traffic jams and noise. Yet, the difficulties relied on the geological conditions on the right side of the Tarn. Finally, the technical feasibility of the route was confirmed by two experts: the geotechnician, Marc Panet and the geologist, Marcel Rat (LCPC).

Figure 8: the four alternative routes



Source: Gillet & Mutel (?)

The last option was selected on 28 June 1989 under a Ministry Decision which required further technical studies for the route and consideration of the most appropriate type of bridge.

The project: difficult choice and thorough investigations 1991-1996

Briefly, the choice of the project could be outlined in four stages:

1. The choice between the low and high solutions;
2. The definition of the project;
3. the competition for the design of the project;
4. The selection of the project.

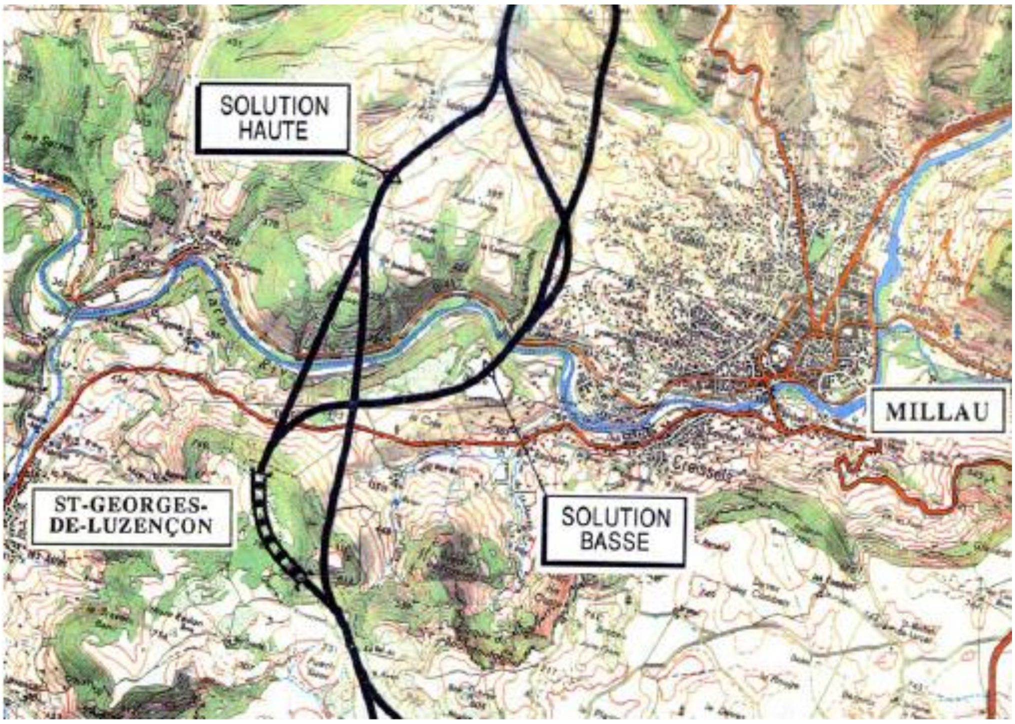
Choosing between the high and low solutions

Two sets of technical solutions to cross the Tarn Valley were examined thoroughly by the CETE *Mediterranee:*

- the 'low' solution whereby the road sloped down to the valley;
- the 'high' solution which comprised a bridge 200m above the valley.

Initially, the low solution was considered as the sole solution but, in the final instance, the high solution was preferred due to safety reasons, economic considerations – the solution was shorter and thus cheaper – and geotechnical constraints. In addition, the high solution had a limited impact on the environment and urbanization, and subsumed sufficient access to the city of Millau via the interchange of St Germain.

Figure 9: the high and low solution



Source : Gillet & Mutel (?)

For the reasons mentioned, the high solution was welcomed by local officials. Indeed, the Director of Roads, Jean Berthier, was convinced of the relevance of this solution and approved it. This led to the Ministry Decision of 29 October 1991, but additional studies were still required by the Minister of the Equipment, Paul Quiles. During 1992, a project team within SETRA led by Michel Virlogeux undertook the studies and investigated seven bridge types. These proposed bridges were selected from amongst eight sets of solutions, comprising technical variants of steel and concrete. These preliminary studies confirmed the feasibility of a single bridge of 2.46km to cross the Tarn Valley. This pre-project was approved by another Ministry Decision on 12 July 1993. Four projects were retained:

1. A project with a large span of 280m above the Tarn. This project had a concrete deck at variable height level and constant access spans 150m long;

2. The same project as project 1, with a steel deck;

3 A project with cable-stayed spans of 320m, with a concrete deck and access spans at a constant height level;

4 A project with a large cable-stayed span of 400m, with access spans of 170m and a steel deck at a constant height level.

Definition of the project

Taking the importance of the technical issues into consideration, Christian Leyrit[3], Director of Roads between 1989 and 1999, wished to enhance the depth and breadth of the solutions investigated for the Viaduct. Subsequently, a competitive procedure for the definition of the project was initiated in mid-1993, with eight design offices chosen from 17 candidates and seven architects from 38. Designers and architects were selected separately[4]. Recollecting Coste's presentation, the objectives of this procedure were fourfold:

- complementing the preliminary analysis with further professional advice;
- proposing new and different solutions;
- setting up an adequate working environment and methods for the development of the project;
- integrating views on the project landscape's consideration into the project design and implementation;
- putting together five design teams.

Ultimately the process was aimed at expanding upon the solutions already put forth by SETRA, and was reckoned as exceptionally fruitful from the technical and architectural perspective. Concurrently, the Director of Roads had set up an Evaluation Committee involving an international group of ten experts, enhancing the level of technical competency and of architectural and landscape visions. The Evaluation Committee was chaired by Jean Francois Coste from the Ministry of the Equipment and comprised:

- David P. Billington of Princeton University (USA), specialist advisor on the aesthetics of bridges;
- Jorg Slaich, bridges' expert (Germany);
- René Walther, expert from the Polytechnical School of Lausanne (Switzerland);
- Alain Davenport of Ontario University (Canada), specialist advisor on the aerodynamics and stability of bridges;
- François Baguelin, engineer and geotechnician (France);
- Jean Claude Foucriat engineer and specialist in steel Construction (France);
- Roger Lacroix, specialist engineer in bridges and consultant for Freyssinet (France);
- Bernard Lassus, landscape architect (France);
- Jean Pera, general engineer from the Ponts et Chaussee, Ministry of the Equipment (France).

