Critical Success Factor Analysis of Millau Viaduct Project

• Presented by:
  Jinsu Lee, Karl Lander, Linda Lin,
  Watcharin (Lhing) Witthayaweerasak

June 5th, 2006
Estimated: 30min
Agenda

1. Introduction
2. Research Methodology
3. Conceptual Framework
4. Millau Project Analysis
5. Results and Implications
6. Conclusion and Recommendation
An excellent ambience “As project manager, we controlled every stage of the erection of the viaduct during these three years of construction. Our recommendations were always taken into account by the teams on the worksite. And the ambience on site was truly excellent. I am not sure that I shall ever experience another construction site like Millau”.

Abel Benzina, engineer with SETEC TPI.”
Introduction

- Millau Viaduct Key Facts
Millau Viaduct Key Facts

- An Engineering Marvel and an Architectural Masterpiece
- World’s Tallest Cable-Stayed Bridge
- A Mega-Project on Schedule
  - 39-month (revised) Contract
  - Completed one month earlier
    Start: October 2001
    Finish: December 2004
- Within Budget
  - €400 million (construction)
More Facts...

Source: http://news.bbc.co.uk/2/hl/europe/3759307.stm
Construction Consortium
Research Methodology

- Framework Selection
- Millau Data Collection Path
- Model Extension Data Path
Research Methodology

Data Organization:
- Project Characteristics
- Contract Arrangement
- Project Participants
- Interactive Processes

Model Extension:
- Extract top 20 CSFs
- Survey Bridge Experts
- Rank top 10 Bridge CSFs

Millau CSFs
Conceptual Framework

- Project Environment
- Hierarchical Model
- Critical Success Factor (CSF)
Typical Construction Project Environment

Source: Chua et al., “Critical Success Factors for Different Project Objectives”
Hierarchical Model

Source: Chua et al., “Critical Success Factors for Different Project Objectives”
Success Factors...

Project Characteristics

- Political risks
- Economic risks
- Impact on public
- Technical approval authority
- Adequacy of funding
- Site limitation & location
- Constructability
- Pioneering status
- Project Size

Contractual Arrangements

- Realistic obligation
- Clear objectives
- Risk identification
- Adequacy of plans & spec
- Formal dispute resolution process
- Motivation / Incentives
Project Participants Factors

Source: Chua et al., “Critical Success Factors for Different Project Objectives”
**Interactive Processes Factors**

Source: Chua et al., "Critical Success Factors for Different Project Objectives"
### Table 4. Ranking of CSFs for Different Project Objectives

<table>
<thead>
<tr>
<th>Success-related factor</th>
<th>Organization Type</th>
<th>Organization Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequacy of plans and specifications</td>
<td>Average Rank (AV)</td>
<td>O1</td>
</tr>
<tr>
<td>Constructability</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Economic risks</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Realistic obligations/clear objectives</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>PM competency</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Adequacy of funding</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Budget updates</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>PM commitment and involvement</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Contractual motivation/incentives</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Risk identification and allocation</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Political risks</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>PM authority</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Scheduling updates</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Construction control meetings</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Capability of contractor key person</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Site inspections</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Pioneering status</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Adequacy of plans and specifications</td>
<td>Average Rank (AV)</td>
<td>O1</td>
</tr>
<tr>
<td>Constructability</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Site inspections</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>PM commitment and involvement</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Realistic obligations/clear objectives</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>PM competency</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Construction control meetings</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Formal communication (construction)</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Capability of contractor key person</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Design control meetings</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Contractual motivation/incentives</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Pioneering status</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>PM authority</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Supplier level of service</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Economic risks</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Note: AV = average rank; O1 = consultant; O2 = contractor; O3 = client; O4 = project management.
**Categorizing Top 20 CSFs**

<table>
<thead>
<tr>
<th>Project Characteristics</th>
<th>Project Participants</th>
<th>Contractual Arrangements</th>
<th>Interactive Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>(External)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Political Risks</td>
<td>• PM Competency</td>
<td>• Adequacy of Plans and Spec</td>
<td>• Budget Updates</td>
</tr>
<tr>
<td>• Economic Risks</td>
<td>• PM Authority</td>
<td>• Real Obligations / Clear Objectives</td>
<td>• Schedule Updates</td>
</tr>
<tr>
<td>• Adequacy of Funding</td>
<td>• PM Commitment</td>
<td>• Motivation / Incentives</td>
<td>• Construction Control Meetings</td>
</tr>
<tr>
<td>(Internal)</td>
<td>• Capability of Contractor Key Person</td>
<td>• Risk Identification &amp; Allocation</td>
<td>• Site Inspections</td>
</tr>
<tr>
<td>• Constructability</td>
<td>• Supplier Level of Service</td>
<td></td>
<td>• Formal Comm.</td>
</tr>
<tr>
<td>• Pioneering Status</td>
<td></td>
<td></td>
<td>• Design Control Meetings</td>
</tr>
</tbody>
</table>
Millau Project Analysis

