THE FINAL SECTION OF THE A89 AROUND PARIS: MANAGEMENT OF THE RISKS OF THE PROJET

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SUMMARY

The final section of the A86 around Paris comprises two traffic levels, 10 km long, on top of each other in the same tunnel, for use only by cars, drilled with a 10.4 m diameter Tunnel Boring Machine (TBM); an underground interchange midway connects both levels to the surface roads. This innovative project is currently under construction; the first section will be opening in autumn 2007.

The project is nothing like anything that has been constructed before and its technical solutions required the setting up of specific committees, as the project, despite its evident qualities, aroused strong local opposition, often on principle, based on the supposed dangers of its innovative nature. In fact, the final design was based on a search for possible simplifications and on proved techniques: only their use in combination could be considered innovative.

The work is being carried out under a PPP (public-private partnership), with its capital cost, estimated at €1.8 billion, financed entirely by tolls, with no guarantee from the State; numerous studies were carried out in order to estimate, and then to control, the risks and to assess the expectations of motorists in this type of innovative construction, and also their willingness to pay.

Finally, the construction work itself posed a challenge, the risks of which have had to be controlled, both on a technical level, as the route of the tunnel crosses 13 geological horizons and 4 water tables, and on a level of the impact of the construction on the particularly sensitive residential areas to the west of Paris.

Cofiroute, an autoroute concessionaire, whose shareholders are the Vinci Group (82.4%) and the Colas Group (17%) was appointed to carry out the work.

1. RISK MANAGEMENT AT THE EARLY STAGES OF THE PROJET

The final length of the A86 was initially conceived as a traditional autoroute solution at ground level or in a cutting; such routes encountered strong opposition and, in 1988, Cofiroute proposed a solution entirely underground, using an innovative concept for the separation of traffic, for which a toll would be charged; there was a need, therefore, to manage the following risks in particular:

1. adaptation of the relevant standards in relation to the innovative characteristics of the project and finalising of the basic design;
2. parameters of the financial equation (capital cost, acceptability of the proposed toll charges, levels of traffic).

1.1. The adaptation of the relevant standards and the finalising of the basic design

The tunnel reserved for cars was innovative in more than one way: it did not comply with current technical standards and the risks of drift, particularly in relation to geometry, were very high; there was a need, therefore, to implement processes and working rules to manage this risk.

The various Government Ministries involved (mainly the Ministère de l'Equipement and the Ministère de l'Intérieur) set up specific committees to check and to reflect upon the technical proposals, and also to establish and to validate the new standards arising from the work, particularly in the fields of geometry (slopes, radii and width of the traffic lanes according to the speeds and the various sections of the construction), signage and safety (method of access and of working for the emergency services, ventilation, smoke extraction, etc.). These committees formed the technical body for the tunnels reserved for cars from 1991 to 1992 and made the changes to the corresponding statutory texts.

The rules that prevailed at that time were rules of common sense:

1.1.1. *Solutions based more on simplification and ruggedness than on innovation:*

This applies, for example, to the decision to separate the different types of vehicles; obviously this choice, which is still considered to be an innovation, is, above all, intended to keep similar vehicles together, and thus to simplify problems in connection with accidents and fires.

The principle of two independent traffic levels (on top of each other), connected by communication stairways, forming refuges for the public, every 200 m, is merely a simple transposition of the principle of mono-directional twin tunnels.

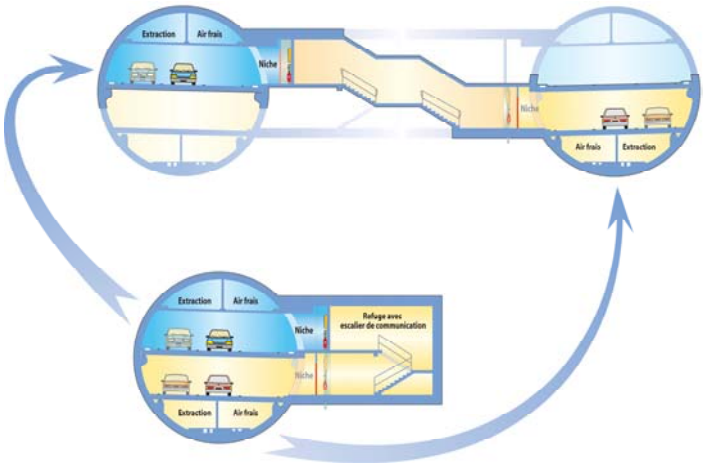

Diagram 1 – equivalence between the project concept and a twin-tunnel

The decision to reserve within the typical section an area for each function and, in particular, an area to be used exclusively for signage (see diagram 1) was also based on simplification.

