CASE STUDIES IN PROJECT MANAGEMENT

BY

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UNIVERSITY OF CALIFORNIA, BERKELEY
MAY 1998

SUBMITTED TO THE DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ENGINEERING IN CIVIL AND ENVIRONMENTAL ENGINEERING
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
JUNE 1999

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Submitted to the Department of Civil and Environmental Engineering on May 7th, 1999, in partial fulfillment of the requirements for the degree of Master of Engineering in Civil and Environmental Engineering

ABSTRACT

This thesis looks into two different project management case studies: the Bilbao Guggenheim Museum in Bilbao Spain, and the San Roque Power Facility on the Lower Agnos River in the Philippines. The objective of the thesis is to analyze these case studies from a project management perspective in order to make an evaluation of the project delivery method used, propose alternative project delivery methods, identify and highlight other project management issues, and acquire a better general understanding of the management of both projects.

The thesis begins with the Guggenheim Museum case study, and then considers the San Roque Power Facility case study. The project delivery methods of both studies are evaluated in light of six basic delivery alternatives: general contractor, construction manager, multiple primes, design-build, turnkey and build-operate-transfer. More information and emphasis is placed on the background and history in the Guggenheim Museum case than in the San Roque Power Facility case because of the significance and impact that the Guggenheim Museum project has had on the architecture, engineering and construction industry.

Thesis Supervisor: Jerome J. Connor
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ACKNOWLEDGMENTS

I would like to dedicate this thesis to the ones I love for it is because of their love and support that I am here today.

To my Mom and Dad, I owe everything that I am today to you for it is your patience, support and love that has enabled me to reach for my dreams. The best of what is in me is merely an extension of what is best in you.

To my Sister Sherry and my Brother Alex, thank you for always being there for me when I needed you. It is from you that I have learnt to be strong and fight on.

To my Love Amy, it is from you that I have learnt to love and be loved. For all your love, encouragement, and kindness, I devote myself to you.

To my friends, thank you for the good times and encouragement over the years.

I would also like to thank Professor Jerome Connor and Mr. Charles Helliwell for their constant guidance and support throughout my studies at MIT.

I would like to recognize Mr. Luis Rodriguez from IDOM, Mr. Christopher Gordon from the Massachusetts Port Authority, Mr. John Zils from S.O.M., and Professor Spiro Pollalis from Harvard's Graduate School of Design for their contributions to this thesis.

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INTRODUCTION

1.1 Thesis Topic and Organization

The thesis will look into two different project management case studies: the Bilbao Guggenheim Museum in Bilbao Spain, and the San Roque Power Facility on the Lower Agnos River in the Philippines. The objective of the thesis is to analyze two case studies from a project management perspective in order to make an evaluation of the project delivery method used, propose alternative project delivery methods, identify and highlight other project management issues, and acquire a better general understanding of the management of both projects.

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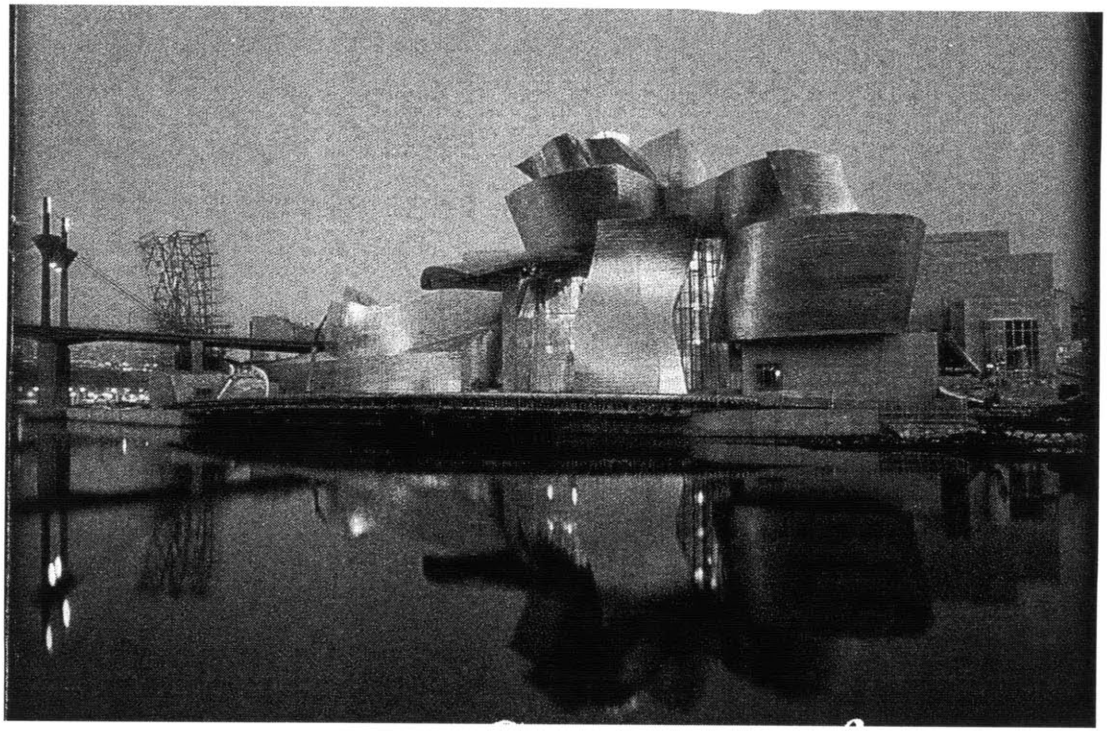
CHAPTER 2

BILBAO GUGGENHEIM MUSEUM CASE STUDY

PROJECT DESCRIPTION



2.1 Introduction

The Guggenheim Museum in Bilbao, Spain, begun in 1991 and inaugurated in 1997, is without a doubt an unique project. With a price tag of 14,000 million pesetas (roughly equivalent to $100 million), the Bilbao Guggenheim Museum -with its fluid, curving forms- has been recognized as one of the most complex, unique and important architectural designs of this century. Unequivocally, the museum's design is outstanding. Both architecture critics and the general public alike have universally applauded the building's abstract architecture created by its freeform titanium frame. Because of the museum's unique shapes and use of materials, the building has become the symbol of Bilbao in little more than a year.

The central feature of Gehry's design is a 165-foot-high atrium that serves as the central buffer for a series of curvilinear bridges and paths that lead to the many gallery spaces. With a total building area of 24,000 square meters, the Bilbao Guggenheim museum is of such a scale that its sister counterpart, the New York Guggenheim Museum, can fit within just the central atrium space of the Bilbao Museum. The overall plan of the museum covers 24,000m^2 including approximately 14,000m^2 of exhibition space, a 300-seat auditorium, a restaurant, a café, shops, offices and parking. See Figure 1 below.

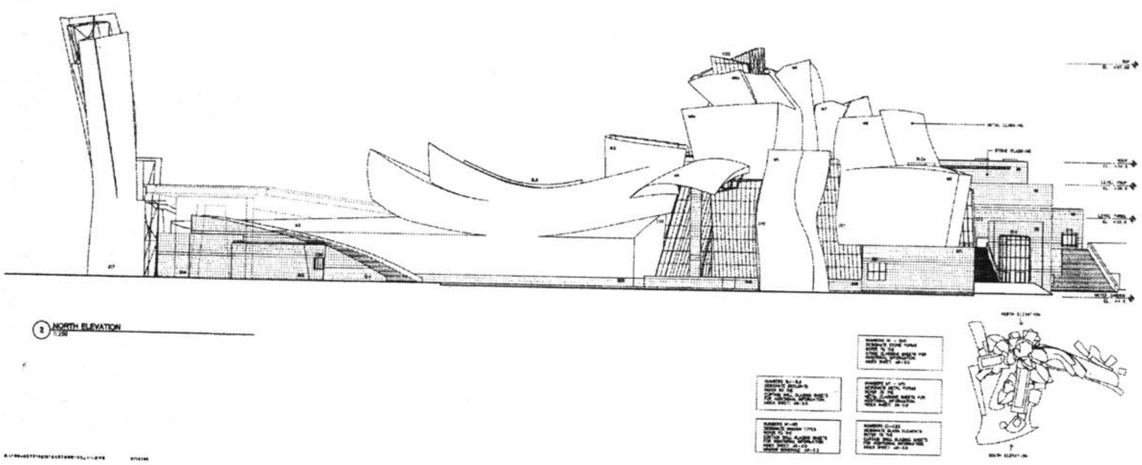


Figure 1 – Elevation of Museum (1)

2.2 Building Site

The museum is located on a 32,700 square meter, triangular-shaped site on the banks of the Nervion River, a 500-year-old highway to the city's shipbuilding, commercial and manufacturing industries. The museum is situated at the center of a cultural and civic district formed by the Museo de Bellas Artes, the University of Duesto, and the Old Town Hall. The 32,700m^2 lot, formerly occupied by a factory and a parking lot, is intersected by the Puente de la Salve -a vehicular bridge providing one of the main entranceways to Bilbao. See Figure 2.(1)

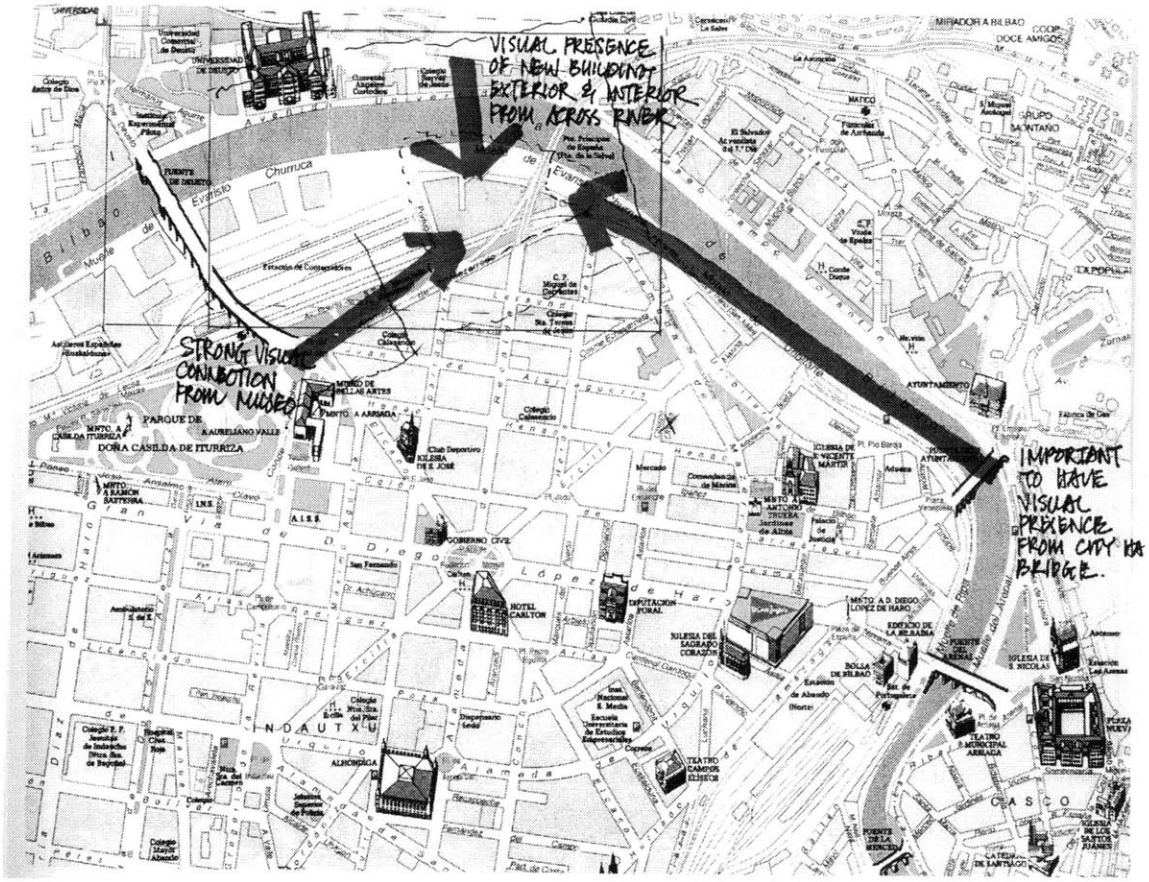


Figure 2 - Map of Museum Site relative to rest of Bilbao [1]

2.3 Introduction to the Primary Project Participants

The Bilbao Guggenheim Museum Project is a result of an agreement reached in 1991 between the Basque administrations (the Basque Government, the Provincial Council of Vizcaya and the Bilbao Municipality) and the Guggenheim Foundation of New York. According the agreement between these three organizations and the Guggenheim Foundation, the Basques would build a singular building in Bilbao to house the Museum and would acquire a collection of modern art. The Guggenheim Foundation would in exchange contribute their own artistic collections, their experience in defining and managing a Museum of international distinction, and not to mention the Guggenheim name.

