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Risk Management for Mega-projects

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Mega-projects tentative definition and characteristics

- **From commonsense perspective...**

Projects internationally recognized to be exceptional because of :

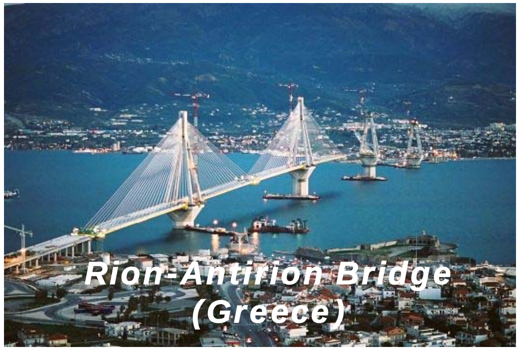
- their dimensions,
- cost,
- architecture,
- or technical specificities...

Mega-projects tentative definition and characteristics

- **Obvious examples of mega-projects :**


Auckland Bay Bridge (USA)


Golden Gate Bridge (USA)


Rion-Antirion Bridge (Greece)


Millau Viaduct (France)


Storebaelt Tunnel (Denmark)


Messina Bridge project (Italy)


Akashi Kaikyo Bridge (Japan)

Mega-projects tentative definition and characteristics

- **From an engineering perspective…**

Generally refers to projects associating :

- great volumes (dimensions, costs)
- and technicity.

For bridges :	Length > 1000 m ;	Cost > 120 M USD
For tunnels :	Length > 10 km ;	Cost > 600 M USD

Mega-projects tentative definition and characteristics

- **From manager or owner perspective…**

  Essentially defined in terms of :

  - costs,
  - cash flow,
  - organisation,
  - planning and responsibilities towards users and project environment

Example : mega-project definition according to the American Federal Highway Administration :

- total estimated cost > 500 M USD
- receive federal financial assistance because of :
  - strategic importance in public or congressional attention
  - extraordinary implications for the national transportation system

Mega-projects tentative definition and characteristics

- **Conclusion**

  - a necessarily quite subjective definition

  - can depend on :

    - the impacting domain of the responsible authority (State, county, city...)
    - the level of development and techniques of the country

  - generally refers to projects of exceptional characteristics (cost, dimensions, architecture, technique) or because it is particularly exposed to some natural or manmade risks

  - exceptional by their intrinsic characteristics, mega-projects can also unfortunately happen to be exceptional by the size of the disasters they can engender when risks or not or badly managed

Risk management framework for mega-projects

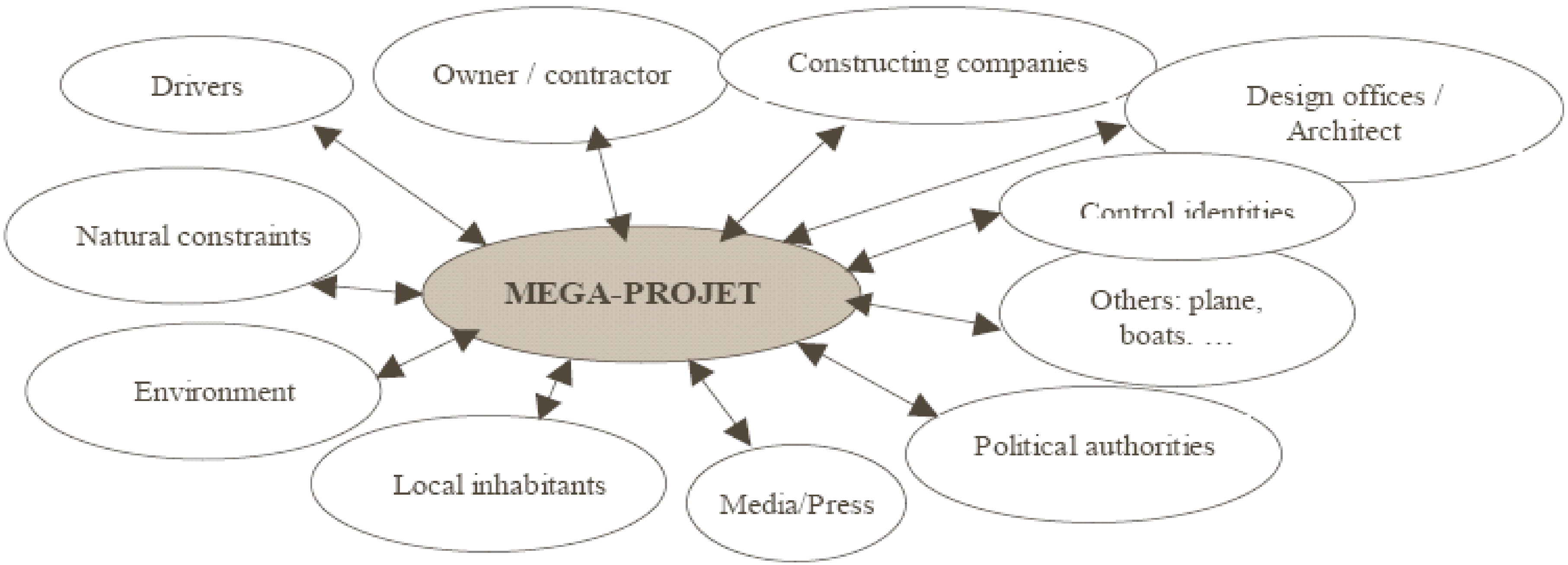
❑ Factors and partners associated with RM in mega-projects