The objective of fluidity in the construction, an objective that divides the number of vehicles in the tunnel for a given flow rate by five, is based, obviously, on the principle of simplification of the problems in connection with safety.

1.1.2. *The use of proved techniques wherever possible:*

This applies in particular to the design and the sizing of the ventilation and the smoke extraction, public refuge areas and facilities for access by the emergency services from the surface or from unaffected parts of the tunnel.

In the same spirit, toll stations have systematically been provided at entrances since the end of the 1980s; this decision has turned out to be particularly wise when it has been necessary to be absolutely sure that the entrances have been closed in the event of an accident.

1.1.3. *The observation, critical analysis, and even the modelising, of the operation of existing constructions:*

The sizes of the traffic areas of the tunnel for use by cars were determined by observing, in particular, the widths of the vehicles, but also the behaviour of motorists in tunnels (wall effect); this has led to the defining of a "psychological width" at the driver's eye level, leading to the choice of lane width (see diagram 2).

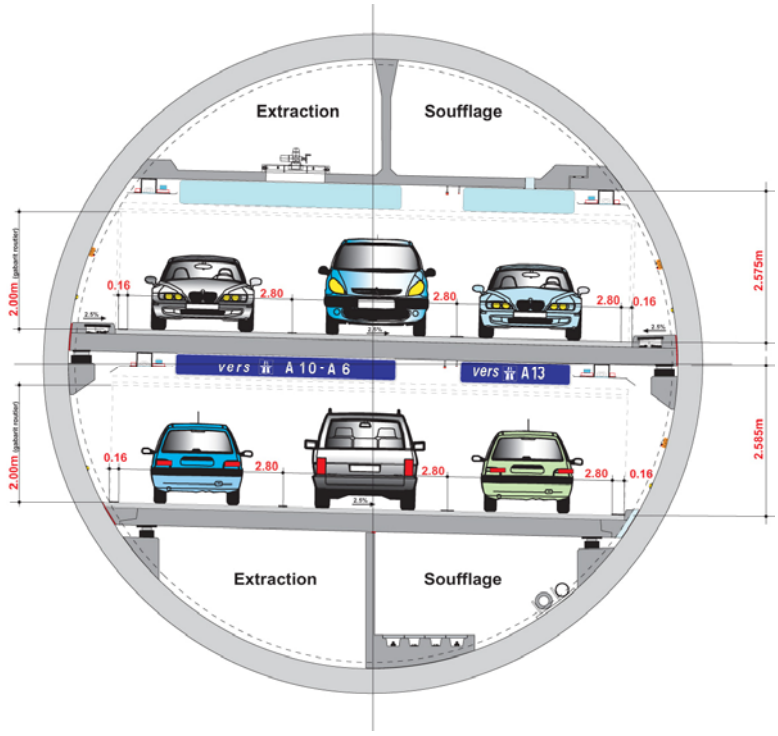

Diagram 2 – Transversal section of the tunnel

Very close observations were also made on the operation of rapid urban thoroughfares, inserted into an urban road network, with traffic light-controlled junctions, in order to assess the ways of managing and regulating traffic flows at the interfaces; it must be borne in mind that the project has to work as an island of fluidity in an ocean of congestion.

In addition to the geometry of the main tunnel, the entrances to and exits from the tunnel, located on the right at the lower level and at the left on the upper level (see diagram 3), required numerous studies into existing constructions and life-size tests; the third lane will be used as a lane reserved for incoming vehicles (entry sliproad) and for outgoing vehicles (exit sliproad); it will be neutralised between the exit sliproad and the entry that follows it.