- Project Characteristics (External/ Internal)
- Project Participants
- Project Contractual Arrangements
- Project Interactive Processes
External Project Characteristics

- Political risk was low
- Millau project is testament to a more visionary France
- The toll collecting for 75 years is not a clear profitable plan.
- € 400 million was funded privately by Eiffage
- All technical approval (Design) was set up before construction started
External Project Characteristics

- Millau provide the shortest route between Paris and Perpignan (60Km short and half an hour less driving)
- Millau residents community warmly welcome to accept the project and supporting
- The site was one of famous tour area in the middle of construction and now
Internal

Project Characteristics

• The world tallest cable-stayed bridge
• New technical approach was used
• Engineering based design approved in early stage and long term preparation (14 years)
• Construction site was above 200m height location (safety issues)
• Weather changes was significantly considered
• Difficult hilly and rural area across Tran river
Internal Project Characteristics

- Eiffage group have qualified previous constructions records and resources (technology and manpower)
- Eiffage group was the key player in technical decision and constructability
### Internal Project Characteristics

#### Key Numbers

<table>
<thead>
<tr>
<th>Details</th>
<th>Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Length</td>
<td>2,460 m</td>
</tr>
<tr>
<td>2 Width</td>
<td>32 m</td>
</tr>
<tr>
<td>3 Maximum height</td>
<td>343 m, i.e. 20 m higher than the Eiffel Tower</td>
</tr>
<tr>
<td>4 Curvature</td>
<td>20 km</td>
</tr>
<tr>
<td>5 Height of the tallest pier (P2)</td>
<td>245 m</td>
</tr>
<tr>
<td>6 Height of the pylons</td>
<td>87 m</td>
</tr>
<tr>
<td>7 Number of piers</td>
<td>7</td>
</tr>
<tr>
<td>8 Width of each span</td>
<td>342 m</td>
</tr>
<tr>
<td>9 Number of cable-stays</td>
<td>154</td>
</tr>
<tr>
<td>10 Cable-stay tension</td>
<td>900 t for the longest ones</td>
</tr>
<tr>
<td>11 Weight of the steel deck:</td>
<td>36 000 t, i.e. 4 times the Eiffel Tower</td>
</tr>
<tr>
<td>12 Volume of concrete</td>
<td>85 000 m³, i.e. 206 000 t</td>
</tr>
<tr>
<td>13 Cost of construction:</td>
<td>400 million €</td>
</tr>
<tr>
<td>14 Length of the concession:</td>
<td>78 years – 3 years of construction and 75 years of operation</td>
</tr>
<tr>
<td>15 Structure guaranteed:</td>
<td>120 years</td>
</tr>
</tbody>
</table>

Source: [http://www.leviaducdemillau.com](http://www.leviaducdemillau.com)
**Construction Key Steps**

1. Raising the piers
2. Launching the deck
3. Placing the final voussoir
4. Installing the pylons
5. The cable stays
6. Applying the coating

Source: http://www.otua.org/
Project Participants

Client
- Department of Transport and Public Work of France
- The Public / Millau Community

Designers / Consultants
- Michel Virangelogex head designer and engineer, later CEVM’s adviser
- Foster & Partners architecture firm
- Europe Etude Gecti S.A., Thales Group, and SociEtE D'Etudes R. Foucault et Associes led concrete design
- Belgium's Bureau Greisch S.A., Lige designed steelwork and erection method, and confirm government's calculations
Project Participants

Contractors
- Eiffage's Compagnie Eiffage du Viaduc du Millau (CEVM)
- Eiffel Construction Metallique S.A. handles steelwork
- Eiffage T.P.

Suppliers and Manufacturers
- German-based supplier Peri GmbH and others

Project Manager
- SETEC TPI
Project Participations

Key players

• **Architectural design**: Foster and Partners
• **Design Concept**: SETRA
• **Structural Engineering**: EEG Simecsol and Greisch
• **Building**: Eiffage Construction
• **Concessions**: Roadways: Appia
• **Electricity**: Forclum
• **Metal construction**: Eiffel
• **Fabricator**: Freyssinet (stay cables)
• **Launching**: Enerpac
• **Formwork**: PERI Formwork and Scaffolding.
Contractual Arrangements

- Build-Operate-Transfer (BOT) Arrangement
- Identification and allocation of potential risks
- More flexibility over budget and schedule
- Fulfillment of safety and security standard
- Realistic obligations and objectives
- Adequacy and clarity of plans and specifications
- Provision of formal dispute resolution process
- Motivations and incentives
Interactive Processes

- Communication
  - Collaborative problem solving process
  - Conflict resolution process with short command chain

- Planning
  - Development of functional plans
  - Completion of design
  - Management of constructability programs
  - High level of modularization, automation and skillful labor
Interactive Processes

- Monitoring and Control
  - Updates
  - Meetings
  - Site supervision and inspection

- Project Organization
  - Flat organizational structure
  - Common goal
  - Excellent working relationships between designers and contractors
Results and Implications

- Interview/Survey Implications
- Critical Factors for Millau
Interview/Survey Implications