Jointly, the three institutions within the Basque administration would form the Bilbao Guggenheim Museum Consortium and hold joint ownership of the Museum. The Basque Government and the Provincial Council of Vizcaya would provide the financial funds for the project, each would hold 45% of the ownership, while the Bilbao Municipality would provide the land and hold the remaining 10% of the stakes. The Consortium, lead by Juan Ignacio Vidarte, would oversee the planning and construction of the Museum. The Guggenheim Foundation would serve as consultants and establish the program for the museum.[(2)]

The Consortium's first task was the selection of an architect. In order to accomplish this, the Consortium held a design competition amongst a limited number of architecture firms. The three competing firms were Arata Isozaki & Associates of Tokyo, Coop Himmelblau of Vienna and Frank O. Gehry & Associates of Los Angeles. Each firm was to submit a schematic design for the museum. The aim of the selection process was to choose a building with a strong iconic identity, greater than the sum of its parts. Frank O. Gehry & Associates (FOG/A) was selected as the design architect in July of 1992 for the strength of his vision. See Appendix A1 through A2 for the entries submitted by each firm for the competition. Frank O. Gehry contracted Skidmore, Owings and Merrill (SOM) and Consentini & Associates as consultants for the non-architectural designs of the museum. SOM provided the structural engineering design, and Consentini provided mechanical and electrical design support.

For the selection of a project manager, the Consortium invited two large local engineering firms to present a portfolio of their capabilities from which one would be chosen. SERVEM and IDOM were the two candidates considered. In December of 1992, IDOM was selected to be project manager because of the firm's rich portfolio in engineering and architectural projects, as well as, the Consortium's belief that IDOM's teamwork oriented work culture was best suited to tackle a project of such complexity, and with so many players. IDOM would eventually serve as project manager and the architect and structural engineer of record despite the fact that the architectural design was created by FOG/A and the structural engineering by Skidmore, Owings and Merrill (SOM).

A summary of the project's major participants and the organizational relationships between the parties is illustrated in Figure 3 below.

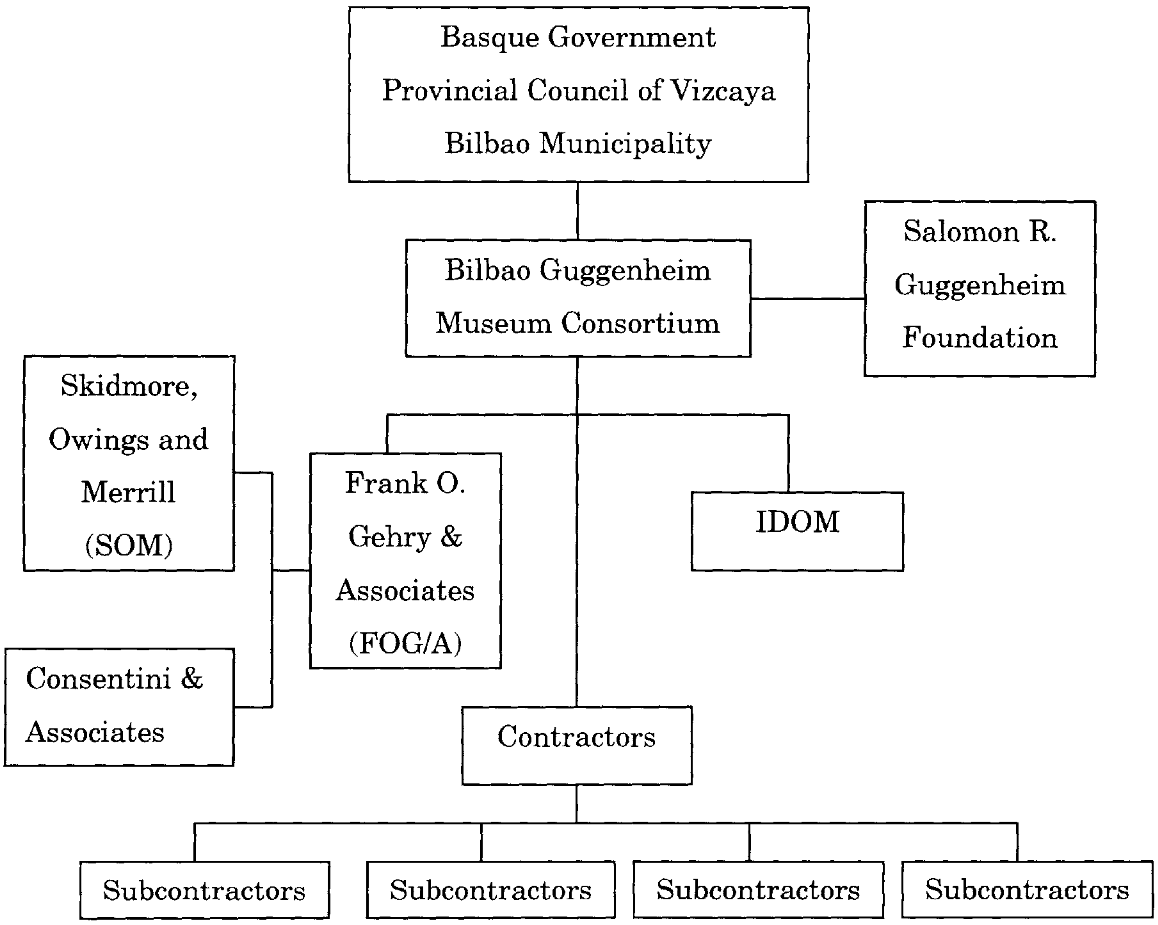


Figure 3 – Project Structure [9]

2.4 Bilbao and the Revitalization Plan

Bilbao, located along the Atlantic coast in the northern region of Spain, is perhaps not the most ideal of areas that comes to mind for a new art museum. The region, with a population of nearly a million inhabitants, is primarily an industrial and manufacturing port that had struggled through an economic depression in the 1980's due to the decline of the steel industry and the emerging competition in heavy manufacturing from Asia. The area's architecture with its many heavy, industrial facilities reflects the city's industrial history. See Figure 4.

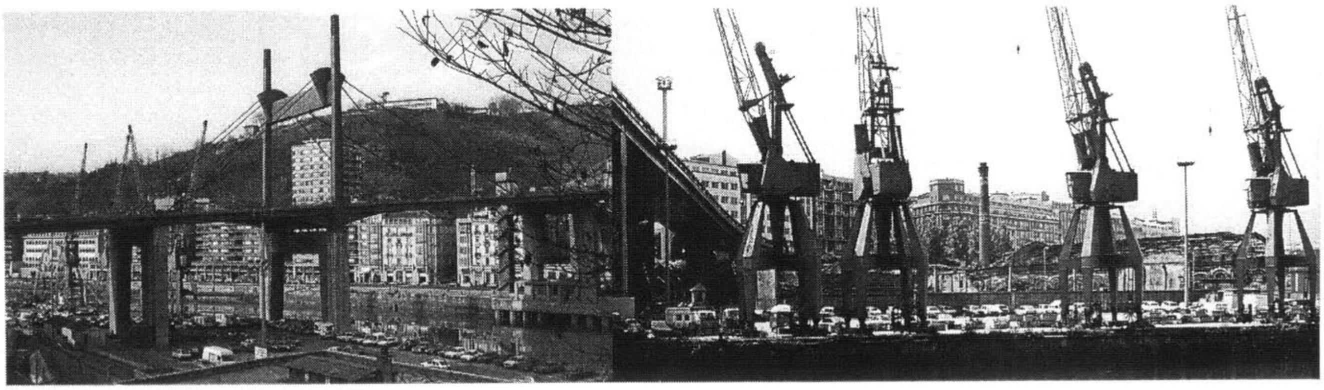


Figure 4 – Pictures of Site before Museum [1]

In 1989, a public and private institution called Bilbao Metropoli 30 prepared a Revitalization Plan for the Metropolitan Bilbao to transform the city into a post-industrial service metropolis. Drawing on the experience at Barcelona (another regional center that had successfully remodeled and revitalized itself), the plan was to address eight critical issues:

- Investment in Human Resources
- Service Metropolis in a Modern Industrial Region
- Mobility and Accessibility
- Environmental Regeneration

- Urban Regeneration
- Cultural Centrality
- Coordinated Management by the Public Administration and Private Sectors
- Social Action

Included in the plan for revitalizing Bilbao were: the design of a new Bilbao Metro Station commissioned to Foster and Partners; a new terminal for the airport and a footbridge over the Nervion commissioned to Santiago Calatrava; a railway station designed by Michael Wilford; a 25,000 m^2 congress hall commissioned to Dolores Palacios and Federico Soriano; and of course, the Guggenheim Museum commissioned to Frank O. Gehry. The Guggenheim Museum was a key component of the Revitalization Plan. It was a central piece and a large driving force behind the revitalization plan of Bilbao's metropolitan area. At stake were not merely the success of a museum but also a part of the revitalization of an entire region.[(2)]

CHAPTER 3

PROJECT PARTICIPANTS

3.1 The Client – Guggenheim Museum Consortium

The Guggenheim Museum Consortium, the entity comprised of representatives from the three holding Basque administrations, was responsible for overseeing and directing the project. Its members were the Basque Government, the Provincial Council of Vizcaya and the Bilbao Municipality. This team's Managing Director was Juan Ignacio Vidarte, who is currently director of the museum. The goal of the Consortium was to create a museum that had architectural qualities equivalent to the art that it would house. The Consortium was searching for a design that would convey the ambitions of the project and of the region's revitalization plan. Ultimately, the museum's image should be that of Bilbao.

As Managing Director, Vidarte established four guidelines for the Consortium's organization:

- The Consortium must establish a clear vision of what it wants. This would reduce the number of errors and changes throughout the project life.

- The Consortium must be consistent in its work. This would establish a level of credibility for the group, and eliminate the number of changes and surprises throughout the project.
- The Consortium must clearly define the set of responsibilities for the players involved in the project. This would reduce redundancy and confusion amongst the different parties.
- The Consortium must keep project goals on track. These goals included the completion of the museum right on budget, and the opening of the museum by 1997.[12]

Vidarte's high level of sophistication and clearly established project goals and objectives proved to be essential in keeping the project on budget and schedule. It was the Consortium's objective to realize the very best museum their budget could produce. It was their goal to use every dollar of their budget, nothing less and nothing more. Vidarte's clearly established expectations filtered to the other participants within the project and ensured that all of the participants were aware of the joint mission.

The Basque authorities' financial contribution to the project involved a $100 million dollar investment for building costs, $20 million to license the Guggenheim brand name, and $20 million to buy new works of art.

3.2 The Curator - The Salomon R. Guggenheim Foundation

Acquiring the Guggenheim Foundation's name for this project was a project in itself. Locating the museum in Bilbao was not the Foundation's idea, but instead was sold to them by the Basque representatives. Thomas Krens, the Guggenheim Museum's Director, and the Basque representatives had first met in February 1991 at a function where Krens was presented with the proposal of a Bilbao Guggenheim Museum. Although Krens was searching for a new museum location at the time, he was skeptical of the Basques' ability to substantiate an offer to fund the construction of a museum in Bilbao.

It required two months of negotiation, a visit to Bilbao and $20 million dollars given in advance to license Guggenheim's brand name in order to convince Krens of the Basques authorities' serious intentions. In the end, Krens agreed to proceed with the project in Bilbao. A feasibility study to evaluate the project and a search for an architect soon followed.

The Basque authorities would invest $100 million dollars in building costs, plus an additional $20 million to buy new works of art. In return, the Guggenheim Foundation would give Bilbao rights to their name brand, and would also loan works of art and provide curator advise from New York for a period of 75 years.

Krens would later return to Bilbao and specify that the design of the museum had to be entrusted to an internationally renowned architect. Two weeks later, he would return to Bilbao once again, but this time with Frank Gehry as an advisor.[(2)]

3.3 The Design Architect - Frank O. Gehry & Associates

Before Frank O. Gehry & Associates (FOG/A) was asked to develop a proposal for the Guggenheim Museum, the firm had recently lost three major competitions: La Sagrera, the Thames bridge and Saint Pancras Station. Moreover, the firm's $200 million dollar Disney Concert Hall project in Los Angeles was delayed as well due to higher than expected tendered costs. At that time FOG/A had received poor critiques which raised doubts about the firm's ability to materialize its ideas. Acquiring the Bilbao Guggenheim Museum project was critical to Gehry's reputation as an architect and the firm's success.