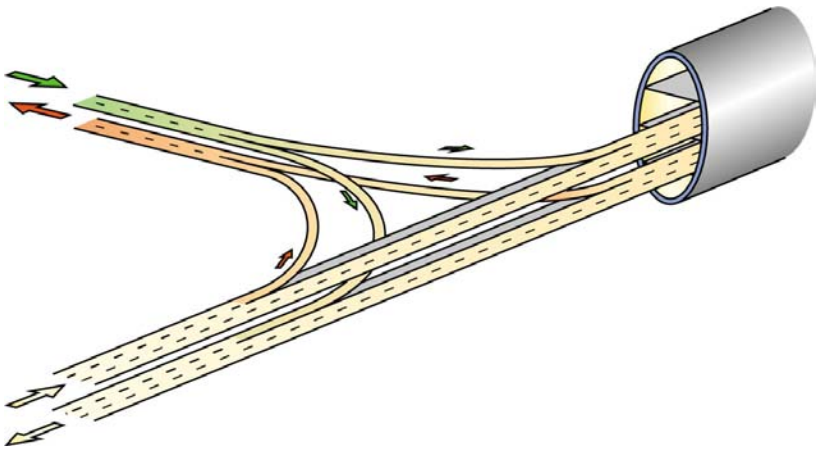

Diagram 3 – dedicated entry and exit link roads at the interchange with the A13

The interchange provided midway, which links the tunnel, at a depth of about 20 metres, to the A13 autoroute, on the one hand, and to local roads, on the other hand, comprises 8

link roads within an extremely restricted site; it occupies only one-fifth of the space of a traditional construction would, providing the same functions and its final design required extensive studies to ensure that this complex construction is simple, attractive and safe for motorists:

- the entrances are all located just before a particularly congested interchange,
- the exits are all located after this interchange,
- the entrance link roads slope downwards and do not include any underground decision points, in order to avoid a particularly dangerous combination of "decision point in tunnel + high speed + chimney effect",
- the exit link roads slope upwards (thus low speeds, natural tendency for fumes to escape behind the traffic) and do not include any underground decision points.

1.1.4. *Conclusions on this phase*

The committees established by the State worked willingly to integrate the proposals of both the State and of the concessionaire; this method of working, which heralded "concurrent engineering", enabled the advantages of the public and private sectors to be combined and permanent dialogue enabled a balance to be found between different points of view, thus preventing the concept from drifting.

The State then implemented the democratic consultation process on the selection of the project, which concluded, at the end of 1995, in a declaration of public utility; the concessionaire took the time to fully understand the terms of the financial equation.

1.2. Control of the parameters of the financial equation (capital cost, acceptability of the proposed toll charges, levels of traffic)

The lifespan of the concession is 70 years. The capital cost, estimated at €1.8 billion, and the operating expenses will be financed, with no contribution from public authorities, by income from the tolls; the level of traffic in 2011 is estimated at 50,000 vehicles per day and the toll charges at €6 at peak times and €2 at night.

The main risks to be managed were the detailed design and construction risk, the commercial risk and the financing risk.

1.2.1. *Management of the detailed design and construction risks*

As far as the concession is concerned, Cofiroute and its shareholders have provided evidence of the optimum management of this risk by awarding a "design and build" turnkey contract, at an overall lump-sum price, to a joint venture formed from the shareholder companies.

This method has been used for 37 years and has enabled the financing and the design and build of about thirty sections of autoroute with a total length of 1000 km.

The same method has been applied to the A86 project and Cofiroute has awarded a single overall, lump-sum contract for the design and build of the project to the Socatop joint venture (Vinci 64%, Eiffage 17%, Colas 17%); this joint venture was created at the very beginning of the project.