In September 1993, the Committee concluded that the high solution was feasible and appropriate to cross the Tarn. However, it was decided that the next steps would not be confined to efforts to develop the multiple cable-stayed span project of Michel Virlogeux. Instead it was proposed to subject the choice of the project to a competition between five teams independent of SETRA, the administration traditionally in charge of studying and conceiving projects. Yet, two main kinds of solutions had emerged, those 'suspended' above the valley and those 'emerging' from the bottom of the valley. Each team had to work

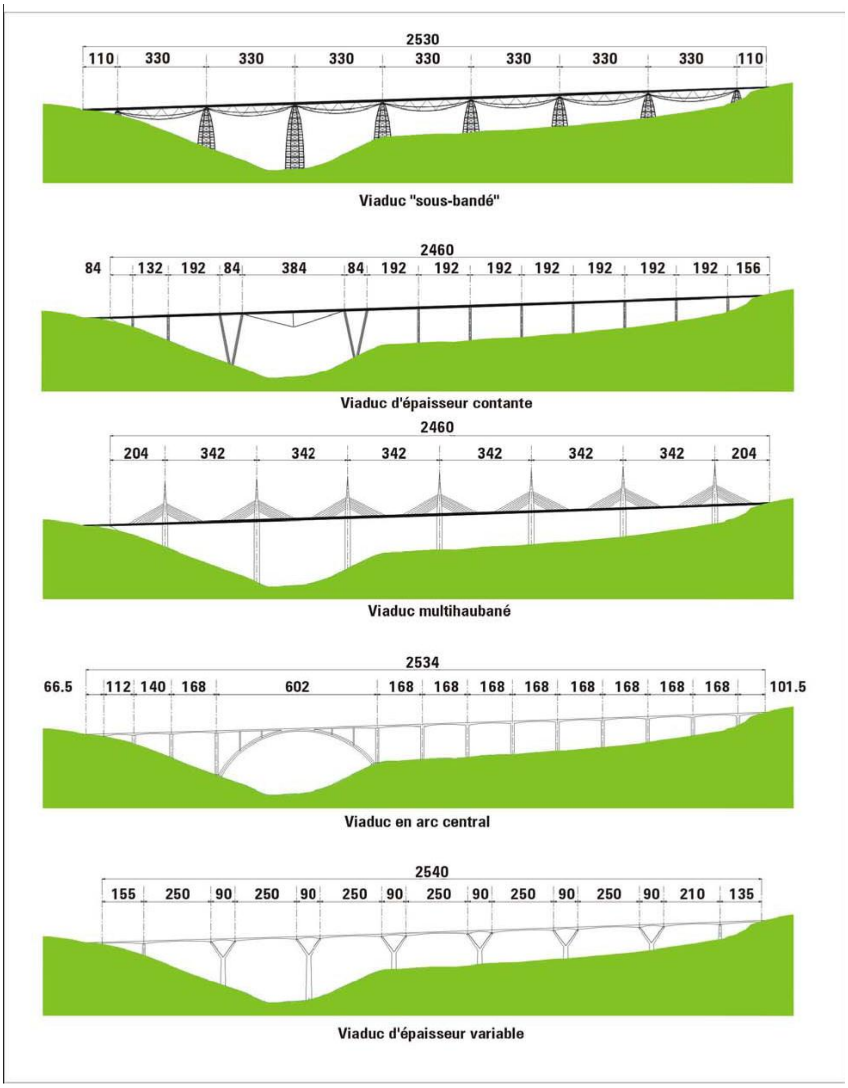
[3] See the interview in PCM
[4] Encadre etude preliminaire (where)

on the five sets of solutions and the entailed specifications depicted in the following order in figure 10:

- a steel deck with multiple sub-bended spans;
- a steel deck with continuous spans of constant depth;
- a steel *or* concrete deck with multiple cable-stayed spans;
- a concrete bridge including an arch with an opening 600m wide over the River Tarn;
- a viaduct with continuous spans of depth in concrete or composite metal.

Source: Coste (2009)

Figure 10: five proposals for the Viaduct



Source: Gillet & Mutel (?)

Here, the rationale underpinning such a procedure could be outlined: calling for experts' propositions amounted to not letting the administration alone decide on the project to be constructed, and then ensured that the intended project would respect the landscape and the environment.

Competition for the design

Consequently, the five teams were officially set up according to the decision of 4 November 1994, whereby the Director of Roads had adopted the proposition of the Evaluation Committee and formed five teams from the following designer/architect ‘couples’:

- SETEC – TPI – Francis Soler;
- Jean Muller International – Alain Spielmann;
- SEEE Sofresid - Denis Sloan;
- Sogelerg & EEG & Serf – Norman Foster;
- Secoa – Jean Vincent Berlottier.

Nevertheless the complete specifications were communicated to the teams only in October 1995. The teams submitted their proposals on 23 April 1996, which were to be examined thoroughly by the DDE. The DDE’s technical committee in charge of evaluating the proposals was divided into four working groups and produced a report establishing:

- the constructability of the projects (detailing the strengths and weaknesses of alternative projects);
- the need to complete the studies before carrying out the project;
- the need to homogenize project estimates.

Source: Gillet & Muttel

Selection of the design

Finally, on 12 July 1996, the *maitre d’ouvrage* (a French term which refers to the client or more specifically the owner of the infrastructure often associated with the *maitre d’oeuvre*, which is the party in charge of executing the work towards the delivery of the project), composed of:

- Government/State representatives;
- local officials;
- and engineers;
- chaired by Christian Leyrit, the Director of Roads,

selected the multiple cable-stayed span project proposed by Norman Foster in light of (1) the quality of the technical and architectural design, (2) the execution period (3) the relative low cost compared to other solutions. The Ministry of the Equipment ratified this choice on 15 July 1996.

Source: Coste (2009)

Meanwhile, the first *Declaration d’Utilite Publique* (*DUP*) to bypass Millau was passed on 10 January 1995.

Conception of the project: elaborating and developing the design (1997-1998)

After the selection of Norman Foster’s project, further technical development took an additional year, until 1 July 1997. Here, it could be stressed that this choice amounts to the initial project planned by the administration, namely the multiple cable-stayed span bridge proposed by the engineer who conceived the famous *Viaduc de Normandie*, Michel Virlogeux. Over the additional study year specific technical issues were examined, the structure's resistance and how the design would respond to wind velocity in particular. The studies focused on:

- geology;
- testing bored pile foundations;
- design of the pier and deck;
- meteorological records;
- snow;
- high performance concrete design;
- seismicity;
- maintenance and operation;
- users' behaviour;
- building methods;
- construction management;
- cost analysis;
- hydraulic studies;
- archeaology.

Source: Coste (2010)

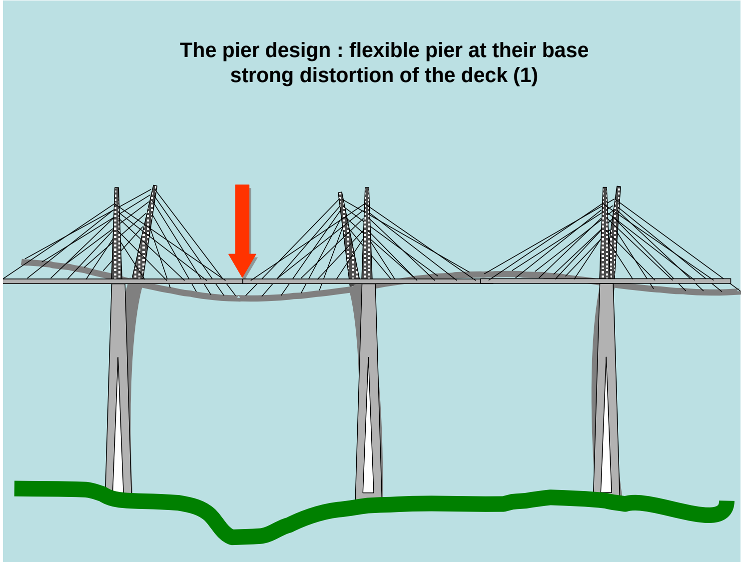
During this intense period of studies, engineers and architects approached technical imperatives, aesthetic requirements and the entailed challenges in close collaboration. This point also largely contributed to the fame and success of the project, since the relationship between the team of architects and engineers, which is commonly represented as tense, in this case was reckoned to be positive, constructive and efficient by all parties. Among other examples, this successful technical collaboration is well illustrated through:

- the design of the piers;
- the actual form of the cross section of the deck.