In July of 1991, Gehry presented a schematic model of his design. FOG/A's architecture had virtually eliminated all right angles and flat walls. Basswood pieces in his model depicted portions of the museum that would be built out of Spanish limestone, while silver painted components represented metal. Refer to the Appendix A3 for a picture of Gehry's entry. The industrial character of FOG/A's proposal embodied the abandoned wharves and industrial plants of Bilbao. Gehry's obsessions were expressed in the fragmented program that organizes the building in pavilions surrounding a central atrium space. Complicated routes extend from the atrium towards the galleries. It is said that the museum echoes of the contemporary Basque sculpture and the figurative ambition of Frank Lloyd Wright's New York Guggenheim. It was the strength of Gehry's proposal that earned him the design architect position in the project.

As design architect, FOG/A was responsible for the aesthetic and visual qualities of the museum. The question of whether or not the curved structures were attainable was still questionable. Gehry commented, "I've got it every bit as exciting as Bilbao. Whether we can afford it is questionable. You first put your dream on paper, then we start agonizing it."[2]

3.4 Project Managers / Executive Architect - IDOM

IDOM's challenge in delivering this project from design to construction was to produce a singular structure that would be on time, right on budget, and of an unprecedented quality. The Consortium had specified for a final product that would be the best museum their budget could produce. They wished the cost of the project to be right on the targeted budget, not under or over. IDOM's challenge was to realize a project with many technical, relational and management complexities. For instance, due to requirements to comply with completion dates, the design and construction stages of the museum were overlapped in a fast-track fashion. The details of IDOM's responsibilities, organization and methodology are addressed in detail in the next chapter.

IDOM was to act as executive architect and project manager. In these roles, it would have to collaborate with Frank Gehry to draw up a project appropriate for the City of Bilbao. It would have to revise and adopt the project as its own, direct the construction, provide support for the owners during the contracting processes and be responsible for making the building constructable in Bilbao, with the expected quality and within the timeframe and budget set.[9]

3.5 *The Structural Engineer - Skidmore, Owings and Merrill*

Skidmore, Owings and Merrill (SOM) was contracted by FOG/A to perform the structural design for the museum. Although IDOM was the structural engineer of record, SOM performed the design and then forwarded their design to IDOM to have it checked. As structural engineers, SOM's challenge was to create an organized, rational structural system within the complexity of the architectural design so that the building could be reasonably designed, detailed and constructed. The conceptual design process from a structural engineering standpoint was unique in that the building was without precedent in terms of geometry, complexity, organization and scale. The Bilbao Museum structure had to be developed without the usual benefit of a comparable benchmark project. The irregularity of the freeform masses and surfaces posed a unique challenged to the traditional view of structural stability, organization, and regularity that is essential to achieve a material efficient and cost effective design.[(4)]

Traditionally, free-form, curved surfaces such as those in the Bilbao Museum have been nearly, exclusively framed in reinforced concrete – as are other Gehry buildings of smaller scale. However, because of the Museum's scale, a lighter structural system was required. A steel structure was selected for its low structural self-weight, and its ability to be controlled and verified in a shop environment.

The inherent problem in using steel is the difficulty of creating curved steel plate elements. In order to overcome this problem, a two-layer system was devised. An interior steel superstructure, consisting of only straight elements, would comprise the support system for the museum. It was desired that the superstructure approximate the final curves as closely as possible. A secondary, exterior façade layer would hang off of the interior superstructure and would create the final, smooth, curved surfaces. This exterior façade layer supported the thin titanium exterior and the waterproofing. See Figure 5.

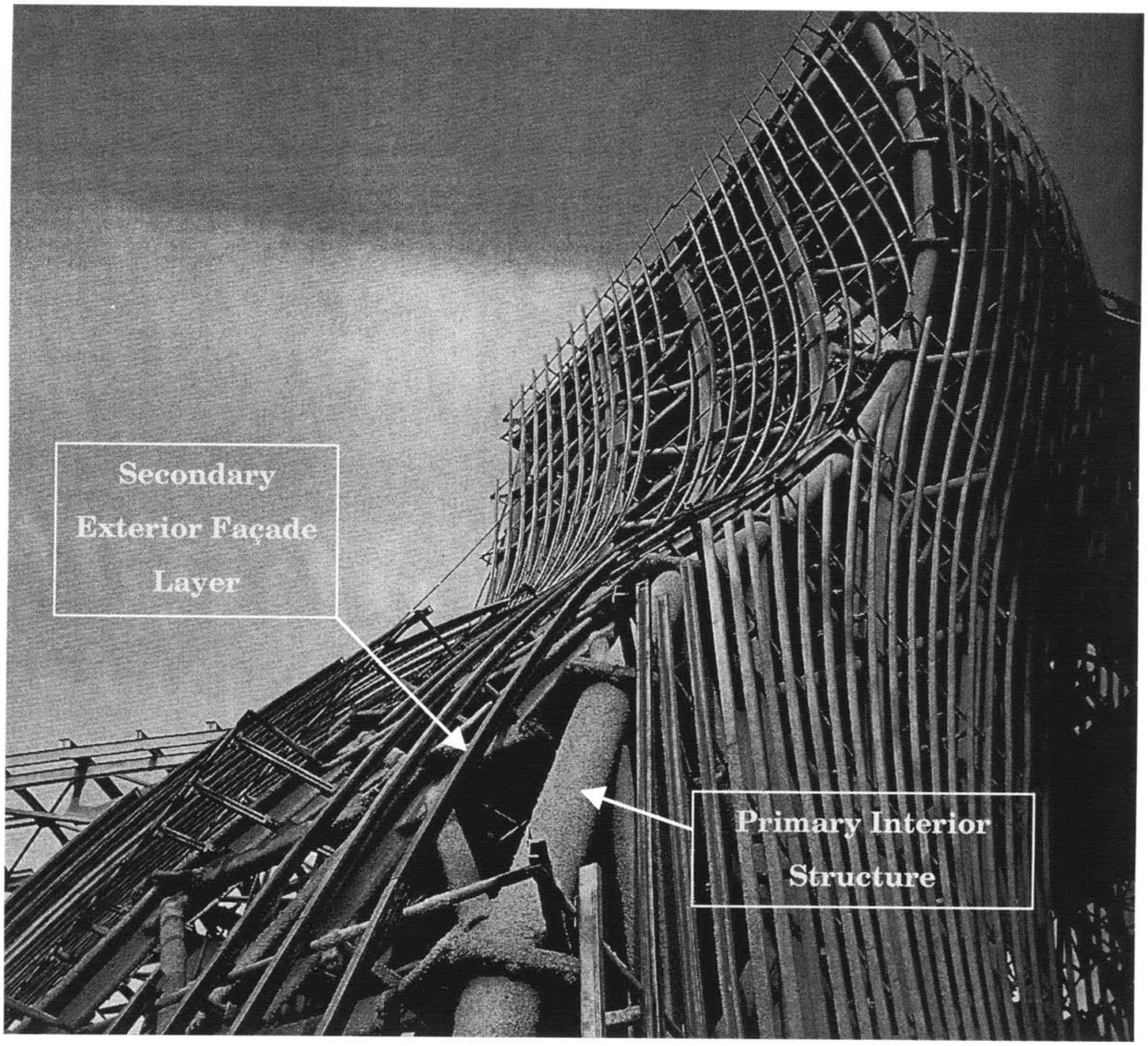


Figure 5 – Exterior Structure and Exterior Façade Support Structure[(5)]

In designing the structural system of the museum, the design team, instead of viewing the complex geometry of the clad surfaces as a hindrance, used the curvature and interconnectivity of the forms as a stiffening device against lateral wind loads and individual column buckling. This is based on the premise that a curved surface is stronger than a flat one. This demanded that the structural system for these curved galleries act much like a three dimensional shell or continuous membrane that could resist lateral wind loads over tall unbraced lengths and span discrete supports located relatively far apart. In order to accomplish this, a dense, discretized, modular, three-dimensional steel fabric grid system, interconnected by diagonals, was devised for the interior superstructure. See Figure 6. This system is equivalent to a traditional concrete bearing wall framed entirely in structural steel.[6]

The dense structural grid system was derived from analyzing the geometry by taking horizontal and vertical slicing planes which lead to the idea of organizing the frames in a disciplined, geometrically rigid fashion. The intersections between these planes became the locations of structural nodal points. SOM engineers set the following rules to impose on the structural development for the purposes of creating a disciplined and regular primary structure within constraints of the architectural design:

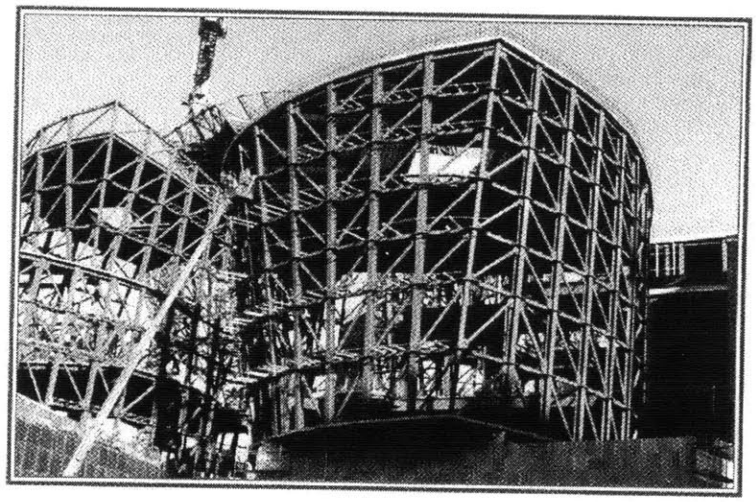


Figure 6 – Picture of Steel Grid Framing System [5]

1. All members would be straight segments between nodal points.
2. The grid spacing 3 meters by 3 meters (10 feet by 10 feet). This was found to be dense enough to generally conform to the curved surfaces while at the same time allowing for reasonably dimensioned horizontal "band" trusses to be prefabricated and transported to the site.
3. The structural nodal work points would be a constant 600mm dimension from the exterior clad surface.
4. Horizontal members would be at constant elevation except at sloping roof lines.

5. Inclined column members would be created by passing vertical slicing planes normal to the ground surfaces and through the offset surfaces in CATIA. The orientation of the column web would lie perpendicular to the exterior surface as determined by averaging the normal vectors along the run of the column. The web orientation of the column would remain at a constant angle for the full vertical run of the column.
6. Diagonal members to be oriented in a tensile arrangement based upon gravity load considerations.
7. Wherever possible, minimum sizes are to be used to create economies in the structural steel mill order and to simplify the architectural/structural engineering coordination process (unless found analytically to be insufficiently structurally). See Appendix A4 for a list of nominal member types.[7]

The use of straight members, with only a limited number of sections, proved to be cost efficient for steel fabrication and erection purposes. The number of nominal member types comprised over 95% of the museum's superstructure. The simplicity of SOM's structural system, despite the complexity of the architecture, contributed to the timely and economic construction of the museum.

CHAPTER 4

PROJECT MANAGER / EXECUTIVE ARCHITECT

IDOM

4.1 IDOM's Responsibilites

As executive architect, IDOM had clear objectives and deliverables established by the consortium. These included the following:

1. The Executive Architect was responsible for maintaining the cost parameters as specified in the Cost Model (see Appendix A6)
2. The Museum should open to the public within 1997.
3. The Museum was to be completed with the highest construction quality standards.
4. The Executive Architect was required to maximize the use of local resources and materials in construction.
5. The Executive Architect was expected to facilitate the Design Architect's creativity.[9]

4.2 IDOM Leadership

In order to undertake this project, IDOM decided to create a rather unusual management structure. Contrary to what is usually customary, the project was headed by an architect, Cesar Caicoya, and an engineer, Luis Rodriguez. Cesar Caicoya was a well respected architect that had successfully collaborated with IDOM in several past projects, and Luis Rodriguez –PhD and MBA- was an engineer with management experience. These two managers were lead by Jose Maria Asumendi, a top executive, in the initial stages of the project. This management approach was created to reflect the two most notable aspects of the project: aesthetic considerations and tight budget, time and quality constraints. Complementing managerial and design skills, Rodriguez and Caicoya were chosen to lead a team of 150 professionals to complete the project.