Mega-projects have the particularity to associate in a common context many partners, companies, political authorities or environment context, of different and sometimes incompatible critical issues.

They involve risks for all parties directly and indirectly involved in the project :

Risk management framework for mega-projects

- Factors and partners associated with RM in mega-projects



Risk management framework for mega-projects

RM at different stages of mega-projects

It is essential to consider and perform risk management at each stage of the project :

- Planning (opportunity studies)
- Design
- Construction
- Operation and maintenance (including post-crises management)

also essential to assure coherence between those successive stages to guaranty RM continuity.

Risk management framework for mega-projects

❑ RM at different stages of mega-projects

A) During the planning phase

… of leading importance because they allow to anticipate problems instead of treating them.

1- Define the mega-project principal characteristics (dimensions, number of lanes, cost…) and context (social aspects, owner responsibilities, environment issues, expected durability, adjacent facilities, role in crisis situations);

2- Identify and estimate (quantify) local hazards according to existing codes (national hazard mapping) and/or site investigations and expertise (seismicity, floods, soil conditions…);

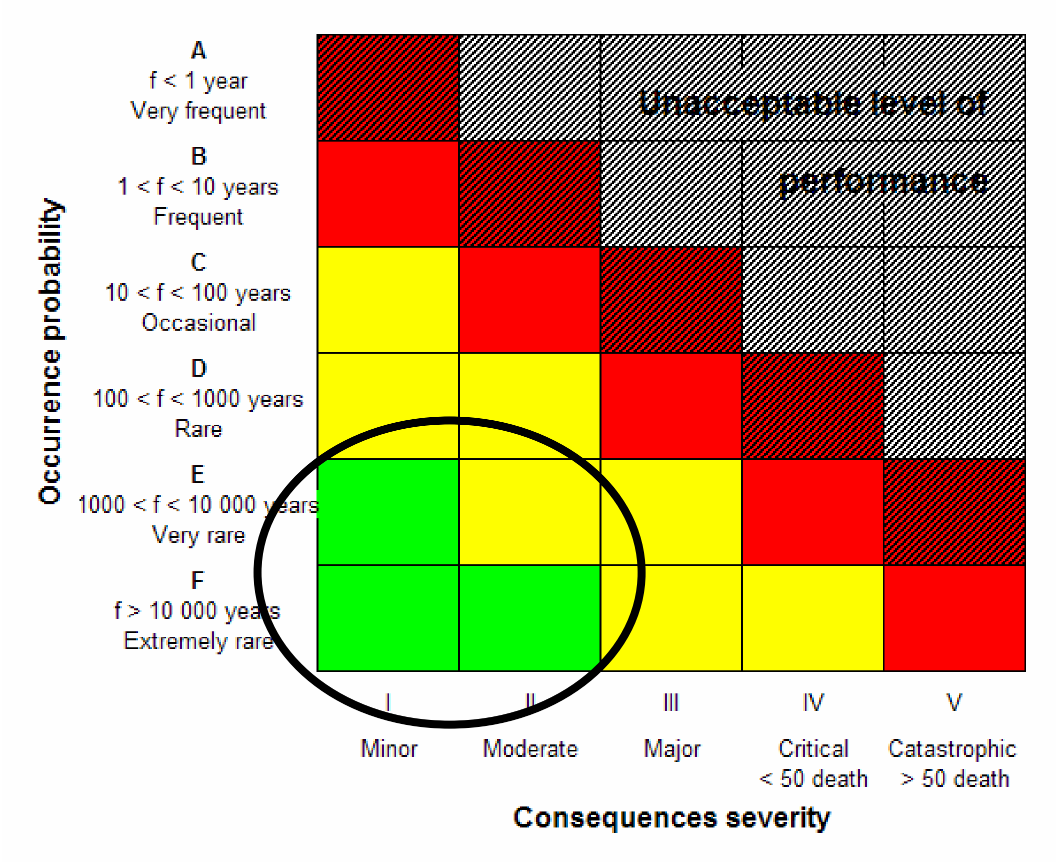
3- Define objectives of performance (extreme events resistance, durability, reliability) in accordance with design codes and owner strategic choices;