<u>The design of the piers</u>

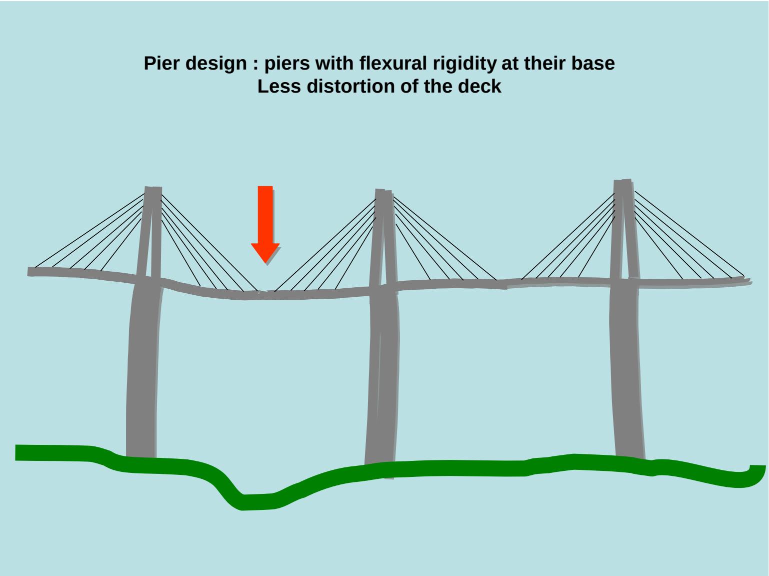
In order to respond to the problem of the distortion of the deck due to the flexibility of the piers' base, it was decided to split the piers into two over 90m (see Figures 11, 12 and 13).

Figure 11: the piers issue



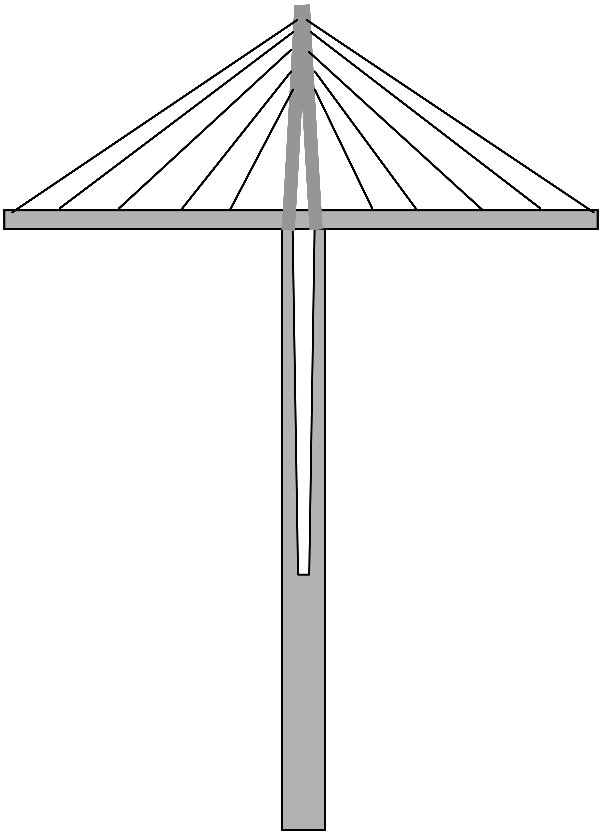
Source: Coste (2009)

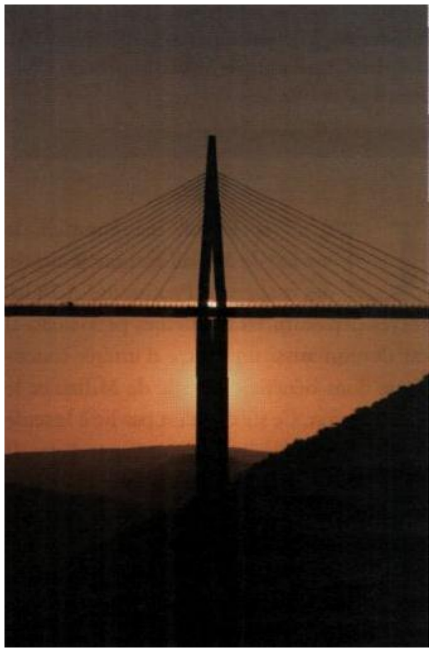
Figure 12: the piers issue



Source: Coste (2009)

Figure 13: actual form of the piers and pylons continuity



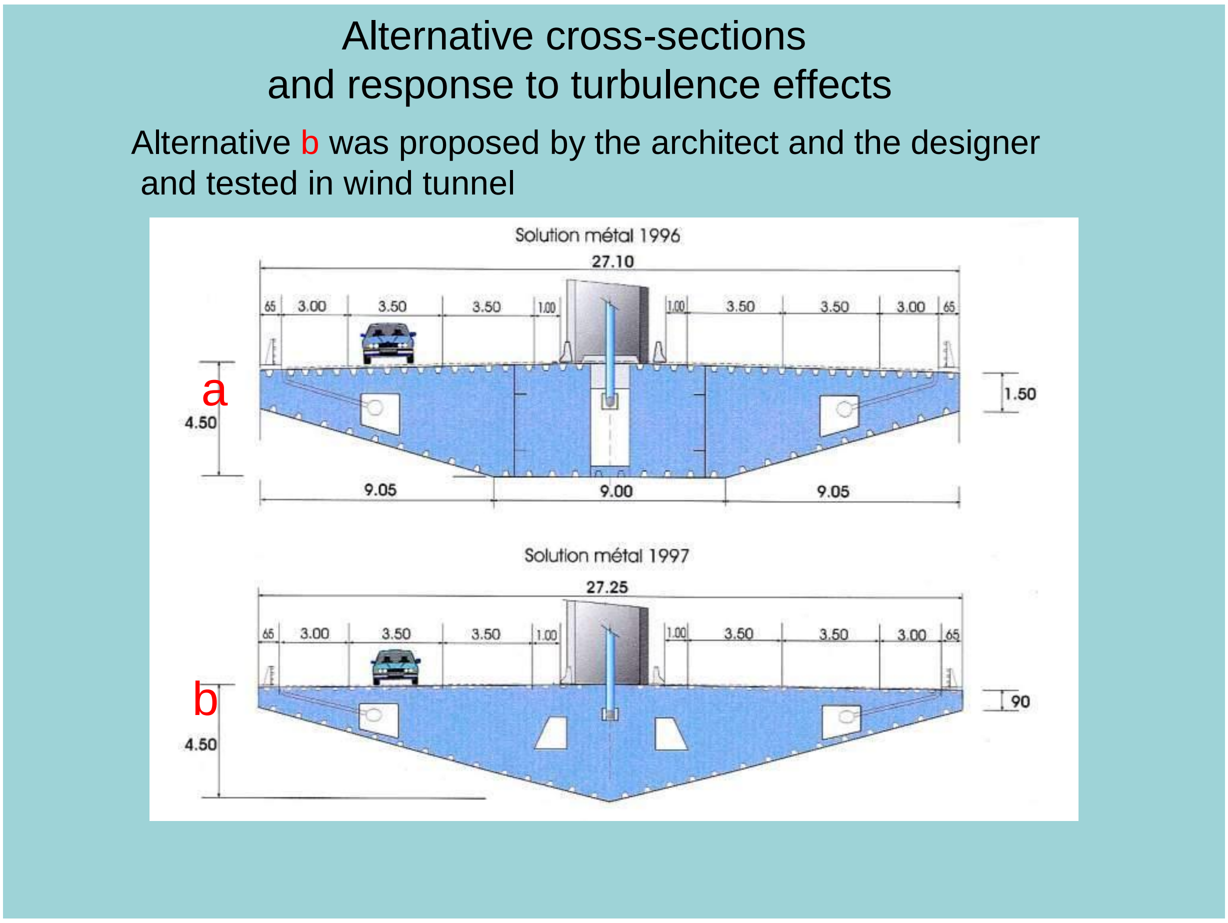


Source: Coste (2009)