From a management point of view, the Guggenheim Museum presented an endless number of complexities, which can be summarized into three categories:

- Technical complexities
- Management complexities
- Relational complexities

4.3 Project Complexities – Technical

A technical complexity is anything that involves something novel, technologically advanced and is not trivial. Within the Museum, there are a large number of elements that comply with this definition. Examples of such a technical complexity are the titanium cladding and budget control issues of the construction (the budget control issues will be covered in the next chapter).

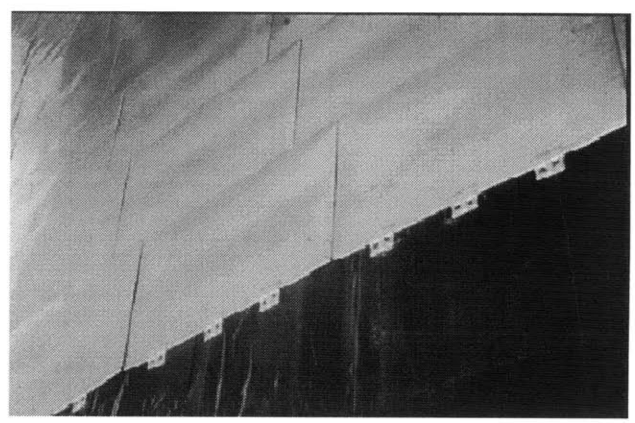


Figure 7 – Titanium cladding w/ waterproofing beneath

The titanium cladding on the museum more than qualifies as a technical complexity. The aesthetic requirement on the metal cladding was very demanding: complex shapes, velvety appearance and perfect joints. Secondly, the use of titanium and the constructive solutions were novel as well. Thirdly, the functional requirements were also demanding. The cladding had to be waterproofed, heat insulated, and acoustically insulated from the noise of bridge traffic. The obvious risk of the cladding not satisfying these requirements would be disastrous to the museum's construction cost, schedule and quality. Moreover, a possible loss or damage of fine art contained within the museum due to the under-performance of the cladding system would also be disastrous. See Figure 7 and 8.

Figure 8 – Workers installing titanium cladding

In order to address this problem and reduce the risks involved, IDOM established a work team including national cladding suppliers to support and aid Gehry in the design. Simultaneously, economic appraisals were made of the proposed solutions to provide instantaneous feedback and monitoring of the expected project costs.[9]

4.4 Project Complexities – Managerial

The management complexities associated with this project were a result of the many different entities that took part in the project. These entities included:

- Guggenheim Museum Consortium
- Guggenheim Foundation
- Frank Gehry & Associates
- Skidmore, Owings and Merrill
- Consentini Associates
- Several FOG/A consultants

- Several IDOM consultants
- Main contractors

The shear number of participants and their wide-ranging geographical locations, together with the scale of the project and its complexity, made the management and coordination the project difficult. This managerial complexity was overcome in the following manner:

- Very clearly defined functions were established for each of the participants. In cases where the objectives were shared among participants and conflicts arouse, the Consortium's decisive role as the owners became imperative.
- IDOM's team was structured in accordance to reflect the diversity of the participants. This will be addressed in section 5.3 of the next chapter.
- Heavy use of telephone calls, faxes and the internet to coordinate tasks between geographically spread participants.

In addition to the organization complexities, the time constraint placed on IDOM also posed a managerial complexity. In order to meet the 1997 deadline, the project had to be fast-tracked, where the design and construction phases were overlapped. Coordination between the IDOM and FOG/A's design team was crucial in order to prevent delays in the construction process. "Freeze" dates established between IDOM and FOG/A represented deadlines by which FOG/A was responsible for delivering certain design packages in order to enable the bidding and construction of those packages to begin. See Figure 9 and 10. Had the project have been coordinated in the traditional design/bid/build delivery method with sequential phases, the project would have consumed two years in development, delaying the start of construction until 1995 and the opening to 1999.[9]

4.5 Project Complexities – Relational

Because of the diversity of the project groups, relations between different parties also presented another level of complexity. Language and cultural barriers, and inexperience with the other parties often created situations where there were high levels of distrust amongst the participants. Nevertheless, communication and trust were developed in time due to the professionalism of all the parties, and their mutual goal of successfully completing the project.

DATES OF DELIVERY OF INFORMATION
TO IDOM

CONCRETE

Full package	Feb. 28, 1994

STEEL STRUCTURE

3th Package	Feb. 28, 1994
Final Package	March 31, 1994

EXTERNAL CLADDING

First Package	April 30, 1994
Final Package	June 30, 1994

INTERIORS

Final information to prepare bid package	Oct. 31, 1994

URBANIZATION

Final information to prepare bid package	July 31, 1994

Figure 9 – Freeze dates (design deadlines) for FOG/A[2]

HEAT VENTILATION - AIR CONDITIONING

Final information to prepare bid package .... Sep. 30, 1994

ELECTRICAL

Final information to prepare bid package .... Oct. 31, 1994

FIRE PROTECTION & PLUMBING

Final information to prepare bid package .... Oct. 31, 1994

LIGHTING & SECURITY

Final information to prepare bid package .... Oct. 31, 1994

ELEVATORS

Final information to prepare bid package .... Nov. 30, 1994

PROYECTO DE EJECUCION DRAWINGS

Final package .... Feb. 28, 1994

It is understood that each of the stated packages represents a significative part of the final information.

Figure 10 – Freeze dates (design deadlines) for FOG/A[2]

CHAPTER 5

CONSTRUCTION MANAGEMENT

5.1 Project Planning

In planning the project, IDOM, FOG/A and the Consortium established the following key procedures:

- The design and construction of the museum would be overlapped in order to meet the 1997 opening deadline
- A real time cost control model will be established in order to monitor project costs throughout the project, particularly during the construction.
- The project construction would be divided into "packages" in order to facilitate the coordination of design and construction overlap.

5.2 Phase Overlap

Having to meet the 1997 opening deadline, IDOM was faced with a very difficult task of accomplishing a project in 5 years which experience suggested would take at least seven. On first estimate, IDOM considered that 1993 would be dedicated to complete the project designs to allow construction work to begin, 1994 to erect the structural systems, 1995 to build the façade, and 1996 to complete the interiors.

According to this plan, the design would have to be developed parallel with construction.

A fast-track schedule was the only option for meeting such an aggressive deadline. This required that the design process be coordinated carefully with the construction schedule. What ensued was the division of the construction into "packages" to facilitate design and construction coordination, and "freeze" dates by which FOG/A had to deliver finished designs. See Figure 9 for Freeze dates and Appendix A7 for the overlapped construction and design schedules.

5.3 Construction Packages

In order to facilitate the coordination between design and construction, the overall construction and design of the project was divided into "packages." These packages were strategically designated to enable design and construction to occur in parallel, which in conjunction with the freeze dates, allowed the continuous construction of the museum without delays. These packages were:

1. Demolitions
2. Foundations
3. Structure
4. Exteriors
5. Interiors and Installations
6. Urban Infrastructure
7. Furniture, Fixtures and Equipment[9]

As a public institution, the Consortium was subject to governmental legislation. According to standard public regulations, the project had to be bid to a single General Contractor who would undertake the entire project. However, it was IDOM's experience with large, complex projects that the subdivision of tasks into clearly defined areas was essential for effective control of the project. Vidarte, Asumendi, Caicoya and Rodriguez proceeded to meet with the *Diputado de Obras Publicas* (Public Commissions Deputy) and convinced him to allow the award of the construction to several contractors based on task divisions.

In managing the different packages, IDOM assigned a project manager within IDOM's team to each package who would be responsible for controlling the quality, cost and time of that package. The inherent risks in dividing the project and assigning the tasks to different people is that certain tasks may be forgotten and slip by between two packages. Clear definition of the exact content of the tasks within each package, and ensuring that no task was left unattended between packages was crucial in this process. Moreover, coordination between project managers and contractors of different packages was also essential. Rodriguez and Caicoya's role in ensuring the coordination between packages was crucial. The organizational structure of the packages and the project managers for each package is summarize in Figure 11.

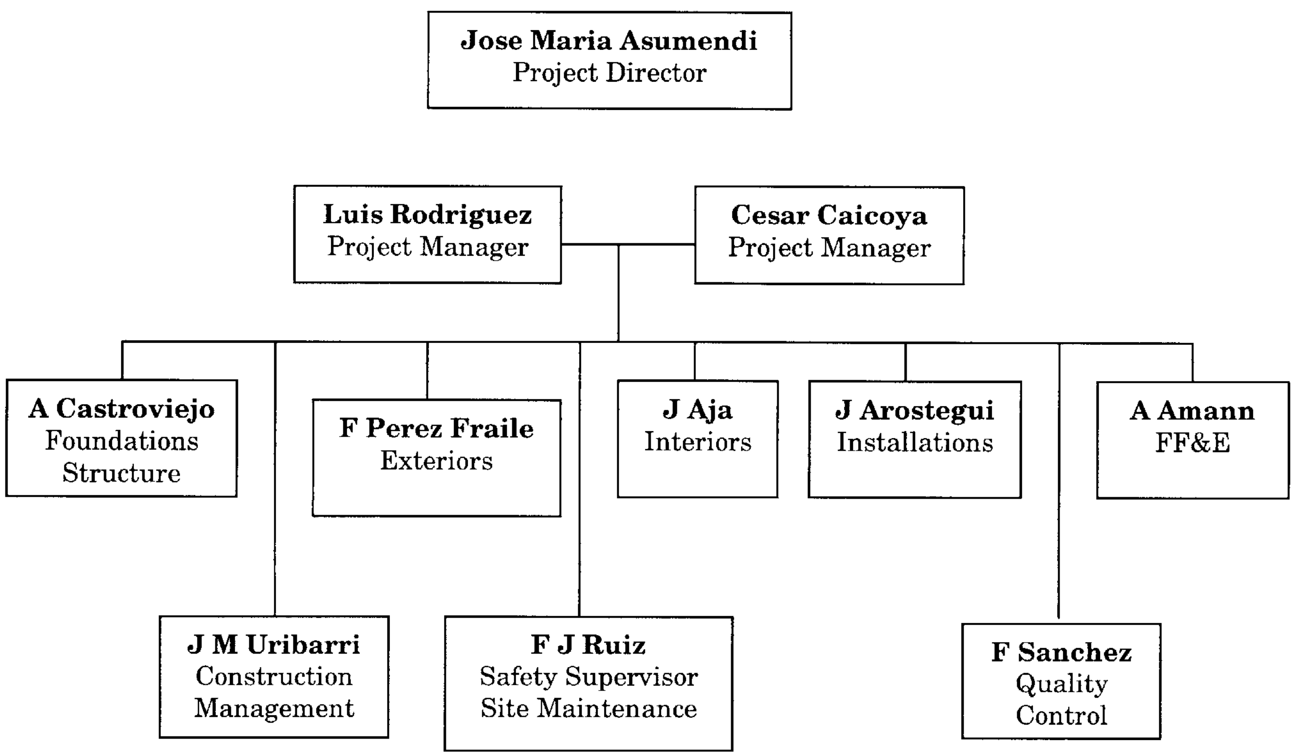


Figure 11 – IDOM and Packages Structure[2]

5.4 The Contractors and Subcontractors

In selecting the contractors and subcontractors, the Consortium specified that local contractors and resources to be used for the construction. Because of the project's complex shapes, it was clear to IDOM and the Consortium that the contractors would play a central role in developing technical solutions that met design challenges. A public qualification competition was held in order to both inform potential contractors of the characteristics of the project, and to establish a ground for selecting the contractors with the technical and economic capabilities to address the needs of the project. The final contractors selected for the project were:

1. Demolition: Petralanda
2. Foundations: Cimentaciones Abando
3. Structure: a joint venture between Urssa/Lauki/Ferrovial
4. Exteriors: Balzola
5. Interiors and Installations: Ferrovial[2]

The Exteriors portion of the bid was the most critical of all bid packages for it represented over 50% of the total budget. The difficulty of this portion of the construction was in creating the fluid, complex shapes with diverse materials, including stone, glass and titanium. A new system of construction had to be devised to make the complicated forms. Five construction companies satisfied the public competition requirements. In the fall of 1994, bidding documents were ready and all five contractors submitted proposals with costs over the set limit. Because of the fast-track nature of the project with a fixed finished price, these higher than expected bids proved to be a critical moment in the project. The negative results of the bids presented high risks in terms of time and budget. A new biding process was initiated, with IDOM working with contractors to clarify designs and adjusting pricing, and resulted with only two companies presenting proposal within the maximum price. Of those two, the Consortium selected Balzola.

5.5 Cost Control Methods

The cost estimate for the project of 14,028 million Pesetas included all design fees, licenses, civil works and furniture. The Consortium had specified that IDOM deliver the best project that the budget could buy. Risk lay in any deviation from the budget either upward or downward. IDOM's task was to balance the equation between design ideas and cost, always considering ways to allow FOG/A to express a maximum creativity within the allowed budget.