A few examples can be given to illustrate the synergies that have been applied to reduce the probability of the occurrence of risks and/or the extent of their consequences:

- The TBM had to cross thirteen geological horizons and four water tables; since the beginning of the 1990s, Socatop has carried out several geological investigations in accordance with its own assessment of the risks, including, more than three years before the start of the excavation works, a major investigation and design work to establish the specification of the Tunnel Boring Machine; this very sophisticated, 11.6 m diameter machine was constructed by Herrenknecht and can work in any of four modes (slurry pressure confinement, open, compressed air semi-closed, closed with earth pressure balance) in order to deal with the various types of ground that it had to cross between the white chalk and the Fontainebleau sands. At the present time, having completed more than 8 km, it has passed, without difficulty, the thirteen geological horizons (see diagram): this is a rather rare feat in the field of underground works, involving a very diversified geology, made possible by accurate forecasting, itself made possible by the way the works were allocated and the virtuous nature of the contracts.
- Socatop's high reaction speed in commissioning design work or works within very short periods of time reduced problems caused by unknowns on many occasions.
- The integrated design of the construction (for example, the three levels of slabs in the tunnel or the recesses and transfer staircases) and of the methods of execution enabled total control over costs and timescale.

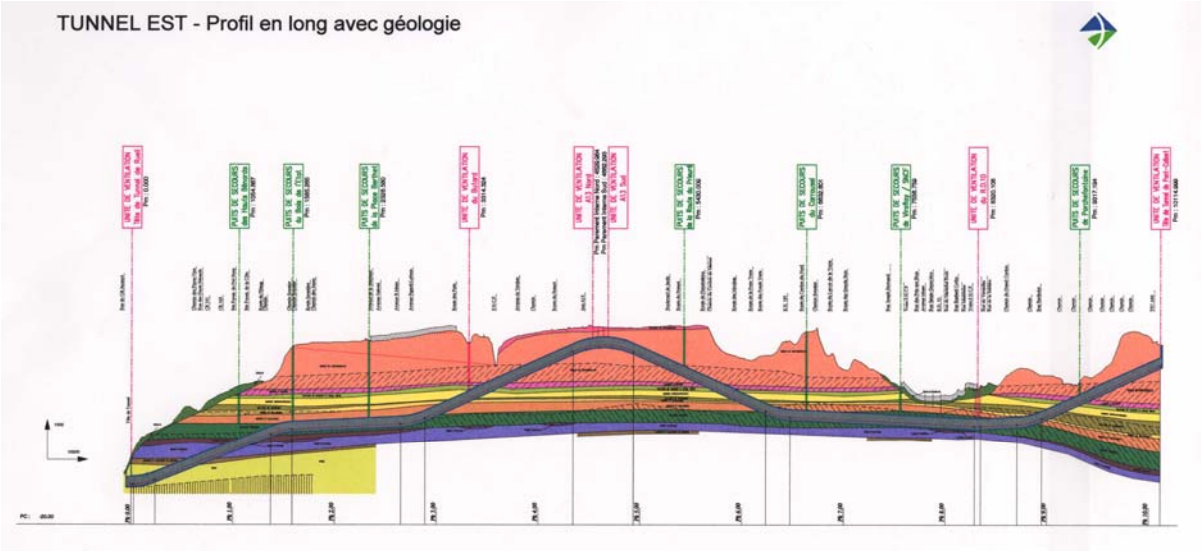

Diagram 3 – geological long profile

1.2.2. *Management of the commercial risk*

As far as the proposed levels of toll are concerned, the elasticity of traffic to the toll is close to -1 and careful checks had to be made on motorists' readyness to pay and how often they would use the tunnel.

Cofiroute therefore acted in several ways:

- Creation of a financial-traffic cell as early as 1990;
- Implementation of a policy of acquiring highly-specialised skills in this field and development of a constantly-updated model of the Île de France region;
- Consultation of the bests experts in relation to the preferences revealed and carrying out of enquiries cross-checked against measurements of travelling times;

- Cross-checking the results of the models against the situations observed on urban toll roads in Marseille (Prado Carénage tunnel), in western Paris (A14 autoroute tunnel) and in California (SR91 freeway operated by Cofiroute);
- Launching of an original procedure to improve quality of service and to understand better why, in the public imagination, tunnels are often represented negatively; for this purpose, in 2000, Cofiroute appointed a team of social science researchers with a wide range of skills – from a psychiatrist to an ethnologist – and used its recommendations to target public expectations better, in relation to the internal fitting out of the tunnel to make driving relaxed. As opposed to tunnels lit by sodium vapour lamps (yellow light), a powerful and economic solution, but one that changes colour perception, the A86 will be provided with white "daylight" type lightings, which are less powerful and are needed in larger quantities, but which gives a better light distribution. The fitting out of the tunnel roadway areas and the choice of colours of the walls and of the road surface will form part of the same search for clarity in the tunnel, and certain options have been tested on driving simulators (see photo 1 below).