<u>The actual form of the cross section of the deck</u>

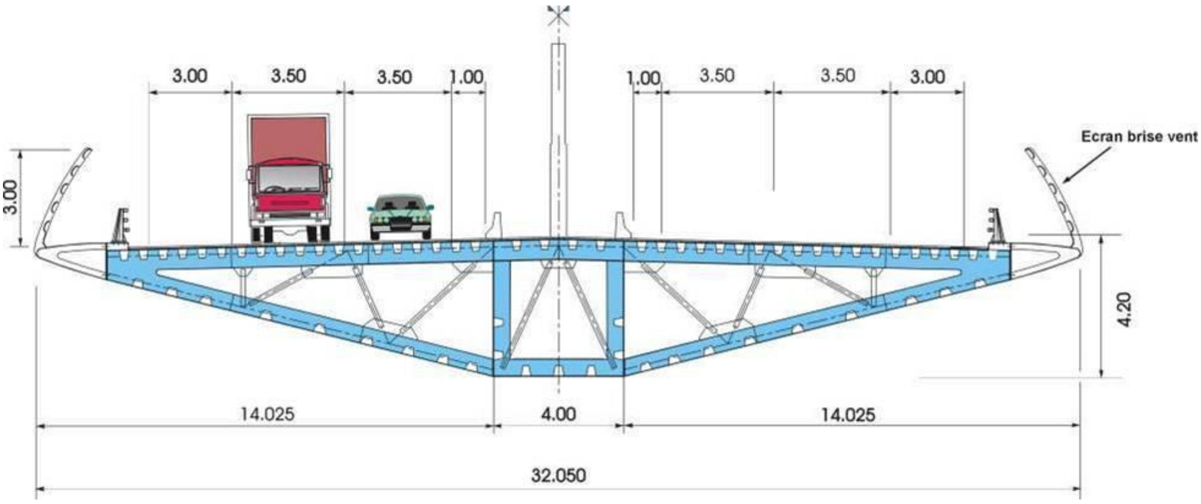
This issue relates to the intensive studies carried out of wind turbulence and its impact on the structure. As Coste emphasized, response to wind actions lies at the core of the design of long span bridge structures and components such as wind screens, pylons and decks. Also the construction of the bridge greatly depended on wind forces and excitations, which represent 25% of the total loads acting on the Viaduct. In response, Professor Alan Davenport, eminent expert on wind and structure issues, was commissioned to investigate the conditions appropriate to building the Viaduct. The structure was subject to tests in a wind tunnel, and the results led to a compromise (see figure 14) between the triangle in the original design and the adequate hexagonal structure (see figure 15).

Figure 14: the deck issue



Source: Coste (2009)

Figure 15: actual form of the deck



Source: Coste (2009)

To further expand on the feasibility of the construction of the bridge, the Millau Viaduct consists of a structure of about 2.5km long and 300m above the Tarn (almost as high as the Eiffel Tower). Yet, drawing on Professor Davenport's analysis of wind forces, Coste outlines the different steps to be taken as:

- Identifying the directional pattern of the wind and then measuring the characteristics based on evaluation on site and statistical records from local meteorological stations;

- Identifying the mechanisms of wind action, such as steady and gust forces, wake and motion induced forces;

- Defining the appropriate model to describe the wind and the structure of the bridge and therefore predicting the subsequent response;
- Deriving model parameters from local wind measurements and wind tunnel tests;

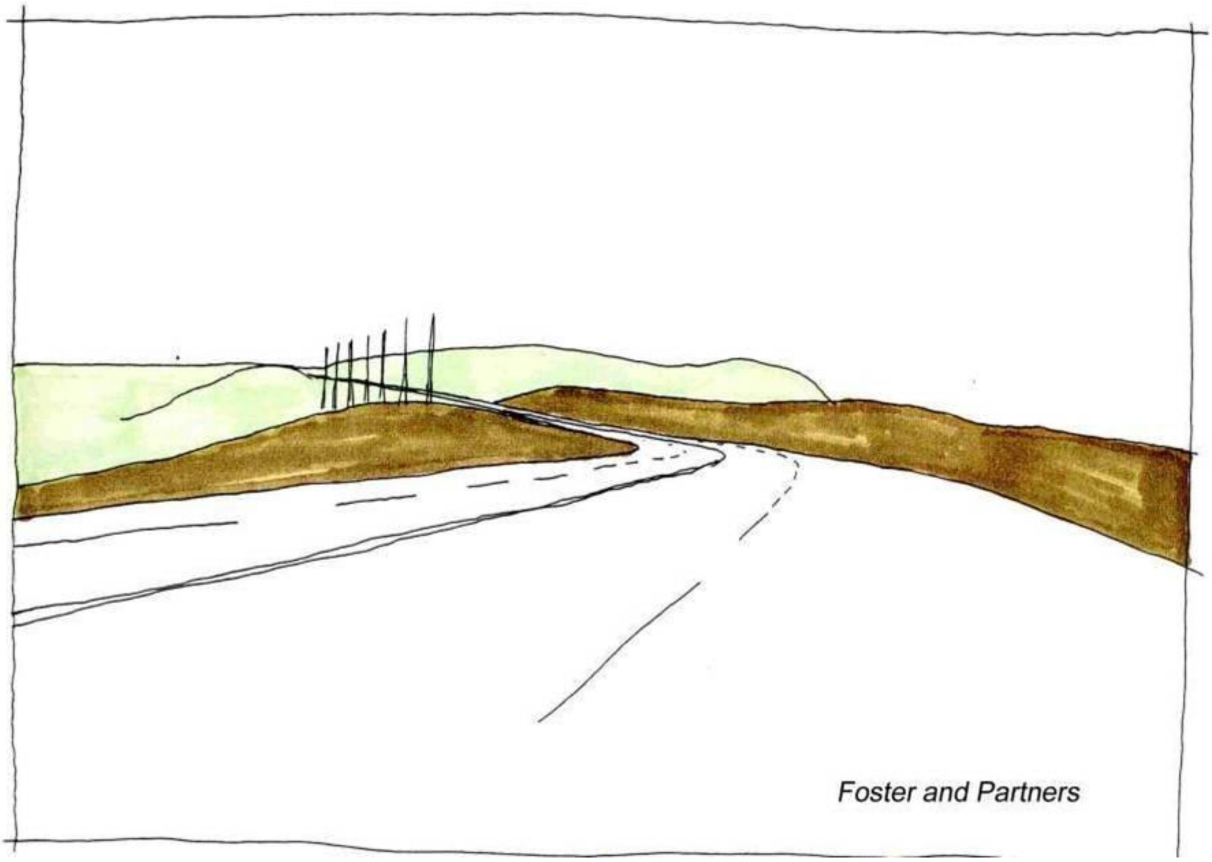
- Assessing the uncertainties of the model and its parameters;

- Controlling the quality of the experimental and analytical results.

However, at this point, it can be stressed that the Millau Viaduct was likely to be built in concrete; it is only after the decision of the Communist Minister of Transport, Jean Claude Gueyssot, to entrust the private sector with the funding and financing of the Viaduct, that the option of building a steel bridge was identified as a worthwhile alternative. Such questions will be further developed in the next part on the procurement and construction phases.