IDOM, in an agreement with the project team, established a continuous control monitoring system that allowed for immediate action in case of a deviation from the projected final cost. Every 6 weeks, a detailed cost estimation would be adjusted and compared with the reference cost basis. This was accomplished during team meetings with all the project participants. Early in the project, these meeting were held in Santa Monica and in Bilbao once construction began. Should a deviation occur in the cost, designers and managers quickly proposed alternatives. IDOM structured its budget monitoring activities in accordance with its "packages" structure. In this manner, each of the package project managers was responsible for achieving the objectives corresponding to his or her own package. In addition, to insure the accuracy of the cost model, the entire cost model was recalculated three times during the design phase.(9)

5.6 Construction Process

Construction began in October of 1993 with demolition work, after the project for foundations was completed. The Museum's foundations are made up of 664 piles with an average length of 14.5 meters. The structure of the building is concrete up to the first floor and steel from that point on. It took 18,000 m^3 of concrete and 4,500 Tm of steel to create the museum. Only 2,900 Tm of the 4,500 Tm of the metal structure was "traditional" in nature. The remainder consists of the titanium, stone and glass used to create the freeform "shapes." IDOM designed and produced foundation documents based on calculations made by SOM. IDOM prepared bidding documents and after a public competition the job was assigned to Cimentaciones Abando.

In the meantime FOG/A was still in the design development phase. The freeze date for concrete documentation was set for February 28, 1994. Thereafter FOG/A had to design with the foundation constraints.

By the end of October 1993, 664 concrete piles had been built in situ 14 meters below the surface. Due to the proximity of the Nervion River, potential floods were considered in the design; hence, 121 water anchors of different sizes were built to prevent the building from heaving upwards. 18,000m^3 of low permeability reinforced concrete structural walls formed the basement and mechanical areas.

Foundation works lasted until April 1995, overlapping almost entirely with the concrete and structural jobs. Had the project not being fast tracked, the time required to complete all design work would have delay the start of the foundation work until June 1995.

A coordination error occurred between SOM and IDOM in estimating the amount of steel required for the project. An underestimation of the structure's weight resulted in a cost increase from the original maximum estimation of 2,270 million pesetas to 2,410 million pesetas. This was a difference of about 2 million dollars. With the structural well on its way, this divergence in a foremost and critical bid caused a great amount of uneasiness for the Consortium. The reaction was immediate. Tense and comprehensive team meetings were held amongst Consortium, IDOM and the entire team in Santa Monica to arrive at a unanimous solution. The meeting resulted in an adjusted cost model with variations in certain shapes in the design and an important reduction of the contingency segment of the model. The construction of the steel structure was started on September 1994.[9]

5.7 Information Technology

Almost incomprehensible in its scale and three-dimensional complexity, the Bilbao Guggenheim extends the limits of what is understood as possible in architecture and construction. The realization of such a complex structure was only possible through the extensive use of information technology to integrate the design, fabrication and construction issues of the project. The flow of information technology is summarized in the flowchart below:

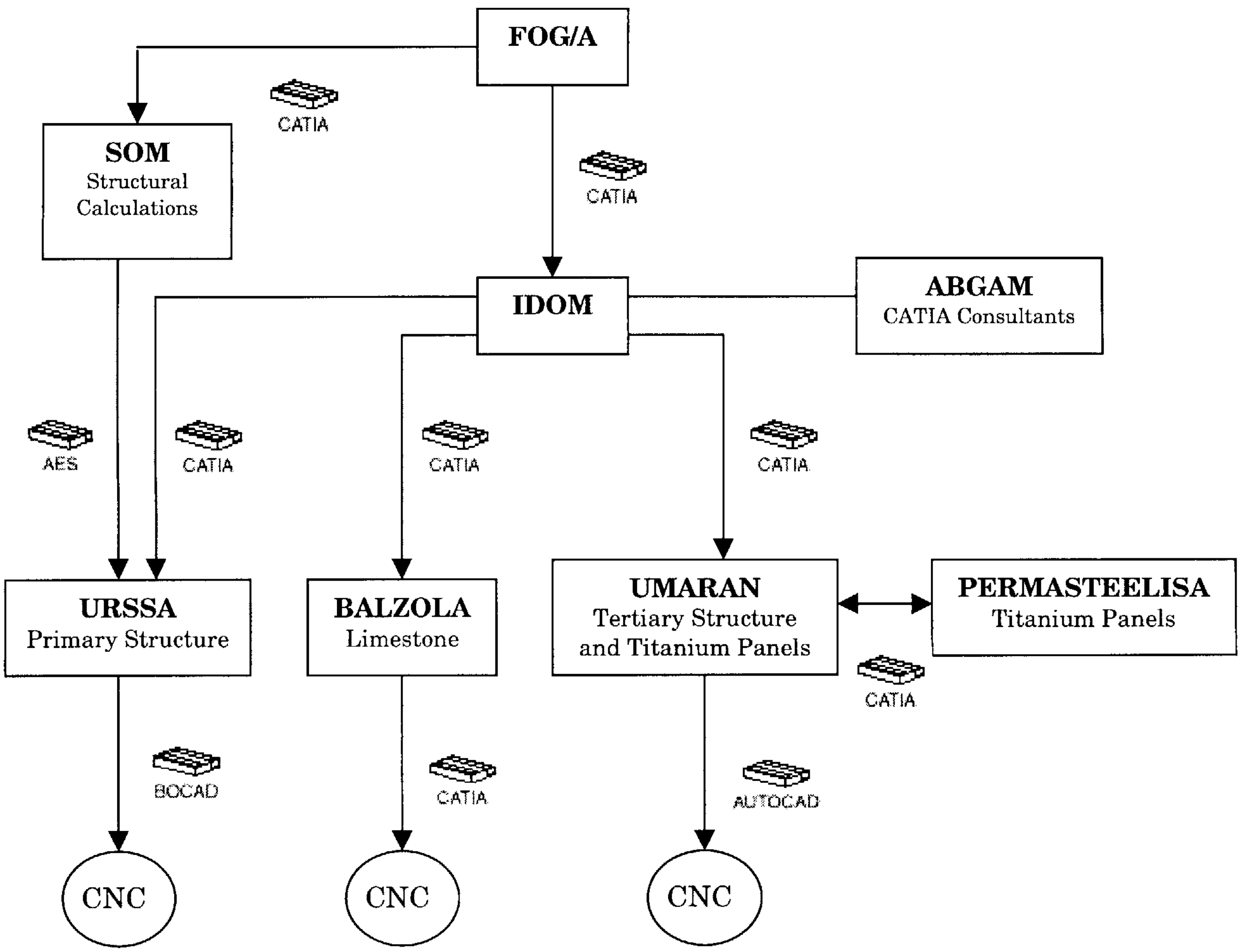


Figure 12 – Information Technology Flowchart[2]

FOG/A used CATIA as a design tool to model the complicated geometry of the project. CATIA is a software package that enables numerical control of complex shapes, defining surfaces by descriptive geometrical mathematical formulas.

Running on IBM RISC System 6000 workstations, it is intensively used in the aerospace, shipbuilding and automotive industry.

FOG/A digitized traditional models into CATIA files using 3Dscanners. Once the building was completed in CATIA, the model containing face and surface element was sent out to a machine shop where a foam scale model was milled directly from the CATIA data. The model was then sent to IDOM on DAT tapes. The size of these files was often in the order of 30MB.

The DAT files contained the three-dimensional drawing of the building's exterior skin. Using this computer model as a reference, IDOM collaborated with ABGAM to work with contractors and subcontracts in developing sketches to determine supporting systems and components. ABGAM was a Vitoria based engineering company specialized in the aerospace industry.

For the primary structure, URSSA used BOCAD, a 3D solid CAD/CAM software specialized in steel structure detailing and workshop management. BOCAD interpreted data from FOG/A's CATIA surface model and SOM's AES structural calculations to draw the resulting structure in three dimensions. Through BOCAD, information was sent directly to CNC machines where robots cut and folded the primary structure members. These members were then bolted in place at the shop to test fit the sections.

IDOM and Umaran developed the design of the secondary exterior structure that would support the titanium and stone cladding. Using CATIA workstations and operators at ABGAM, geometry and intersection data of the skin and structure was extracted. IDOM sent DAT tapes to Permasteelisa in Venice, where titanium panels were cut directly from the CATIA files. Umaran in turn translated the CATIA information to AutoCAD files to fold the panels.

In order to cut the limestone, IDOM sent Balzola CATIA files where the files were used directly to cut stone panels on CNC machines.

Only through the extensive used of information technology was the construction and fabrication of the museum possible.

CHAPTER 6

PROJECT DELIVERY METHOD ANALYSIS

6.1 Introduction

This chapter will be dedicated to the analysis and evaluation the appropriateness of the project delivery method used by the Consortium for this project, in light of the advantages and disadvantages of alternate project delivery methods. In particular, this paper will analyze this case study with respect to the six main delivery methods: general contractor, construction manager, multiple primes, design-build, turnkey and build-operate-transfer. This chapter will briefly discuss the six basic contract types but largely assumes that the reader has a basic understanding of the basic differences between the different delivery types. Although this thesis will mainly discuss each option from the owner's perspective, the Consortium (and thus largely the project manager's as well), it will also incorporate the points of view of the other participants of the project in order to determine an appropriate and feasible delivery method.

Any project delivery or contracting method has four fundamental parts: scope, organization, contract and award. In order to identify an appropriate delivery method, this thesis will analyze each of the four fundamental parts and utilize a process of elimination to identify obviously inadequate methods.[3]

6.2 Strategic Alignment

The essence of selecting an appropriate delivery method is to align three key items within any project: the market, the process, and the product. Each of the three items within the project must match the needs and qualities of the other two. In other words, the process by which the product is brought to fruition should match the qualities of the product. Likewise, the product should be representative of the market demands. This triangular relationship is summarized in by Figure 13.

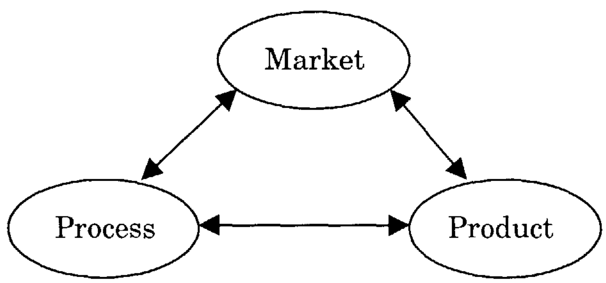


Figure 13 - Strategic Alignment Chart [2]

The goal of this chapter is to identify whether or not the Consortium selected an appropriate delivery method that aligns the product with the market, the process with the product, and the process with the market. In order to accomplish this, a thorough understanding of the market trends, the product and the process is essential.

In the case of the Guggenheim museum, the requirements and expectations of the Basque administrations and the Guggenheim Foundation largely define the market trends and the product specifications. Because the museum is a publicly funded project, the client market is largely defined by the Basque administration. The market should be viewed in light of the Revitalization Plan for Bilbao and the museum's role in it. The product is largely defined by what the Guggenheim Foundation's needs. The process chosen for such a project should be one that enables the completion of a product that satisfies the Basque administration and the Guggenheim Foundation.

6.3 Organization Type

The first step of our analysis will involve identifying the appropriate organization by eliminating the inappropriate ones. Within any appropriate organization, three types of drivers must be addressed and assessed by the owner: project drivers, owner drivers, and market drivers.

Project drivers or project characteristics consist of: the time constraints on the project, the flexibility needed in the design and construction of the project, the preconstruction services needed for the project, the amount of interaction needed between the owner and designer during the design process, and the financial constraints on the project. Depending on the owner's requirements for these project characteristics, certain organization types are more adequate to tackle the project than are other organization types. Table 1 summarizes the adequacy of different organization types in satisfying different project characteristics.