Risk management framework for mega-projects

RM at different stages of mega-projects

A) During the planning phase

Objectives of performance are generally defined within a so-called risk matrix :



Risk management framework for mega-projects

❑ RM at different stages of mega-projects

B) During the design phase

4- Evaluate and prioritize the risks on the structure ;

5- Define the best design of the structure (bearing positioning, choice of materials and geometry, construction method) in order to reduce the risk occurrence on the structure by reducing its exposure and/or vulnerability;

Steps 4 and 5 can be gathered in one single risk identification and analysis table :

Risk management framework for mega-projects

RM at different stages of mega-projects

B) During the design phase

Example of risk analysis table :

	Considered risk	Priority coefficient	Design 1	Design 2	Design 3
Naturals	Landslides	0	++	++	++
	Floods	1	++	+	++
	Earthquakes	2	+	++	- -
	Rock falling	0	++	++	++
	Wind storm / Hurricane	5	++	-	++
	Forest fires	0	- -	- -	++
Man-mades	Trafic accident	4	+	+	+
	Overloading	1	+	++	++
	Ship collision	0	-	++	++
	Airplane crash	2	- -	-	- -
	Transport of dangerous goods	3	+	+	+
	Vandalism	3	++	-	++
	Terrorism	3	-	- -	-
	Fire	3	-	-	++
Technical	Structure dimensions	3	-	-	-
	Architectural complexity	3	- -	+	- -
	Innovating degree	3	+	- -	- -
	Material choices	1	+	+	+
	Geotechnical aspects	4	-	+	+
	Construction method	4	-	+	- -
Socio-political and economical	Costs (estimated + incertainties)	5	+	-	- -
	Attractiveness	5	+	++	+
	Environmental impact	4	- -	++	+
	Landscape impact	4	- -	++	-
	Local inhabitants disturbs	3	- -	+	- -
	Srikes	2	- -	-	- -
	Work delays exceedance	5	- -	+	-
	Socio-political context	5	+	++	+
	Juridical issues	5	- -	- -	- -
		GLOBAL GRADE:	-26	25	-26

❑ RM at different stages of mega-projects

B) During the design phase

6- Design the structure for its expected service life according to existing codes and engineers considerations (state-of-the-art) in order to reduce the risk consequences on the structure;

7- Compare the risks with the outlined wished (measurement of eventual differences with initial performance objectives);

8- Communicate on the risk management procedure and the objectives of performances required for the structure;

RM at different stages of mega-projects

B) During the design phase

It is during this design phase that main choices are taken that make the structure able to withstand to an appropriate extend events such as explosions, natural disasters, crash forces or consequences of human mistakes.

Choices related to risks management can lead to specific measures or local equipments (security barriers for bridges, fume extractors in tunnels, special paintings against corrosion, crash protections for bridge columns…).

They can also modify the architectural and global design of the structure (reducing of the number of columns in case of a bridge exposed to ship or truck collisions, constitutive material, construction method, choice of a strong or slender type of structure, etc…) …

… in agreement and under the responsibility of the owner of the project.