Photo 1 – driving simulator

2. RISK MANAGEMENT AT THE EARLY STAGES OF THE PROJET

2.1. A common shareholding, long-standing project organisation and teams

As the two entities, Cofiroute and Socatop, have the same shareholders, major contractual disputes are pointless and all energy has been spent on the objective to be met.

2.1.1. *A long-standing organisation*

The two teams (Cofiroute, the Owner; Socatop, the Designer and Builder) have been established since 1990, using a project organisation with clear duties, intended to avoid duplication and "internal frictional losses"; the Owner's team is very restricted (fewer than ten people).

The perennity of the teams is to be noted, as some of the members, in particular the Project Manager, Michel Barfety, and the people responsible for the most sensitive design work (Antoine Arlet, Christian Bouteloup, Pierre Gastineau) have spent more than fifteen years on this project.

2.1.2. *Great openness to different cultures*

The Owner's teams contain members with very different backgrounds (public, private companies, consulting engineers, etc.) and call, as needed, on the services of specialist consultants (risk, social sciences specialists, etc.).

During the course of construction, it was decided to transpose the technology of water mist fire-fighting, used in ocean liners, to the tunnel; many tests were first carried out in a full-size tunnel in order to check the relevance of this solution in order to improve, yet further, the safety conditions in the tunnel. The reactivity of the site organisation enabled this innovative process to be adapted to the project in a very short period of time.

2.2. Continuous presence at the side of the parties involved

To be successful in a development project, which, moreover, is in an environmental, technological and political context such as that of the A86 to the west of Paris, needs everyone to have his place and to play his part: the more participants there are involved, the wider the general interest sought for and the wider the legitimacy of the project.

2.2.1. *Numerous participants involved*

There are numerous indispensable participants:

- elected representatives: as part of their duties, they carry the challenge of regional development;
- community associations: consisting of associations for the protection of the environment, users or consumers, neighbours; in opposition to the Client, they are, to a certain extent, the Users. Some of them, moreover, have a high level of expertise and of professionalism, and have time to spend on the project; there are forty or more of them on the project;
- the economic world: with very specific challenges and expectations, they are the vectors or regional development, leaders of urban or rural activities and users of infrastructure works;
- the public: its involvement is a democratic requirement, a position reinforced by the latest national and EC statutory guidelines.

Regular meetings and site inspections have taken place with each type of participant throughout the life of the project.

2.2.2. *A desire for a local commitment*

More particularly for the attention of the elected representatives, Cofiroute implemented, in February 2000, a "service commitment charter", setting out the contractor's commitments in relation to information and communication. This charter, produced with a desire for transparency, responsibility, listening and proximity, lays down procedures for dialogue and cooperation between Cofiroute and the 14 communes directly affected by the works. In February 2002, Socatop, designer and constructor, associated themselves with it by committing themselves to specific measures in respect of the works being carried out, namely measures relating to compliance with the laws on water, noise, traffic and the cleanliness of lorries, as well as advising neighbours in the event of unforeseen circumstances in the organisation of the works.

Cofiroute has taken care to appoint clearly-identified spokesmen to communicate with the elected representatives. While the contractor's commitment is to hold three-monthly meetings with the communes in which the work is taking place and six-monthly meetings with those where it has not yet started, Cofiroute often exceeds these theoretical commitments. In certain communes, committees for specific joint action have been formed. Their members comprise representatives of the mayor's office, local associations and neighbours, and are at the root of true local consultation. These meetings enable the concrete implementation of measures relating to the organisation of the works – definition of site lorry routes, working hours arranged to suit the nearby environment (market, day nursery), improvement of wooded visual protection, acoustic arrangements – but also involve these partners in the taking of decisions relating to the permanent architectural and landscaping details, for example. Established in addition to the prior consultation, these measures play a part in improving the comprehension of the project, the acceptance of the constraints imposed by the works, and also local relationships.