Drivers	GC-FP	GC-R	CM	MP	DB-FP	DB-R	T-FP	T-R	BOT
Fast Track Schedule		*	*	*	*	*	*	*	*
Sequential Schedule	*	*	*	*	*	*	*	*	*
More Flexibility		*	*	*		*		*	
Less Flexibility	*	*	*	*	*	*	*	*	*
Pre-Const. Advice Needed		*	*		*	*	*	*	*
No Pre-Constr. Advice Needed	*	*	*	*	*	*	*	*	*
Design Interaction	*	*	*	*		*		*	
Less Design Interaction	*	*	*	*	*	*	*	*	*
Construction Financing							*	*	*

Needed									
Permanent Financing Needed									*
Owner Financing	*	*	*	*	*	*			

GC=General Contractor DB = Design Build Team CM = Construction Manager T = Turnkey
MP = Multiple Prime Contractors BOT = Build Operate Transfer R = Reimbursable Price
FP = Fixed Price

Table 1 - Organization Types vs. Possible Project Drivers

The time constraint on a certain project refers to the constraints placed on the schedule of a project. In the Guggenheim museum, the obvious time constraint is the need for a fast track schedule and the need to meet the 1997 opening deadline. As we can see from Table 1 above, only certain organization types are suited to tackle a fast-track schedule. It is now possible to eliminate the organization types that are inadequate. The first step of elimination has begun.

The flexibility needs refers to the amount of flexibility allowed in the schedule and design for changes. The level of flexibility needed in the schedule and the design is extremely high in the museum due to the uncertainty associated with a fast track schedule, and the client's specification for a singular design.

Preconstruction service needs refers to the amount of consultant services that the project needs because of the unique character of the project. The more sophisticated or complex a project, the more preconstruction services it will require. In the case of the museum, because of the high quality and uniqueness required, a high level of preconstruction services will be required.

Given the Consortium's need to create a singular design, and ensure that costs of the design fall on budget, the owner's interaction with the designer during the design process is essential. For this reason a high level of design interaction is needed.

The financial constraints on the project refer to the owner's ability to finance the entire project. Given that Bilbao has allocated over $100 million dollars to the project, obviously the project will be owner financed.

Having summarized all these project characteristics, we can eliminate at this stage five out of the nine organization types. This is illustrated by Table 2.

Drivers	GC-FP	GC-R	CM	MP	DB-FP	DB-R	T-FP	T-R	BOT
Fast Track Schedule		*	*	*	*	*	*	*	*
More Flexibility		*	*	*		*		*	
Pre-Const. Advice Needed		*	*		*	*	*	*	*
Design Interaction	*	*	*	*		*		*	
Owner Financing	*	*	*	*	*	*			
APPROPRIATE	NO	YES	YES	NO	NO	YES	NO	YES	NO

GC=General Contractor DB = Design Build Team CM = Construction Manager T = Turnkey
MP = Multiple Prime Contractors BOT = Build Operate Transfer R = Reimbursable Price
FP = Fixed Price

Table 2 – Organization Types vs. Museum Project Drivers

The remaining organization types that may be adequate are: general contractor on a reimbursable price, a construction manager or a design build team on a reimbursable price.

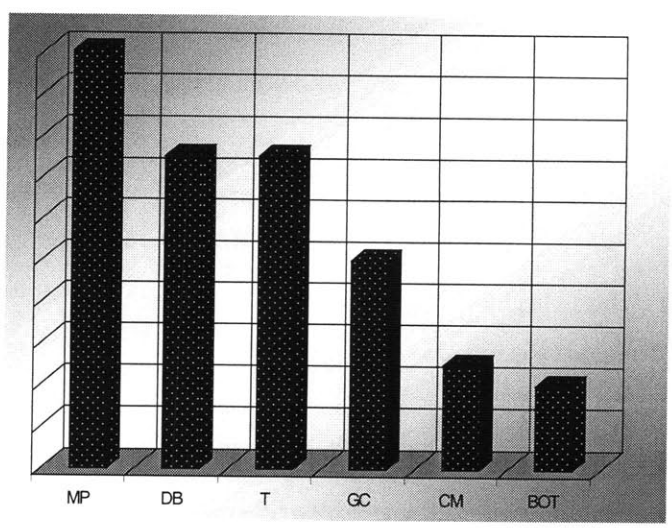


Figure 14 Required Owner Sophistication Graph

The next step in selecting an appropriate organization type is to analyze the owner drivers or owner characteristics. These characteristics include the owner's level of construction sophistication, the owner's current capabilities, risk aversion and restrictions on methods. Given the Consortium's lack of experience in building museums in the past, the Consortium's construction sophistication is rather low. As Figure 14 illustrates, certain organization types require more construction experience from the owner than others do. It is now possible to eliminate design build from the remaining list of adequate organization types; leaving only general contractor and construction manager. It should be noted that because the Consortium is very concerned about keeping project costs on budget, utilizing a general contractor instead of a construction manager would cut back on the premium paid on extra management.

The owner's current staffing capabilities to oversee and direct the project is also a limiting factor. The amount of staff the owner can commit to monitor the project limits the types of organization types it can select from. As Figure 15 illustrates, certain organization types require a larger amount of owner management and supervision. We can now eliminate a general contract organization, which leaves only construction manager.

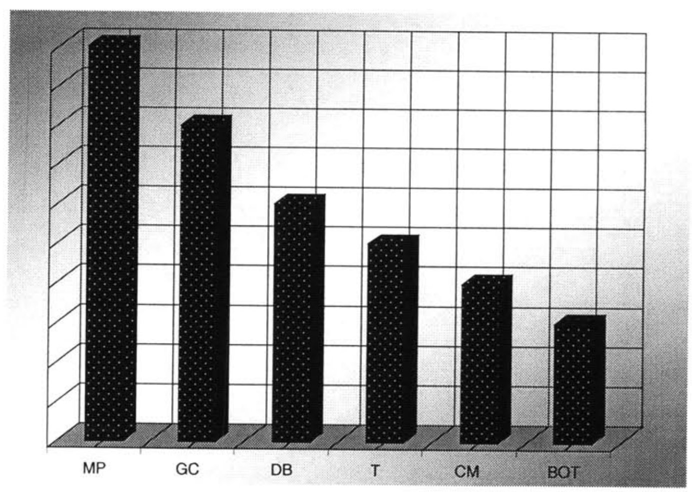


Figure 15 Owner Involvement Graph

In terms of risk aversion and restrictions on methods, this paper will assume that the owner will bear the financial risk of the project, and there are no restrictions imposed on the owner on the organization type it can use. Although there were restrictions imposed on public projects in Bilbao that required the use of a general contractor, given that the Consortium and IDOM were capable of convincing the Public Commissions Deputy to allow for other delivery methods, this paper will assume any other method would have been acceptable as well.

The Consortium's choice of having a project manager organization was an excellent decision based on this analysis. The primary difference between a construction manager and a project manager, from a management point of view, is that a project manager not only manages the construction process, but also works closely with the owner and designer to establish project scope, definition and budget. Due to the complexity associated with the project. IDOM's ability to interact with FOG/A, the Consortium and contractors throughout the project was crucial to the coordination of cost, quality and schedule between all the participants in the project. Given this, a project manager organization was certainly an appropriate choice.

6.4 Contract Types and Risk

Having established the organization as a construction manager, it is now possible to pick an appropriate contract type. The question of selecting an appropriate contract type revolves around the issue of risk allocation and management. In selecting a contract type, it is necessary to assess the risks involved in the project, allocate the risk to the appropriate parties and manage the risks. This section will focus on selecting a contract type that minimizes risk for the owner, and therefore largely the project manager IDOM (although differences will be highlighted). There are three steps in the selection of an appropriate contract type:

1. Understanding the types and phases of risk
2. Assessing the risks of a particular construction project
3. Drawing up a contract type that places risk in those most adept to manage it

There are basically three types of risks: financial, schedule and design. The first kind of risk is financial, where the project may exceed its budget and endangers the financial health of the stakeholders. It should be noted that budget overruns are not always the result of poor construction supervision. Often, budget overruns occur because of bad planning, wishful pricing or poor coordination. The second type of risk is not having the building finished on schedule. Delays can often have devastating financial effects, particularly in projects where the opening date is crucially timed for peak seasons such as hotels and retail outlets. The third type of risk is design related, where the completed building does not meet the organization's needs.

In traditional, design/bid/build projects these three types of risks change as they go from the preconstruction phase of a project to the construction-settlement phase. All three kinds of risks can be addressed in both the preconstruction phase and the construction-settlement phase, although more control of risks exists in the preconstruction phase. The preconstruction phase is often the most grueling and most important for the owner and/or owner's representative. The owner is responsible for making projections about marketing, budget, space and schedule. The risk although seemingly small because construction has not begun yet, is in really quite large because a planning mistake can cause big problems later on. There is a great deal of uncertainty and ambiguity in the preconstruction phase because the design-cost equation is constantly changing. The key to success in this phase, as elsewhere, is picking the right team – then providing coordination and central direction. In the case of the museum, clearly defined objectives from the Consortium, and the management of these objectives by IDOM, are crucial.

In traditional design/bid/build projects, the risk factors in the construction-settlement phase move from planning to supervision. The design is mostly fixed; time risk no longer depends on creating a realistic schedule but on sticking on it; budget risks are no longer a matter of pricing but of cost control.

In the case of the Guggenheim museum, the traditional design/bid/build risks and phasing of risks must be analyzed in light of a fast-track schedule. In the Guggenheim museum, many of the traditionally non-concurrent activities were actually performed in parallel due to the fast-track schedule. To begin with, all three risks –financial, schedule and design – were extremely high in the museum because of the "first of its kind" factor associated with the design. The fast-track schedule, and fixed cost nature of the project, not only exacerbated the three risks identified but also introduced a coordination risk associated with concurrent management of traditionally phased risks. Having to deliver an unprecedented project, on time, of quality, and within budget, with an up front promise of a final project cost, without knowledge of the final design, creates a great amount of uncertainty and risk for the project manager IDOM. Having to keep the cost, schedule and quality of the project through the many design/bid/build packages, all the while ensuring the continuity and final cost of the project, is the major challenge.

In order to address the financial, schedule, quality and coordination risks associated with the project, IDOM established the following,

1. A very large 20% contingency in their initial Cost Model (refer to Appendix A5). Although this was brought down to 8% later on (refer to Appendix A6) due to FOG/A protest that it was exceedingly high, it illustrates IDOM's uncertainty about the project.
2. IDOM reduced the preconstruction risks by working closely with the architect and owner in defining project objectives and design issues.
3. IDOM controlled the construction-settlement risks of the project by closely working with contractors to establish fixed cost estimates based on clearly defined designs.
4. IDOM was careful and astute in managing the two traditionally non-concurrent risk by means of a continuous cost model and freeze dates. These allowed IDOM to control and integrate the cost and schedule risks of the two parallel phases; thus reducing the coordination risk.

In terms of IDOM's management of its risks, IDOM was astute in its assessment, allocation and management of its risks. From the owner's perspective however, it should be noted that in establishing a fixed price, the owner took on a very large risk should any changes or problems have arose in the project. With a fixed price, the Consortium took on the risk of having to pay very large premiums for change orders, and out-of-sequence work should problems have arose. Moreover, it also forced the project manager IDOM to place a relatively large contingency on its cost estimate for which the Consortium would have had to pay for. As the owner, the Consortium had to weigh the benefits of having a commitment on final costs versus the premium paid for it.

An alternate contract method would have been to have proceeded with the project on a fixed priced contract for the portions of the project that were not "out of the ordinary," and contracted the more "unique" or less defined items on a reimbursable fee. This would have enabled the owner to fix a large portion of the museum's costs, and reduce the amount of premiums it would have to pay for changes on the more risky items (which are very likely in such a unique project).

6.5 Award Method

In terms of the Consortium's award method of work to contractors, credit should be given for the comprehensiveness of their award method. Although importance was placed on the price of the bids in terms of whether or not they were below the estimates, the real emphasis was on each of the firm's qualifications and ability to complete the project. One addition that might have been added would have been to require firms to submit unit prices for out of sequence work or change orders. This would have reduced the owner's risk for future changes.

6.6 Conclusion

This analysis, although performed in hindsight, supports the use of a project manager in Bilbao. It should be noted however, that several issues in the delivery method could have been improved. These were:

1. By having IDOM serve as the executive architect and structural engineer, IDOM's fiduciary relationship with the Consortium was compromised. Although a small compromise, particularly given that FOG/A and SOM were incapable of stamping legal documents in Spain, IDOM's conflicting responsibility to both the owner and itself places the owner at risk of having a project that isn't managed according to their interests. In such a situation, the project manager's reputation and track record is crucial to ensure that they will perform their task in the best interest of the owner.

2. The owner should not have committed to a fixed price contract given the complexity and uncertainty of the project design in the early stages. By doing so, the Consortium exposed itself to the unnecessary risks associated with having to pay very high premiums for possible change orders. This risk may have been reduced by requesting for unit prices from the contractors during the bidding phase for change orders and out of sequence work.
3. The use of a hybrid contracting method with fixed prices for portions of the museum and unit prices for others could have been an effective means of allocating risk. This would have enabled the owner to lock down a large portion of the project cost, while allowing flexibility for design while reducing the risk of high premiums associate with change orders.