Ultimately, the design of the Millau Viaduct and its development pay specific attention to landscape considerations. Beside the thin and delicate structure designed by Norman Foster, regarding the curve (see Figure 16) it is possible to discern the early idea of the landscape designer Bernard Lassus, also a specialist advisor to Christian Leyrit.

Figure 16: the curve of the Viaduct



Source: Foster & Partners in Coste (2009)

Figure 17: the curve of the Viaduct

Source: PCM (2005)

Later during the construction phase, SETEC, the *Maitre d'Ouvrage*, dealt with the wind issue with an in-house developed program, Pytagore. The model and its parameter were tested against another program developed by the engineering office Greish and the University of Liege. In addition, the Scientific Centre for Techniques of the Built Environment (CSTB: Centre Scientific et Techniques du Batiment).

The concession: delivering the Millau Viaduct under a BFOT scheme

The decision to build and deliver the Millau Viaduct under a concession type of procurement was primarily motivated by the lack of public funds available to provide the infrastructure. Entrusting the private sector was viewed as an alternative to postponing the beginning of the work. Nevertheless, as explained before, this decision implied an issue concerning the legitimacy of accepting private infrastructure, including a toll, on a free highway. Even if initiated by a Communist Minister, at this time this question raised tensions among local politicians. To this purpose, a second and ultimate *DUP* had to be re-passed on 23 November 1999. Indeed, such a decision did not occur in a vacuum. To a large extent it coincided with (1) European guidelines and (2) a national context that marked the end of cross-subsidies for the development of the highway network (cf *partie de Patrick Vieux et Pascal Lechanteur*).

For a long time the attribution of the concession contract relied on the parties' mutual agreement. The Government used to give responsibility for building and operating new sections of the network to the highways companies, with an extended period of concession if needed. The revenues generated by the operation used to be re-allocated to the funding of new sections, for the purpose of developing the network. During the 1990s, the state government had to formalize procedures in order to comply with European principles of nondiscrimination, equal opportunities and transparency, introducing the obligation to advertise projects and call for competition.

The current practice favoured a balanced distribution of investment; to some extent, it was viewed as a tool for developing a coherent network across the country. However such a system of cross-subsidies became incompatible with European requirements as the system, in itself, gave an advantage to the highways companies currently in charge of the network (see the Loi Sapin of 16 September 1999 regarding conditions for the extension of concession periods). Hence, the concession practices involved new rules which were manifested in:

- the spread of a specific legislative and accounting system that forbid the Government to warrant the debt of the highways companies or to extend the period of concession;

- the implication of local government and authorities as actors in the funding and financing of the operation, implying the increased participation of users in the evaluation of the conditions and quality of the service.

From this perspective, the case of the Millau Viaduct well illustrates these new rules, since it was planned initially as a free highway. A toll was not expected but the insufficiency of public resources led to a second *DUP*, the State decree of 23 November 1999, and the revision of the *SDRN*, the Master Scheme for National Roads, to conform to the previous law of 30 December 1982 (LOTI).

Regarding the Millau Viaduct, such national context introduces the conditions for attributing the procurement of the infrastructure to a private contractor.

From the concession concept to the signature of the contract: a 'three steps' process

<u>First step: tendering process and candidates' selection</u>

The call for tenders was published in December 1999. Candidates had to provide a basic case with several variants in respect of the functional imperatives of the architectural and technical design. The criteria to judge the proposals were:

- technical criteria:
  - the technical quality of the case;
  - the period and delay of realization;
  - the master scheme for quality, the control mechanisms and monitoring of the quality of the studies;
  - the governance structure – the role distribution among the MOA, MOE and their supply chain;
  - the proposed scheme for the operation and maintenance of the infrastructure;
  - the level of service and safety and;
  - metrological monitoring;

- financial criteria:
  - the financing structure and the part of stakeholders' equities involved in the financing;
  - the agreement and level of involvement of potential partners;
  - the level of additional financing means available to face potential delays and cost overrun during the construction phase;

- the formal assurance to pursue the operation of the infrastructure and deliver the services even in case of cost overrun and insufficient revenues;
- the expected internal rate of return;
  - the period of concession;
  - the toll policy and subsequent fee structure.

On 24 January 2000 (the deadline for handling in proposals), four candidates had applied but the last one withdrew from the competition:

- Societe Eiffage (France) involving Eiffage Construction and Eiffel;
- Societe du Millau Viaduct: ASF, Egis, Groupe GTM, Buygues Travaux Publics, SGE, CDC Projets, Tofinso (France) et Autostrade SpA (Italy);
- Generale Routiere: GTI (France) CINTRA, NECSO, Acciona and Ferrovial Agroman (Spain);
- Dragados (Spain), Skanska (Sweden) and Bec (France).

These candidates comprised three international consortia, and Eiffage which decided to bid alone with its subsidiaries. The candidates had ten months to provide the complete case by 21 November 2000.

Source:

<u>Second step: Judging and elaborating bidders' proposals</u>

The tender includes:

- the rules of the tendering and bidding process;
- the technical studies of the Millau Viaduct;
- the results of the public enquiries of 1993 and 1998;
- the report of the enquiring committee and the commitment of the State/Government;
- a concession contract template that welcomed bidders' amendments as far as they were explicitly justified.

Source: Coste (2009)

This template was aimed at allowing the State to assess the risk transfer entailed in each proposal and the nature of the commitment (guarantees) required by candidates, while comparing the different proposals under a standard format.

After 21 November 2000 the committee, which had accepted the candidates ten months before, undertook a thorough analysis of the three subsequent offers. It was divided into three working groups:

- legal – assisted by the law firm Clifford Chance;
- financial – assisted by PricewaterhouseCoopers;
- technical.

The committee interviewed the three bidders in February 2001 and its decision was communicated on 26 February 2001. The day after the Minister announced Eiffage as 'expected concessionaire'. Yet the State had still the opportunity to negotiate with other candidates.

Figure 18: the concession offers

Source: Coste (2009)

<u>Third step: negotiating and finalizing the contract</u>

This phase was particularly quick; the negotiation required less than a month, with the redaction of a contract template over the previous phase deemed to have eased the assessment of the offers. In addition, the quality of the technical element of Eiffage's proposal contributed to the evaluation process since the contractor's conception of risk sharing met the State's expectations. In compliance with the current *jurisprudence* (case law), the contract was signed on 30 May 2001. The decree of 8 October 2001 approved the concession contract which was published on JO (official journal) on 10 October 2001, enacting the concession contract.

However, referring to the context outlined above, the signature of this contract reflects on the nature of the risks and their allocation, questioning whether the concession of the Millau Viaduct would constitute an exemplary case of 'new' concession BFOT contracts?

The contract was elaborated in close collaboration with the Road Directorate. It implies two interpretations of the underlying risk issues:

- risks as 'the entrepreneur's own risks'; *versus*
- risks as 'the entrepreneur's own profits'.

The traditional principle of the French regulation of concession contracts means that the responsibility for the subsequent public services is transferred to the concessionaire, which is expected to use its expertise and competencies to deliver the project. An article in the convention of the concession of the Millau Viaduct formulates this principle in these terms:

> “Art 2: the CEVM (Compagnie Eiffage du Millau Viaduct) committed to finance, conceive, operate and maintain the infrastructure to its own costs and risks according to the agreed specifications”.