Risk management framework for mega-projects

❑ RM at different stages of mega-projects

C) During the construction phase

9- Plan and respect some quality and security procedures to guaranty a good monitoring control of works and their impact;

10- Plan adapted control procedures to be executed by qualified independent organisms;

11- Always prioritize safety, working environment and environment along with Time-Budget-Function / Quality;

Risk management framework for mega-projects

❑ RM at different stages of mega-projects

C) During the construction phase

12- Carry on communication with local inhabitants, their representatives and future road users, on project final objectives, technical choices, construction method, eventual disturbance;

13- Test the structure reliability under service and extreme or accidental loading before service opening;

14- Anticipate on crisis management (accessibility, moveable barriers, phone cabs, equipment stocking for repair, crisis and intervention planning, monitoring center…);

Risk management framework for mega-projects

RM at different stages of mega-projects

D) During operation phase

In normal situation…

15- Instrument and record the structure response within the service state (traffic load, wind, earthquakes…);

16- Inspect regularly the health of structure, materials and specific devices;

Risk management framework for mega-projects

RM at different stages of mega-projects

D) During operation phase

In post-crisis situation…

17- Inspect and evaluate residual resisting capacity (and eventually repair) of the structure;

18- Communicate and inform every concerned identity (police, ambulances, civil security services, drivers…);

19- Eventual feed back to hazard maps, local risk characterization and design codes and practices;

Risk management framework for mega-projects

RM at different stages of mega-projects

E) General prescriptions and management aspects

Some transversal global measures for a good RM all along the project life and an efficient transition between its different phase :

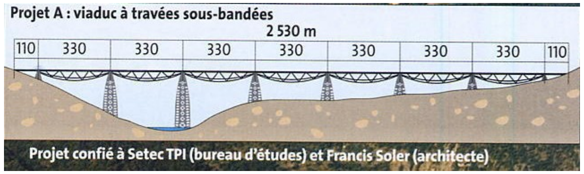
- Decide a general plan for the project's RM;
- Have a coordinator dedicated to RM in the management;
- At the end of each stage, deliver the project's top 10 prioritized risks to the next phase with suggestions for action;
- State demands in the contract for the contractor's own RM.

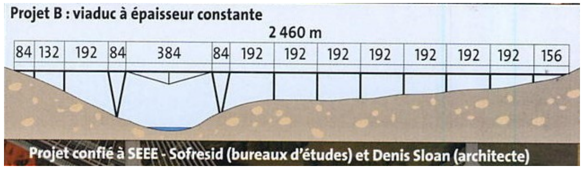
Example of good practice : the Millau Viaduct

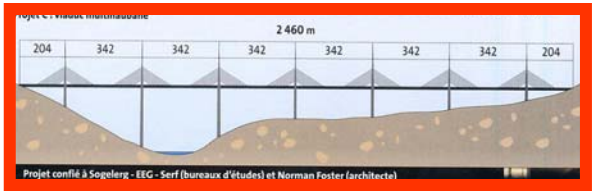
- **The Millau Viaduct from RM perspectives…**

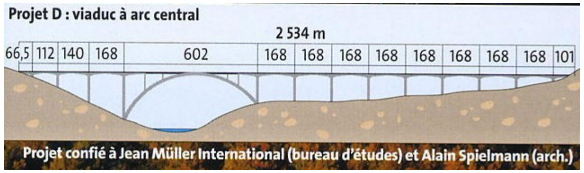
Example of good practice : the Millau Viaduct

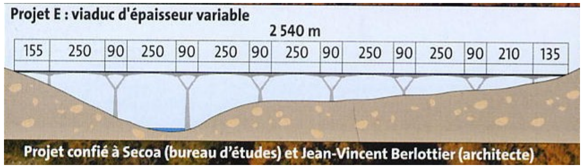
❑ The Architectural / Environmental Risk











- 1993 : international competition, 5 design teams (each made of 1 architect and 1 engineering office), 1 referee committee of 20 people (national road authorities, technical experts, finance specialist, regional and national representatives)

- Chosen solution with minimal impact on the landscape

- “1% landscape policy” aimed at developing the tourist exploitation and environmental insertion of the Viaduct

- Environment Respecting Plan (PRE) to minimize impact of worksite on local environment (site environmental constraints and pollution risks identification, preventive dispositions, control and emergency planning)

Insertion of the Viaduct in the landscape

The Viaduct visitors center

Example of good practice : the Millau Viaduct

The Financial / Economical Risk

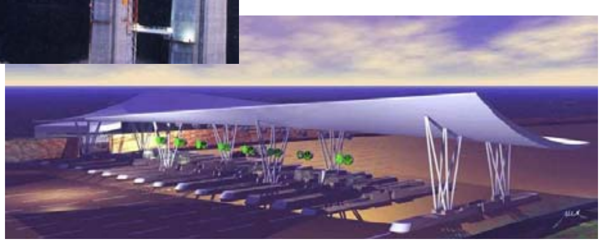
From the State perspective

- A 75 years operation contract attributed to Eiffage consortium including financing, design, construction, operating and maintenance
- State-owned status after 75 years of private operating