CHAPTER 7

SAN ROQUE POWER FACILITY CASE STUDY

PROJECT DESCRIPTION

7.1 Introduction

The San Roque Power Facility (the "Project") consists of massive clay core rock fill dam on the Agno River that will not only generate electric power but will also provide irrigation, flood control and water quality benefits. The dam is located on the Agno River at San Roque, Panganisian Province, Philippines, about 200km north of Manila (See Appendix B3). The site is downstream of two other hydroelectric power facilities at Binga and Ambuklao. The dam will rise to a height of about 195 meters above the existing river valley floor, and will contain nearly 40 million m^3 of zoned fill material. The crest of the dam will have a length of 1,130 meters. See Appendix B1.

Water impounded in the Reservoir will flow into a power tunnel intake, located 85m below the dam crest. This tunnel will be just over 1,000 m in length, and will lead to a powerhouse that will contain three vertical Francis hydraulic turbine units, each rated at 115 MW. The power generating facility (the "Power Station") for this project will therefore have an aggregate installed generating capacity of 345 MW. Water discharged through the turbines will flow back into the river.

A spillway will be located on the right abutment of the dam (looking downstream) to permit water to be released from the Reservoir. This is designed for a maximum flow of 12,800 m3 per second. In addition, there will be a low-level outlet tunnel to remove sediment and debris from the intake area, and act as a minimum flow outlet should the powerhouse be unavailable to discharge water.

The power Station will operate as a peaking plant and will operate for a minimum of eight hours per day. Power generation will ramp up and down during these times to produce a minimum of 85 MW of capacity (the "Dependable Capacity"). If additional water is available, energy may be produced outside the daily eight-hour peak period.

This project was begun in 1996 and should be completed by December 31st, 2002. Construction work on the Project commenced in March 1998. The project schedule was fast-tracked in order to meet the December 31st, 2002, deadline.[3]

7.2 Introduction to the Primary Project Participants

In July 1996, the National Power Corporation (NPC) issued bidding documents for the development of a 345MW San Roque Multipurpose Project on a build/operate/transfer (BOT) basis. A bid from a consortium led by Marubeni Corporation, Sithe Philippine Holdings, Inc., and KPIC Singapore Pte. Ltd. (the Sponsors) was made in February 1997, and was thereafter evaluated for technical and financial compliance.

On October 11, 1997, the San Roque Power Corporation (the Company), a special-purpose company formed by the Sponsors (see Appendix B3), entered into a Power Purchase Agreement (the "PPA") with the NPC for the development of the Project. Under this agreement, the San Roque Power Corporation would own and operate the power station for a period of 25 years. During this period, the NPC would guarantee to constantly purchase at least 85MW of the power station's capacity regardless of demand. After 25 years, the San Roque Power Corporation would transfer ownership of the power station to the NPC.

The Company's first task was the selection of an engineering firm and a construction firm to design and build the project. The Company selected a design-build team formed by Raytheon Ebasco Overseas Limited and United Engineers International, Inc. United Engineers International is a wholly owned subsidiary of Raytheon. The Company also chose to hire Sithe Energies as an agency construction manager to manage and oversee the construction process.[3]

CHAPTER 8

PROJECT PARTICIPANTS

8.1 Sponsor - Marubeni Corporation

Marubeni established in 1858, is one of Japan's leading "sogo shosha", or general trading companies. Its operations encompass international trading businesses throughout the world, and extend from the development of natural resources to the retail marketing of finished products. In addition to 35 offices in Japan, Marubeni has 73 overseas branches and offices. Together with its 30 overseas subsidiaries, Marubeni operates a total 167 offices in 83 countries.

In order to facilitate the development of a global network to promote its independent power production activities, Marubeni acquired a 29.46% stake in Sithe Energies, Inc. in April 1996.

Recognizing the constantly growing IPP market, Marubeni's Power Project Department has been actively pursuing projects, both as developer and contractor, through its worldwide network. The department is involved in a comprehensive range of electric power related projects, including the construction and rehabilitation of steam turbines, combined-cycle, geothermal and hydroelectric power plants as well as various types of power transmission lines and substations.

As developer, the department has ownership stakes in power plants, either in operation or under construction, with capacity totaling almost 1,200 MW. Apart from the San Roque Project, other projects with total capacity of over 1,500 MW have been awarded to Marubeni and its joint-venture partners.

8.2 Sponsor - Sithe Philippines Holdings, Inc.

Sithe Philippines Holdings, Inc. is an independent subsidiary of the Sithe Energies, Inc., ("Sithe") which is currently the seventh largest private-sector electric power generation company in the world. Founded in 1985 to develop, own and operate electric generation facilities throughout the United States, Canada, Australia, China and other international markets, Sithe has grown consistently with annual revenues approaching US$ 1 billion. From only two hydropower plants in the US totaling 5MW in 1985, Sithe today owns and operates 35 power plants on three continents providing 4,690 MW of installed capacity and generating more than one million pounds of steam per hour. This includes 1,653 MW of gas/oil-fired steam plant capacity, 2,667 MW of combined –cycle and gas turbine capacity, 192 MW of diesel capacity, 100 MW of coal-fired steam plant capacity and 78 MW of hydroelectric capacity.

Sithe was recently ranked in the top ten of more than 125 independent power firms based on net capacity ownership. In addition, Sithe is currently constructing or developing additional projects totaling over 10,000 MW worldwide. Electricity generated from its operating plants is sold primarily to major electric utilities, and steam is sold to industrial and other users, mostly under long-term contracts. Its development and business strategy is based on a long-term commitment to owning generating facilities and ensuring their proper operation. Locally dedicated professionals with experience in technical, financial, operational and management matters are placed in each of the countries in which Sithe power plants are operated. Sithe is also involved on a limited scale in the exploration, development and sale of natural gas reserves.

8.3 Sponsor - KPIC Singapore Pte Ltd.

KPIC Singapore Pte Ltd. is an indirect, wholly owned subsidiary of The Kansai Electric Power Co., Inc. ("Kansai"). Founded in 1951, Kansai is the second largest electric power company in Japan. It is a monopoly electricity provider to more than 12 million customers in the Kansai region, covering major cities including Osaka, Kyoto, Kobe, Nara and the industrial area along the coast of Osaka Bay. Electricity consumption in these areas is around 18% of total national consumption.

Kansai specializes in power generation, transmission and distribution of electricity. It owns and operates 143 hydropower, 21 fossil fuel and 3 nuclear plants, with a total installed capacity of 37,049 MW. It possesses extensive experience particularly in the development of hydroelectricity, which accounts for 20% of its total installed capacity. In fiscal year 1997, Kansai produced 15,428 million kWh of hydroelectric power.

8.4 Contractor and Designer Contract

The construction, engineering and procurement contractual arrangements are reflected in a series of contracts, consisting of the following:

1. A Construction, Procurement and Related Services Contract (the "Construction Constract") between San Roque Power Corporation (the "owner") and Raytheon-Ebasco Overseas Limited (the "Contractor"), an independent wholly-owned subsidiary of Raytheon Company.
2. An Engineering, Procurement and Related Services Contract (the "Engineering and Procurement Contract") between the owner and United Engineers International, Inc. (the "seller"), also an independent, wholly owned subsidiary of Raytheon Company.

3. A Coordination Agreement between the Contractor, the Seller and the Owner, which defines and describes how performance under the two contracts is to be conducted to produce the Project.
4. A completion guarantee by Raytheon Company (the "Raytheon Completion Guarantee") which guarantees the performance by the Contractor and the Seller of their respective obligations under the Construction Contract and the Engineering and Procurement Contract. It also provides that such performance will result in a completed Project, by the Guaranteed Substantial Completion Date of December 31, 2002, for the Aggregate Contract Price (as defined in the Coordination Agreement).[3]

This is summarized by the Figure 16 below:

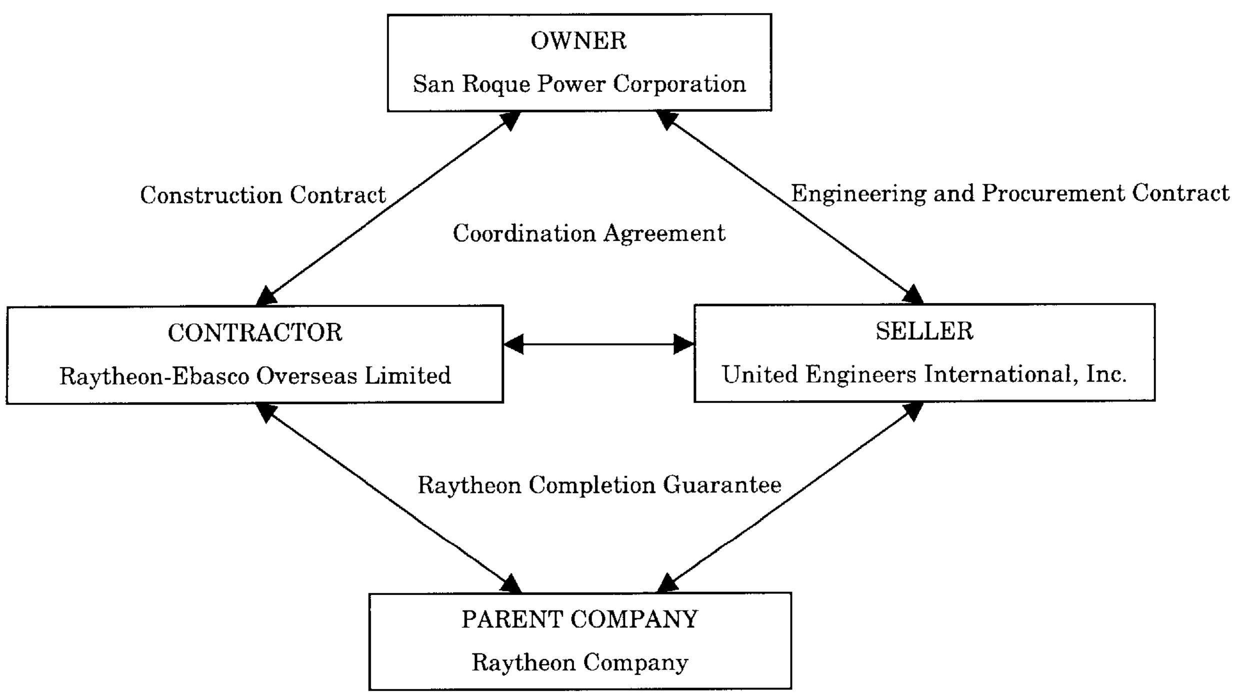


Figure 16 – Owner/Contractor/Designer Contractual Relationship

The contract requires the Contractor and Seller to achieve together the following:

1. Design and construction of the project

2. Procurement of equipment, supplies and services for the project
3. Obtaining certain specified permits
4. Supervision of the work of and establishment of a training program for the project's operations and maintenance personnel until the substantial completion date
5. Perform all start up and testing of the project
6. Ensuring the compliance with the mitigation measure in the EIA, environmental management plan and the applicable permits.
7. Effecting interconnection and synchronization of the project with the NPC grid.

The Owner's obligations under the respective contracts include:

1. Obtaining financing for construction of the project
2. Providing the site and ensuring access to and from the site for the Contractor and their subcontractors
3. Furnishing personnel for training, testing and operation of the project
4. Obtaining certain specified permits
5. Paying VAT, local taxes and certain import duties arising in connection with importation of equipment and materials for permanent use and installation in the Project
6. Providing the Transmission Line and the bridge providing access to the Site

Under the Coordination Agreement, the Contractor and Seller each recognizes that the two Contracts constitute a fixed price obligation to produce a project complete in every detail prior to the Guaranteed Substantial Completion Date for the Aggregate Contract Price. Each party agrees that it will not be excused by reason of, or defend any claim on the basis of the other's non-performance.

Each of the Contractor and Seller will be paid in total its Contract Price in Installments. There is a 10% retaining clause in the contract, where the Owner can hold onto 10% of the contract price until the project passes certain tests and inspections.

The owner shall have the right to inspect any of the work and shall have the right to reject any portion of work that does not conform to the respective contracts.

Each of the Contractor and Seller has respectively agreed to maintain in full force and effect:

1. General liability insurance covering all activities of the Contractor and Seller respectively other than at the Project
2. Worker's compensation
3. Employer's liability insurance
4. Automobile liability insurance

The owner is to maintain the Construction and Erection All Risk ("CEAR") insurance.