2.3. The implementation of innovative procedures at a local level

In the context of the special care and attention described above, the A86 project is a laboratory for the implementation of innovative tools to enable the construction of the tunnel to act as a lever for action at a local level. Two procedures may illustrate this aspect:

2.3.1. *The "1% landscaping" or the recovery of the landscape in western Paris*

For about twenty years, a circular entitled "1% landscaping and development" has enabled, as part of the construction of certain surface autoroutes in France, the financing of landscaping carried out by communes or third parties, provided that the landscaping meets quality and, especially, covisibility criteria. This concept can be summarised as the ability to "see and be seen", in other words to see the autoroute and to be seen from it.

Such a concept is hardly suited to the case of a tunnel project in a suburban environment, of which there is very little on the surface, thus hardly visible at all.

Nevertheless, the State and Cofiroute have agreed to apply the "1% landscaping" policy to the A86 and to devote part of the cost of the construction of the tunnel to landscaping improvements in the fourteen communes affected by its route (€7.5 million). The criterion of covisibility has thus been adapted and enlarged to one similar to a level of impact, which incorporates visibility, but also the presence of interchanges or even traffic.

A guiding committee, chaired by the préfets of Hauts-de-Seine and of Yvelines has authorised 27 schemes, in the spirit of the improvement of the landscaping and historical assets in the areas adjacent to the route. Pedestrian footpaths, cycle tracks, promenades along the Seine, bridle paths, and restoration of parks and estates are a few examples of projects carried out by public official bodies, formalised in the "1% landscaping" Charter, co-signed in May 2006 by the State, the communes and Cofiroute.

2.3.2. *An air quality observatory*

Because of the fluidity of the traffic, the ever-improving quality of new cars and the ventilation system designed for the tunnel, the pollution generated by the construction will remain low: studies and simulations have shown that pollutant levels will be well below current French and European standards. However, at the request of the State and of Cofiroute, a permanent and independent air quality observatory has been established, with three duties:

- to evaluate the impact of the opening of the tunnel;
- to provide permanent monitoring of air quality;
- to provide regular information for the public.

This observatory, the management of which has been granted to Airparif – an association appointed to monitor air quality in Ile-de-France, approved by the French Environment Ministry – is a first in France.

It is based on an original methodology combining the taking of sets of measurements, before and after the tunnel opens, with the development of a dedicated model, enabling the mapping of air quality in the sector affected by the tunnel to be reproduced hour by hour. This mapping will be made public on Airparif's internet site. In the communes affected by the interchanges, the measurement points (approximately one hundred passive tubes and 4 mobile laboratories) have been defined in consultation with the elected representatives and the associations.

2.4. A policy of active communication

One part of the above-mentioned social sciences survey (see §1.2.2) related to acceptance of the project by its neighbours and future users. It thus became apparent, on the conclusion of the enquiry, that the project was, for the most part, well received, with a large improvement since a first survey carried out in 1996. However, a feeling of lack of information did remain, despite the effort made. Cofiroute has therefore developed several communication tools:

- An exhibition devoted to the project, "A86 l'expo": since opening to the public in May 2001, neighbours, companies, schools, etc. in Hauts-de-Seine and in Yvelines have been received there by a team of guides and have been able to learn about all the aspects of this final section of the A6 west: history, organisation of the works, technologies used, landscaping and architectural details, etc., up to a full-size model

of one level of the tunnel to be used for cars. Up to the present time, almost 100,000 visitors have been received there.

- A magazine "Le Lien A86", with 250,000 copies distributed in the communes directly affected by the final section of the A86 west, or those adjacent, it is designed to present in as direct a way as possible the progress of the A86 to the inhabitants of western Paris, by means of interviews, articles and eyewitness accounts, in the spirit of information and proximity, to which Cofiroute has been committed since the start of the works.
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