From the constructing-operating company perspective

Challenge was to build the Viaduct very fast so that to get reimbursed by toll as early as possible

- “a days and nights” running construction…
- Each pier construction treated as an independent worksite
- use of a specific fast setting concrete



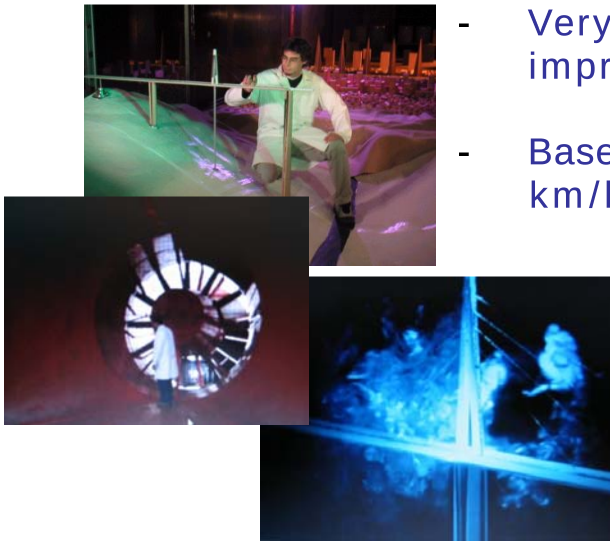
Toll fees adapted to remain attractive compared to other N-S links :

4.90 € / car during winter time

6.50 € / car during summer time

Example of good practice : the Millau Viaduct

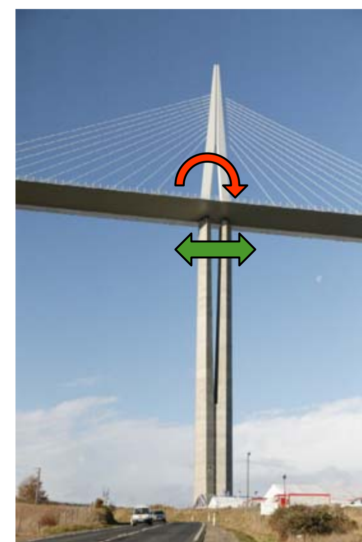
❑ The Technical Risk



- Very strong wind and temperature effects due to location and impressive dimensions

- Based on site investigations, structure was designed to resist 185 km/h wind speed during construction and 225 km/h during operation

- Series of tests in wind tunnel performed to check the response of the structure under average and turbulent wind conditions



- Shape of the piers strongly influenced by behavior of the bridge under service loads and temperature effects

- Permanent monitoring of geotechnical, material and dynamic behavior under normal traffic conditions

Example of good practice : the Millau Viaduct

❑ The “Bad Ageing” Risk

Following “Sustainable Development” concept and objectives, the Viaduct was designed for a service project life of 120 years

This was achieved throughout different design strategies and material choices :

⇒ use of high performance concrete (B60) for the piers

⇒ pre-stressing of the piers in order to limit cracking

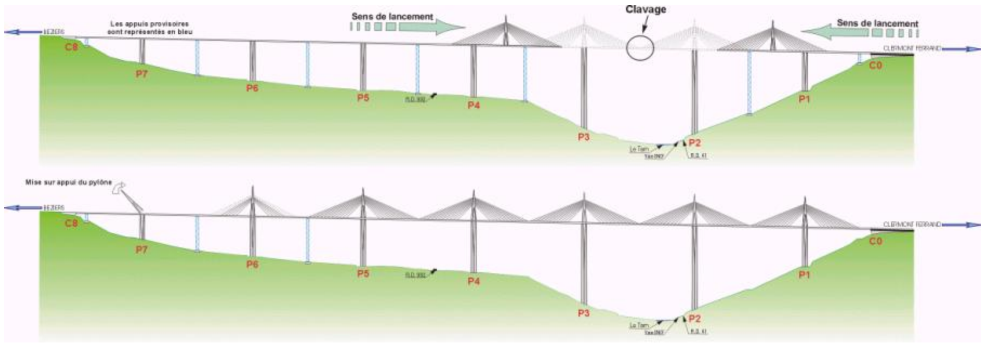
⇒ series of test aimed at validating the characteristics of materials and elements :