However this formulation could be viewed as obsolete regardless of the actual risk sharing process, and downplays the underlying notion of ‘partnership’ and the risks as ‘the entrepreneur’s own profit’. In fact, this does not mean that the contractor bears the responsibilities and is exposed to all risks alone under every circumstance. Indeed, the current case law entails principles concerning:

- unforeseeable conditions;
- *le fait du prince:* an expression that refers to a decision that would depend on the State and would constitute an authoritative prescription;
- a case of force majeure.

On the one hand, the law does not aim at confirming the absolute or exclusive responsibility of the concessionaire but rather at ensuring the continuity of the public service. However, the contractor is naturally interested in the operation, and therefore the subsequent risks, of the infrastructure due to the incentive structure of the contract: the one who operates the infrastructure can collect the profits or the losses. On the other hand, the concessionaire/ contractor bears the construction risks of the project since he is responsible for the whole procurement and delivery process.

In other words, the corollary of ‘the entrepreneur’s own risk’ principle is a greater autonomy and capacity of action in the hands of the concessionaire. The State entrusts him the same rights for the construction, including the capacity to buy land. Therefore the State supports the compensation costs related to the existence of the infrastructure, such as noise, the protection of the environment and visual disturbance, although such effects are dealt with at a fixed rate so that the concessionaire has an incentive to minimize them. In addition, the contract does not guarantee the financial equilibrium of the business case of the concession (neither for debt nor for financial return). Some concession contracts used to encompass conditions whereby the work programme could be transferred or reconsidered if the concessionaire was unable to finance it due to cash flow or debt problems. In this case the solution consisted of transferring responsibility for financing to the State, since it had to support the cost of delays. This solution was considered as an ‘adjustment mean’ but it amounted to the State supporting a risk that it could not manage effectively since it had no way of influencing the investment and equity policy of the contractor/concessionaire or his level of debt.

Such relation between investments and financial return rates was widespread at the time when the State was involved directly in financing and funding of highways, an intervention that materialized through State warranties. However, such practices have been banished by the ‘new generation’ of concession contracts; in contrast, the contracts stipulate that the concessionaire could lose his rights if he does not secure the needed resources and face the required expenses on time.

Nevertheless, there is no standard and definitive process regarding risk-sharing practices. In fact, the principle of allocating risks to the party best able to manage them raises practical issues and difficulties. The State has also to take into consideration *jurisprudence* (case law), the economic stability of the country, the financial arrangement, and how risks and costs are balanced in practice. In other words, the more accurate the specifications associated with the contracts are, the better the risks supported by the State are appreciated.

Finally, the ‘entrepreneur’s own profit’ principle implies a correct reward for the risks. The reward should not be excessive and should be proportional to the risks. Of course, this depends on the characteristics of the project, on how realistically the contractual configuration treats the effective risks, and the risk matrix. In this domain there is no absolute truth and relying on market mechanisms does not allow for a thorough analysis of the terms of the contract and the conception issues underlying the process of risk allocation.

Main features of the concession contract

- The concession is at the concessionaire’s own risks and own profits;
- The total period of the concession is 78 years:
  - three years of construction: 36 months plus three months without penalties;
  - 75 years of operation.
- Respecting the architectural design is compulsory;
- The concessionaire is responsible for the development of the technical aspects: at this stage the State did not require a particular method of construction, either steel or concrete;
- The toll rates should be approved by the Minister of Transport;
- The durability of the structure is guaranteed for 120 years.

Source: Coste (2009)

Financing and risk allocation issues

The total investment represents about EUR 350m (2 Mds FF) and was financed primarily through the equity of Eiffage, the shareholder of CEVM, the actual concessionaire. The EIB contributed to the financing and awarded a loan to Eiffage S.A. on 28 October 2002, because the project is of European interest (ie an important piece of infrastructure for the development of the region and for improvement of the quality of life in Millau). The capital expenses related to the Viaduct could be summarised as follow:

- Eiffage: 100% of the financing of the site works (EUR 320m);
- The European Bank of Investment (EIB): a loan of EUR 50m to Eiffage;
- The State financed the end of the A75.

The profitability of the infrastructure relies on the toll barriers, whose revenues constitute the main source of income for the concessionaire (CEVM). In this regard one of the reasons for selecting Eiffage’s offer was the absence of subsidy from the government. It is the only toll on this highway. This toll aimed at compensating the concessionaire for the risks taken over such an ambitious construction project. All the profitability of the infrastructure is based on it.

The duration of concession (75 years) was calculated on the following basis: traffic / tariff. However it can vary according to performance, indeed, it can be reduced to 44 years in the case of increasing traffic. The toll rates are regulated by the contract and indexed to the retail price index. The rates at the opening of the Viaduct in 2004 were:

- EUR 6.1 (40F) in July and August;
- EUR 4.6 (30F) for the rest of the year;
- EUR 19.4 (125F) for trucks.

Differentiated rates for the months of July and August were part of Eiffage's offer when the company bid for the concession. It is a way of discriminating the demand by charging more for the traffic generated by holiday trips and transit via Millau.

Concerning the concession period, the concession will expire on 31 December 2079, 75 years after the opening of the Viaduct. On the one hand, such a long concession period aims at:

- improving the visibility and paying off the debt;
- easing the amortisation and making the infrastructure more profitable for the concessionaire.

On the other hand, it creates an opportunity for the concessionaire to benefit from 'undue income' by generating excessive revenues from the operation of public infrastructure. To this purpose, the period of the concession can be reduced:

- upon the concessionaire's request;
- as soon as the accumulated income is greater than EUR 375m (accounting for a discount rate of 8%);
- but not before 31 December 2044.

To put it differently, if the generated revenues exceed EUR 375m, the infrastructure could be transferred to the State from 44 years of private ownership (including the period of construction).

Once the construction risks had been dissipated, Eiffage re-financed the Viaduct, calling on various banks and funding agencies. "Travellers along the major European transport corridor between Paris and Barcelona benefit from the EIB's EUR 143m loan for the long-term maintenance of the Millau Viaduct. In 2002, an initial EUR 50m EIB loan supported the construction of the 2.5km-long bridge to relieve a traffic bottleneck on the A75 between Clermont Ferrand and Béziers at Millau. The 2007 loan will ensure that the bridge is properly maintained after the initial years of operation and supports the European objective to improve the movement of people and goods within the Union." (EIB,2008)

Source: EIB (2008)

Construction plan

- 10 October 2001: Beginning of construction;
- 14 December 2001: the French Ministry of Transport puts down the first stone of the bridge;
- January 2002: beginning of piers and abutment construction;
- September 2002: beginning of assembling the steel deck;
- 9 December 2003: completion of the pier construction;
- 25/26 March 2003: launching of the steel deck;
- 28 May 2004: joining the two sections of the deck;
- October-November 2004: installation of pylons, setting up of 154 cable stays and dismantling of temporary piers;
- 14 December 2004: the President of the Republic, Jacques Chirac, inaugurates the Millau Viaduct.

The complexity of the construction process mainly relates to the launching of the steel deck. This process requires favourable meteorological conditions. Notwithstanding this complexity, this method enabled Eiffage to achieve a reduction of three months in the time taken for the delivery of the bridge, a total of 36 months. In addition, the steel method involved fewer working hours in altitude since most of the related work was done in factory or at ground level on site. Consequently it reduced the risk of injuries and death.