- Definition of “success” will determine which critical factors are the most significant.
- Project managers polled all indicated that success was quality of output was more critical than budget or schedule.
- Factors selected as more important by PMs corresponded more closely with quality rankings from model.
### Critical Factors for Millau

<table>
<thead>
<tr>
<th>Project Characteristics</th>
<th>Budget Performance</th>
<th>Schedule Performance</th>
<th>Quality Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Millau came to market just as the French government was approaching build-operate-transfer procurement</td>
<td>Constructability - &quot;the design is very much an engineering generated form.&quot;</td>
<td>Constructability - &quot;the design is very much an engineering generated form.&quot;</td>
</tr>
<tr>
<td></td>
<td>Constructability - &quot;the design is very much an engineering generated form.&quot;</td>
<td>Advanced weather monitoring system in place to ensure safe working conditions</td>
<td>Numerous bridge solutions were extensively analyzed, and best option chosen.</td>
</tr>
<tr>
<td></td>
<td>Significant private funding secured by construction consortium</td>
<td></td>
<td>Used most advanced technologies (GPS, Laser, self-raising platforms, specific coating, high performance concrete, innovative materials.).</td>
</tr>
</tbody>
</table>
## Critical Factors for Millau

<table>
<thead>
<tr>
<th>Contractual Arrangements</th>
<th>Budget Performance</th>
<th>Schedule Performance</th>
<th>Quality Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Build-operate-transfer contract with the government</td>
<td>Realistic Obligations/Clear objectives</td>
<td>Realistic Obligations/Clear objectives</td>
</tr>
<tr>
<td></td>
<td>Full, flexible control over budget</td>
<td>High level of risk identification and allocation</td>
<td>High level of risk identification and allocation</td>
</tr>
<tr>
<td></td>
<td>High level of risk identification and allocation</td>
<td>High motivation among participants</td>
<td>Sufficient plans and specifications between designers (consultants) and contractors</td>
</tr>
</tbody>
</table>
### Critical Factors for Millau

<table>
<thead>
<tr>
<th>Project Participants</th>
<th>Budget Performance</th>
<th>Schedule Performance</th>
<th>Quality Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eiffage controlled its 400 million Euro privately funded budget</td>
<td>Many workers had long work history with Eiffage. Same culture and same work flow.</td>
<td>Highly qualified designers, architects and contractors with abundant experience with cable stayed bridges.</td>
</tr>
<tr>
<td></td>
<td>Consortium reduced overall cost as compared with prime-sub contractor arrangement</td>
<td>SETEC TPI brought in as consultant to assist Eiffage</td>
<td>Architects are also engineering inclined.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SETEC TPI brought in as consultant to assist Eiffage.</td>
</tr>
</tbody>
</table>
## Critical Factors for Millau

**Interactive Processes**

<table>
<thead>
<tr>
<th>Budget Performance</th>
<th>Schedule Performance</th>
<th>Quality Performance</th>
</tr>
</thead>
</table>
| • Integration of engineering, construction, and operation knowledge and experience | • Frequent schedule updates  
• Functional plans regarding schedule, work methods, tools, organization, and resource allocation  
• High level of modularity and automation  
• Integration of engineering, construction, and operation knowledge and experience  
• Sufficiency and high quality of equipment  
• Site management and supervision  
• Good team building and communications  
• Short command chain | • Communication and collaborative troubleshooting  
• An excellent working relationship between contractors, designers, and consultants  
• Frequency of report updates  
• Site inspections  
• Frequency of control meetings during construction  
• Sufficiency and high quality of equipment  
• Completion of detailed design at start of construction  
• Short command chain  
• Good conflict resolution process |

**Critical Factors**

- Integration of engineering, construction, and operation knowledge and experience
- Completion of detailed design at start of construction
- Frequency of control meetings and plan and budget updates during construction
- Short command chain

- Communication and collaborative troubleshooting
- An excellent working relationship between contractors, designers, and consultants
- Frequency of report updates
- Site inspections
- Frequency of control meetings during construction
- Sufficiency and high quality of equipment
- Completion of detailed design at start of construction
- Short command chain
- Good conflict resolution process
Conclusion and Recommendation

- A couple of questions
- Final Thoughts
- Limitations
A couple of questions

- Was the bridge actually completed on schedule?
  - If the project is extended early and a new completion date is set, on time completion is open to interpretation
A couple of questions

- Was the bridge actually completed on budget?
  - Eiffage secured private funding for this project on the agreement that the French government would buy the project out form them later on. So from the governments perspective so long as the original terms of the contract are fulfilled, it will be on budget.
  But is that the true budget?
Final Thoughts

• The final assessment always depends on the metrics
• No individual factors can be singled out for the success of the project
• Eiffage consortium idea was critical to success, particularly given the enormity of this project
Limitations

- Majority of background info was taken from Eiffage publications, so some bias regarding processes is possible.
- Critical Factors Used are not tailored for bridge construction.
- Limit stretching projects may fall outside the realm of traditional project models.
Questions & Answers

Thank you for your attention.