- creep, shrinkage, durability and ageing testing for the concrete under the site specific conditions
- fatigue and permeability testing for the cable-stays and associated coating
- permeability and flexibility testing of the waterproofing course and pavement

Example of good practice : the Millau Viaduct

The Construction Related Risks

- Due to difficulty and danger of working at such height in strong wind conditions, steel deck elements were welded on banks behind the abutments and pushed to final position



- Launching phase performed under permanent wind speed recording and stopped in case of wind speeds exceeding 85 km/h

- Special training at extremely high working conditions provided to workers

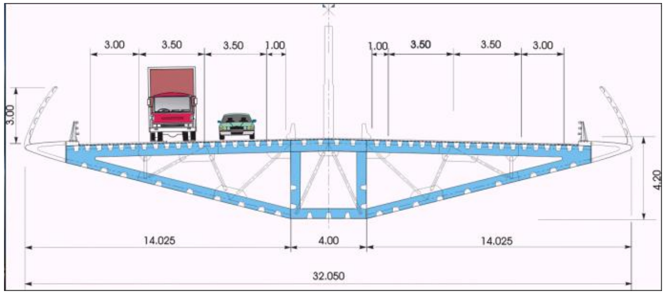
Example of good practice : the Millau Viaduct

The Driver Related Risks

- Directly connected to the financial/economical risk,
- Can be expressed in terms of attractiveness, comfort, security

Attractiveness

- 3 hours saved on a 10 hours trip from Paris to Montpellier
- The rest of the highway being free makes the Viaduct very competitive compared to other ways connecting North and South



Comfort and security

- Viaduct equipped with 3 m high transparent fiberglass windscreens

- Windscreens tested in wind tunnel to measure their efficiency, effect on the whole structure aerodynamic characteristics and to limit induced noises
- Bridge equipped with overloading detection, wind speed monitoring, ice detector and video surveillance

Example of good practice : the Millau Viaduct

❑ The Local Population Related Risks

At the very beginning of the project, the local population feared :

- a bad insertion of the structure in their landscape,

- a lack of benefits from traffic congestion in Millau city for the shops and restaurants.

Risk for the company to face manifestations and possibly worksite disturbance

Many communication campaigns were necessary to make local population accept, appropriate and be proud of “their Viaduct”

Finally,

- The viaduct permitted a large local workers employment and the construction of many low cost housing facilities

- The technical performance of the viaduct has made the little city of Millau famous all over the world and has brought thousands of tourists since the beginning of the construction

- The governor of California invited the mayor of Millau to get some political advices on how to make such a big bridge and worksite accepted by the local population...

Example of good practice : the Millau Viaduct

Some conclusions

- The Millau Viaduct was presented through the original perspective of risk management
- It clearly comes out that the whole process, from preliminary studies to construction and operating, was strongly influenced by risk analysis considerations
- Even more than the technical risks, the social, political, financial risks aspects seemed to be critical for this mega-project
- Communication campaigns, quality control and good coordination between political authorities (State and local), the constructing-operating company, technical experts and architects, were key elements of the success of the operation

Example of good practice : the Millau Viaduct

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General conclusions (1/2)

➔ Mega-projects are characterized by unusual size and cost, but also in terms of technical, economical and environmental risks

➔ Exceptional by their intrinsic characteristics, mega-projects are also exceptional by the number of partners, companies, political authorities or environment issues that they associate in a common context

➔ To each of those identities correspond a certain number of risks that have to be evaluated, quantified, prioritised and treated

➔ To be efficient and adapted, RM processes should be integrated since the very beginning of the project, within the planning and design phases, and should be pursued at the construction and operation phases

General conclusions (2/2)

→ RM tends to become an increasing worldwide concern matter, even if processes still need to be better formalized and systematized

→ Examples where integrated RM processes have been adopted on mega-projects tend to demonstrate that this action is extremely efficient and beneficial

→ RM enables to minimize uncertainties, and keep projects on track by avoiding difficulties resulting from over-costs and over-delays, while maintaining public trust and confidence

→ RM : a “technical jump” consisting in taking into account the consequences of an accident as a new design parameter and integrating in the analysis the “cost not to pay” in addition to “the cost to pay”

Thank you for your attention…

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