Main organisations involved

- The State represented by:
    - RCA;
    - AIOA.
- The Contractor/Concessionaire:
    - *MOA*: CEVM;
    - *MOE*: Group SETEC and SNCF;
    - Supply chain for the construction:
        - Civil engineering: Eiffage TP;
        - Steel manufacturer: Eiffel CM.
- Engineering office:
    - Civil engineering: STOA/Eiffage TP/EEG-Simecsol (+ Thales+ SERF)/Arcadis;
    - Steel and launch of the deck: BE Greisch.
- Experts advising the *MOA*:
    - J. Foucriat;
    - J. Piccardi;
    - F. Schlosser;
    - M. Virlogeux.
- Architect: Norman Foster & Partners

Source: Coste (2009)

Regarding the organization, CEVM, which is wholly owned by Eiffage, constitutes the contractor and is therefore responsible for *la Maitrise d'Ouvrage* (MOA), transferred by the State according to the concession contract. CEVM had an arrangement with two other subsidiaries owned by Eiffage: Eiffage TP and Eiffel. Indeed these subsidiaries also contracted the work to other subsidiaries of Eiffage such as Forcum and Appia or other firms when the best competencies were not available within the Group Eiffage (for example, Freyssinet for stay cable technology). The main actors all have ISO 9001 certification.

Concurrently, *la Maitrise d'Oeuvre* (MOE) is assigned to an external organization, the Engineering Office SETEC and the Engineering Department of SNCF. This *MOE* ensured the construction process complied with the plan and validated the wind-related calculations .

In addition, a large group of experts assisted the *MOA* with important technical choices. Here, the State and its representatives from the administrations concerned played a role of control. In this regard, control meetings were organized to ensure that construction methods were correctly applied, the architectural design was respected, and the landscape and the environment were taken into consideration on site. Such a role for the State is specific to the concession arrangement; rather than controlling the process as a *MOA*, the role of the State becomes that of ‘controlling the control’, represented by George Gillet and Francois Lepingle within the ACDC. To this purpose, a second expert committee was established to ensure the fulfilment of the contract specifications and the durability of the infrastructure. This committee was also chaired by Jean Francois Coste and involved experts from the first evaluation committee of 1993:

- Francois Baguelin, geotechnical engineer;
- Emmanuel Bouchon, bridge and civil work engineer at SETRA;
- Alan Davenport, professor and international expert in the aerodynamism of bridges;
- Manfred Hirt, professor and international expert in steel construction;
- Roger Lacroix, engineer, expert in bridge construction;
- Bernard Lassus, landscape architect;
- Marcel Rat, geologist;
- Rene Walther, professor and expert in bridge construction;

Source: Coste (2005) La mission des experts du Millau Viaduct.

D PROJECT DELIVERY

The project was delivered on 14 December 2004, three years after putting down the first stone and 38 months after the commencement of construction. Despite some benign accidents and bad weather on site, the success in completing the project on time relates to:

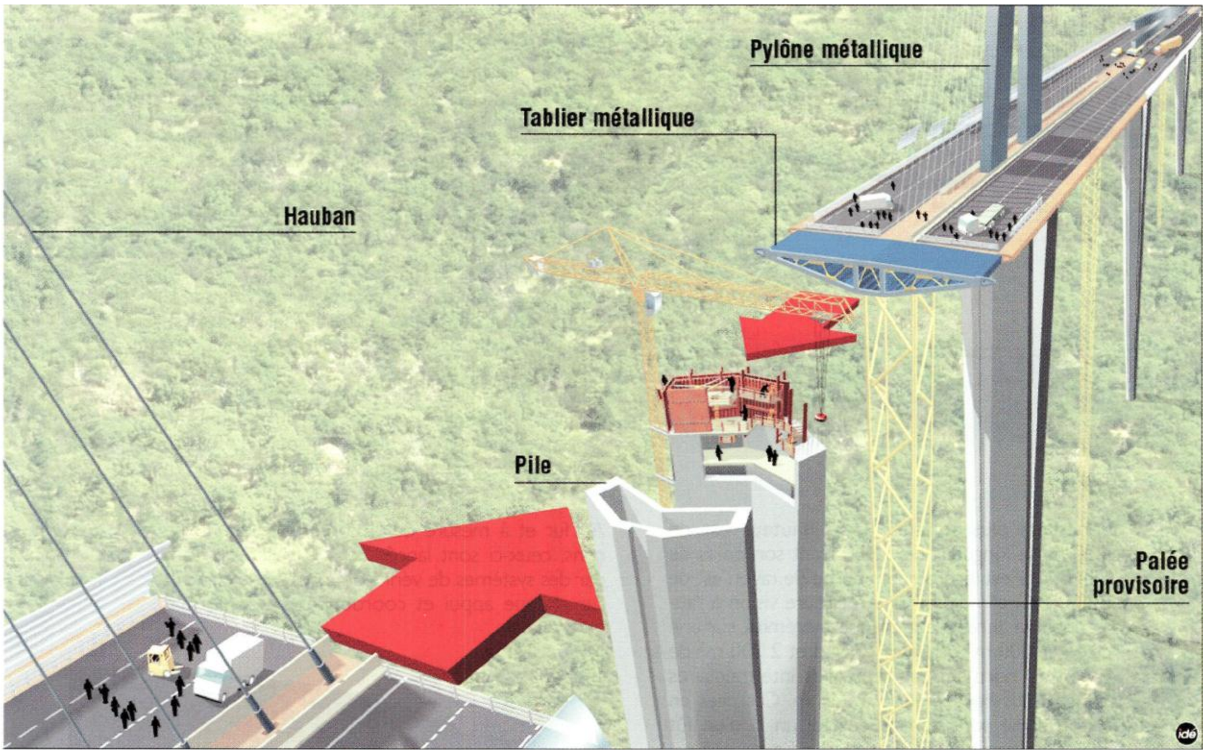
- the choice of constructing the bridge in steel (compared to about 52 months in concrete) which allowed:
  - building the piers and the deck at the same time;
  - pre-fabricating the work pieces in factory.
- the choice of the launching method;
- integrated research and studies;
- the work organization consisting of autonomous working units.

Source: Coste (2009)

The launching phases rely on the construction of temporary piers to then launch steel pieces from both north and south sides of the Viaduct. Each part of the deck is first assembled in six weeks, and then launched in three days. This construction cycle reduces vulnerability to bad weather, as only the three days of launching involve high altitude work and require meteorological considerations.

Source: Legrand (2002)

Figure 19: construction principle of the steel deck



Source: PCM (2002)

Again, such choices by the concessionaire complied with the wishes of the State. As explained by Jacques Huillardle, whether the concessionaire was responsible for the construction methods, the choice of building the deck in steel made a reduced construction period possible and allowed the Viaduct to open to the public in three years. This aim concurred with State and local government concerns, bypassing Millau to avoid the city bottleneck whilst making the city more accessible.

From a more practical perspective, delivering the project on time was also facilitated by the State and the Administration, who wished the use of the Viaduct to commence as soon as possible. The AIOA under the direction of George Gillet provided the access roads for the construction site at the earliest stage. Among these facilities were:

- a 10km private road for the needs of the construction site, which was then reforested to avoid any impact on the landscape;
- two bridges to cross the RD 992 on the *Plateau de France* and the Tarn, and a railway and another departmental road at the end of the valley.

To this extent, the convoys related to the Millau Viaduct did not interfere with local traffic, which greatly benefited Eiffel in transporting the steel piecework.

E FUNDING

The ultimate funding of the Millau Viaduct relies on users, trucks and motorists, and depends on the BFOT – PPP type of procurement.

According to P. Bourrier, PPP and concession types of procurement introduce themselves as innovative forms of funding and financing; the entire, or part of the, financial and construction risks are the responsibility of the private partner. His revenues are generated from toll collection or subsidies. Drawing on different cases of financial engineering, local government could participate in plenty of arrangements for urban transport systems, highways or exceptional infrastructure. In general, the principle is the following: the concessionaire seeks to offer the best level of service to the users and organize the operation in accordance. He evaluates the estimated costs and maintenance expenses. Taking into consideration specific toll rate policy, the level of traffic, or the level of services, the concessionaire selects the most appropriate mode of financing and then determines the financial return on his investment. For the Millau Viaduct, the concessionaire investigated the tariff rates so as not to require any subsidy from the State. Recalling the aim of the Viaduct, relieving Millau's bottleneck, the adopted solution consisted in discriminating between current and seasonal traffic. The rate was fixed at EUR 6.50 in July and August and reduced to EUR 4.90 during the rest of the year. Neither local governments nor the State contributes to the funding of the services in any way, i.e through subsidies or traffic guarantees, so it does not cost taxpayers anything.

F PROJECT COSTS

- Project development: EUR 15m;
- Preliminary work: EUR 10m;
- Construction and delivery: EUR 320m (including 1% for economic and regional development).

Source: Coste (2009)

Traffic forecasts

From the opening of the Millau Viaduct the level of traffic was superior to the forecast. The tariff policy proposed by the concession contract was based on the predicted revenues. Eiffage relied on SETEC for the traffic forecast. In 2005, 4,400,000 vehicles crossed the Viaduct, 20% more than anticipated. In 2008, there were 4,670,449 vehicles and heavy goods traffic represented 8.39% of the traffic.

Source: (Coste, 2009)

H OPERATION

The toll barriers of the Viaduct comprised 14 lanes in 2004, and were extended to 18 lanes since 2005 due to traffic flows which were greater than forecast. In this regard:

- traffic flow varies from 1 to 17, from 2,500 to 62,300 vehicles per day in July and August;

- recruitment of employees adapts to the flows, with 54 permanent cashiers and 33 additional persons over the summer;

- fees are collected manually, as subscriptions systems are not appropriate due to the absence of other tolls on the highway (the Viaduct is on the A75 – a free highway).

Besides the toll activities, the Viaduct includes four additional services:

- security: five employees and five polyvalent cashiers for July and August;
- Maintenance: four employees for day-to-day maintenance (technical care of the lanes, machines, electrical systems, etc.);
- communication: six employees including four permanent tourist guides.

The importance of the communication service could be explained by an unexpected effect: the Viaduct became one of the most important tourist sites in the region and receives from 600,000 to 900,000 visits per year, 15,000 visits with charge. Spin offs from the Viaduct also generate revenue.

Source: Visit to the Millau Viaduct (23/12/2009)

I CONCLUSION AND MAIN ATTRIBUTES OF SUCCESS

Recalling the FNTP's Conference in October 2003 chaired by the Director of the Road Directorate Patrice Parisé, Jean Francois Coste, Pascal Lechanteur and Marc Legrand outlined the main factors of success as decisions related to:

- the initial planning and route;
- the procurement decisions and the concession;
- the technical choices, in particular the decision to build the bridge in steel;
- the people who contributed to the different phases of the Viaduct.

Source: Viaduc de Millau, Revue Travaux n°216 , Février 2005

Taking the whole project process into consideration, the success of the Millau Viaduct is manifested in:

- *The planning:* from the studies of the initial route to the choice of the project. The design of the Millau Viaduct consists of the original design proposal of the Administration (SETRA) conceived by Michel Virlogeux. However, expert and public scrutiny challenged this initial project leading to the involvement of the British architect Sir Norman Foster and international expertise and competencies. As a result, the project improved over the process.

- *The procurement:* the success of the BFOT process relies on sound project governance and treatment of risks. The Millau Viaduct is a case of cooperation and coordination between actors at the different stages of the project. The procurement stage drew greatly upon the previous conception stage led by the Administration.

- *The construction:* the Millau Viaduct does not constitute a technological innovation in itself but is characterized by a genuine and innovative application of existing techniques. The decision to build the deck in steel is part of this process and helped in reducing delays, delivering the project on time and providing good safety conditions for workers on site.

Ultimately, the Millau Viaduct represents a good balance between State control and constructive interactions with the concessionaire EIFFAGE.


Source: allendemontreal.wordpress.com/le-monument-2/

J BIBLIOGRAPHY

CEVM (?) *Historique d'un projet né en 1987. Quelques étapes significatives d'un grand viaduc à Millau.* Unpublished document.

Coste J-F (2009) *The Millau Viaduc,* Royal Aeronautical Society, 20th October 2009.

Coste J-F (2005) *Le viaduct de Millau: la creation d'un haut lieu.* PCM Décembre 2005

Coste J-F (2005) *La mission des experts du Millau Viaduct .* Unpublished document .

Coste J-F (2006) *The Millau Viaduc,* Presentation at French Economic Mission in Ankara/Turkey.

EIB (2008) *Project Finance magazine applauds record number of EIB projects in 2007, /* http://www.eib.europa.eu/about/press/2008/2008-018-project-finance-magazine-applauds-record-number-of-eib-projects-in-2007.htm

Gillet, G & Mutel, JF *Millau Viaduct , de l'idée d'un pont à sa mise en service* http://www.mtq.gouv.qc.ca/portal/page/portal/Librairie/Publications/fr/minist... [pdf] (1972 ko) (17/02/2010)

Godfrain J. (2004) *Millau Viaduct, an exceptional steppong stone for the economic future of the south of Aveyron* , Ponts Métalliques 2004 pp.8-11:

Legrand, M (2002) *La concession du Millau Viaduct .* PCM Décembre 2002.

Ministere de l'Equipement (2004) « Le Millau Viaduct , un ouvrage exceptionnel initie par le Ministère de l'Equipement » Dossier de presse. http://www.environnement.gouv.fr/IMG/pdf/millau_cle148b14.pdf (17/02/2010)

Virlogeux M*. Bridges with multiple cable-stayed spans* Structural Engineering International 1/2001, published by the International Association for Bridge and Structural engineering, Zurich, Switzerland

K GLOSSARY

Acronyms	French meaning	English translation
ACDC	Authorite de contrôle auprès du concédant	The control authority of the concessionary entity (the State).
AIOA	Arrondissement Interdépartemental des Ouvrages d'Art de l'autoroute A75	The inter-departmental authority for the bridges of the A75 Highway.
CEVM	Compagnie Eiffage du Millau Viaduct	Eiffage Company of the Viaduct of Millau. (The concessionaire).
CSTP	Centre Scientifique et Technique du Batiment	Scientific Centre for Built Environment Techniques
DDE	Direction Départementale de l'Equipement (Ministere de l'Equipement)	Departmental Direction of the Equipment (Ministry of Transport and construction)
DUP	Déclaration d'utilite publique	Declaration of Public Utility (for public infrastructure projects)
LOTI	Loi d'Orientation sur les transports interieurs	The fundamental of 30 December 1982 regimenting the offer of public transport services
MOA	Maitrise d'ouvrage	Client
MOE	Maitrise d'œuvre	Designers
RCA	Mission de contrôle des societes concessionaires d'autoroutes (Ministere de l'Equipement)	Control agency for motorway concessionaries (part of Ministry of Transport and Construction)
SETRA	Service d'etudes techniques des routes et autoroutes, rattache a la Direction des Routes (Ministere de l'Equipement)	Service of Technical Studies for Roads and Motorways, linked to Directorate of Roads (Ministry of Transport and Construction)
SDRN	Schema Directeur des Routes Nationales	
Jurisprudence		Case law