The owner may terminate work with or without cause at any time by giving notice of termination to each of the Contractor and Seller. The Owner may at any time or from time to time, and for any reason, suspend performance of the Work or any portion thereof by giving notice to each of the Contractor and Seller.

1. A change in the Work may entitle either the Contractor or Seller to an increase in the Contract Price and/or an extension of the Guaranteed Substantial Completion Date. Changes in work can only result from:
2. A change in the work at the Owner's request
3. A change in law
4. The occurrence of an event of Force Majeure such as an earthquake, storm, etc.

Substantial Completion of the project is defined to include all the following:

1. Contractor and Seller have each certified that the Project is designed and operating in accordance with the Contract Documents and Owner's standards,

that each of the Contractor and Seller has completed training program and performed all other provisions of each of the Contracts in a timely fashion.

2. The Owner has received all final permits, all drawings and specifications, satisfactory results of the Performance Test or payment of the Buy Down Amount, preliminary operations, maintenance and spare parts manuals, special tools, evidence that al mechanics, labor or materialmen's liens have been satisfied or discharged.[3]

8.5 Construction Manager Contract

The Construction Management Agreement (CMA) has been establish between an affiliate of Sithe Energies, Inc. (the "Construction Manager"), and San Roque Power Corporation (the "Owner"). In this agreement, it is specified that the Construction Manager will provide to the Owner advice and assistance in the administration and management of the Construction Contract and other support services as required by the owner. The Construction Manager is a consultant to the Owner, so it has no authority to supervise, control or be responsible for acts, methods and techniques used by the Construction Contractor. However, it may communicate with the Construction Contractor but only by way of recommendations and not directions. The Construction Manager has the obligation to provide such construction management services required to manage and oversee the Construction Contractor.

The Construction Manager has the responsibility of employing all of the contractors, agents and consultants it considers necessary to facilitate the performance of the services, including a Project Manager.

The services provided by the Construction Manager include:

1. Establishing and implementing a quality assurance plan
2. Coordinating on-site activities with the Construction Contractor
3. Assist in resolving potential construction disputes and claims.

The Owner will pay the Construction Manager a set fee of US$ 100,000 per month for performance of the services, but not any additional or reimbursable costs. Each month the Construction Manager will submit a written application for payment of the monthly fee, the relevant reimbursable costs, and any other charges for additional services.

According to the provisions of the Construction Contract, the Construction Manager and the Owner are to maintain insurance.

The Owner is entitled to suspend performance of the services for various reasons including: Construction Manager's failure to remedy a material breach following notification; suspension or termination of the Construction Contract; or for the Owner's convenience. The termination by the Owner is permitted by the termination of the Power Purchase Agreement or the Construction Contract or if the project is permanently abandoned or canceled.

The Construction Manager is entitled to terminate the CMA if there is a failure by the Owner to remedy the breach following notification, insolvency, abandonment of the project, delayed completion date, financial closing not having occurred by the specified date or termination of the Construction Contract or the Power Purchase Agreement.(3)

CHAPTER 9

PROJECT DELIVERY METHOD ANALYSIS

9.1 Introduction

This chapter will be dedicated to the analysis and evaluation the appropriateness of the project delivery method used by the San Roque Power Corporation for this project, in light of the advantages and disadvantages of alternate project delivery methods. In particular, this thesis will analyze this case study with respect to the same six delivery methods use in the Guggenheim Case Study: general contractor, construction manager, multiple primes, design-build, turnkey and build-operate-transfer. This chapter will briefly discuss the six basic contract types but largely assumes that the reader has a basic understanding of the basic differences between the different delivery types. Although this thesis will mainly discuss each option from the owner's perspective, the San Roque Power Company (and thus largely the construction manager's as well), it will also incorporate the points of view of the other participants of the project in order to determine an appropriate and feasible delivery method.

Any project delivery or contracting method has four fundamental parts: scope, organization, contract and award. In order to identify an appropriate delivery method, this thesis will analyze each of the four fundamental parts and utilize a process of elimination to identify obviously inadequate methods.

9.2 Strategic Alignment

As pointed out in Chapter 6 of the Guggenheim Case Study, the essence of selecting an appropriate delivery method is to align three key items within any project: the market, the process, and the product. Each of the three items within the project must match the needs and qualities of the other two. In other words, the process by which the product is brought to fruition should match the qualities of the product. Likewise, the product should be representative of the market demands. This triangular relationship is summarized in by Figure 17.

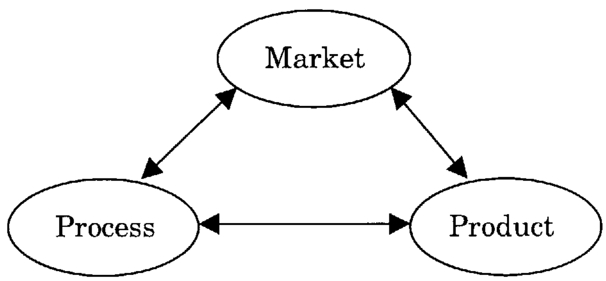


Figure 17 – Strategic Alignment Chart

The goal of this chapter is to identify whether or not the San Roque Power Company selected an appropriate delivery method that aligns the product with the market, the process with the product, and the process with the market. In order to accomplish this, a thorough understanding of the market trends, the product and the process is essential.[1]

9.3 Organization Type

The first step of our analysis will involve identifying the appropriate organization by eliminating the inappropriate ones. Within any appropriate organization, three types of drivers must be addressed and assessed by the owner: project drivers, owner drivers, and market drivers.

Project drivers or project characteristics consist of: the time constraints on the project, the flexibility needed in the design and construction of the project, the preconstruction services needed for the project, the amount interaction needed between the owner and designer during the design process, and the financial constraints on the project. Depending on the owner's requirements for these project characteristics, certain organization types are more adequate to tackle the project than others are. Table 3 summarizes the adequacy of different organization types in satisfying different project characteristics.

Drivers	GC-FP	GC-R	CM	MP	DB-FP	DB-R	T-FP	T-R	BOT
Fast Track Schedule		*	*	*	*	*	*	*	*
Sequential Schedule	*	*	*	*	*	*	*	*	*
More Flexibility		*	*	*		*		*	
Less Flexibility	*	*	*	*	*	*	*	*	*
Pre-Const. Advice Needed		*	*		*	*	*	*	*
No Pre-Constr. Advice Needed	*	*	*	*	*	*	*	*	*
Design Interaction	*	*	*	*		*		*	
Less Design Interaction	*	*	*	*	*	*	*	*	*
Construction Financing Needed							*	*	*
Permanent Financing Needed									*
Owner Financing	*	*	*	*	*	*			

GC=General Contractor DB = Design Build Team CM = Construction Manager T = Turnkey
MP = Multiple Prime Contractors BOT = Build Operate Transfer R = Reimbursable Price
FP = Fixed Price

Table 3 - Organization Types vs. Possible Project Drivers [(1)]

The time constraint on a certain project refers to the constraints placed on the schedule of a project. In the San Roque Power Facility, the obvious time constraint is the need for a fast track schedule and the need to meet the December 31st, 2002, completion deadline. As we can see from Table 3 above, only certain organization types are suited to tackle a fast-track schedule. It is now possible to eliminate the organization types that are inadequate. The first step of elimination has begun.

The flexibility needs refers to the amount of flexibility allowed in the schedule and design for changes. Because of the commonality associated with the design and type of dam, the amount of flexibility needed in the design and schedule is minimal. Subsequently, minimal amounts of preconstruction services and owner involvement are needed as well.

The financial constraints on the project refer to the owner's ability to finance the entire project. In the case of this project, the San Roque Power Corporation has financed the project itself through several lenders.

Having summarized all these project characteristics, we can determine eliminate at this stage four out of 9 organization types. This is illustrated by Table 4.

Drivers	GC-FP	GC-R	CM	MP	DB-FP	DB-R	T-FP	T-R	BOT
Fast Track Schedule		*	*	*	*	*	*	*	*
Less Flexibility	*	*	*	*	*	*	*	*	*
No Pre-Const. Advice Needed	*	*	*	*	*	*	*	*	*
Less Design Interaction	*	*	*	*	*	*	*	*	*
Owner Financing	*	*	*	*	*	*			
APPROPRIATE	NO	YES	YES	YES	YES	YES	NO	NO	NO

GC=General Contractor DB = Design Build Team CM = Construction Manager T = Turnkey
MP = Multiple Prime Contractors BOT = Build Operate Transfer R = Reimbursable Price

Table 4 – Organization Types vs. San Roque Power Facility Project Drivers

The remaining organization types that may be adequate are general contractor on a reimbursable price, construction manager, multiple prime and a design-build team either on a fixed price or reimbursable price.

The next step in selecting an appropriate organization type is to analyze the owner drivers or owner characteristics. These characteristics include the owner's level of construction sophistication, the owner's current capabilities, risk aversion and restrictions on methods. Given the vast experience of the members of the San Roque Power Corporation in past hydroelectric projects, the owner is considered to be very sophisticated. As Figure 18 illustrates, certain organization types require more construction experience from the owner than others do. Because of the Corporation's sophistication, the Corporation qualifies for any delivery method. It should be noted that traditionally the owner's sophistication level required is inversely related to the premium the owner must pay for extra management.

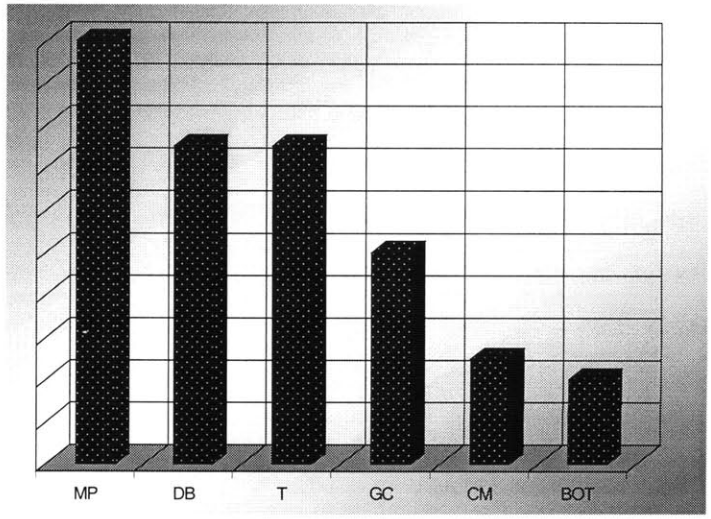


Figure 18 - Required Owner Sophistication Graph[1]

The owner's current staffing capabilities to oversee and direct the project is also a limiting factor. The amount of staff the owner can commit to monitor the project limits the types of organization types it can select from. As Figure 19 illustrates, certain organization types require a larger amount of owner management and supervision. It is assumed that the San Roque Power Corporation had a limited staff since it decided to hire

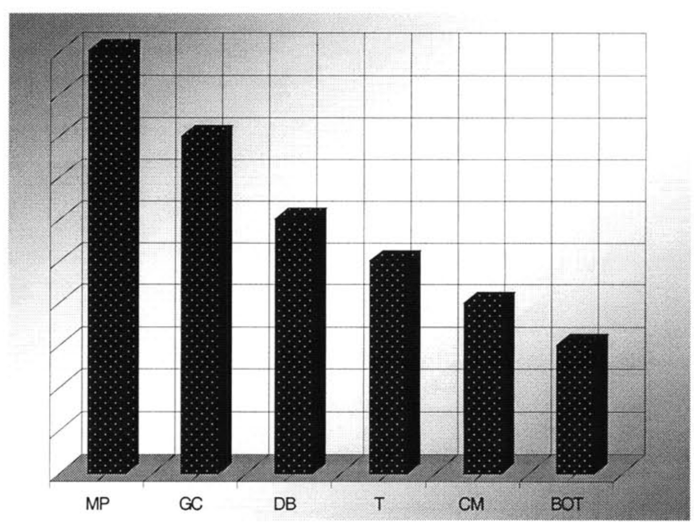


Figure 19 – Owner Involvement Graph[1]

both a construction manager and a design-build team. For these reasons, we can now eliminate multi-prime and a general contractor, leaving a design-build team as the only possibility. It should be noted that it is probably because the amount of monitoring the owner must have over a design-build team that the owner chose to hire a construction manager to oversee and manage the construction process. The efficiency issues associated with the Corporation's use of both a construction manager and a design-build team will be discussed in a later section. The

In terms of risk aversion and restrictions on methods, the San Roque Power Corporation financed the project and there were no restrictions on the project delivery methods it could use.

9.4 Contract Types and Risk

Having established the organization as a design-build team, it is now possible to pick an appropriate contract type. The question of selecting an appropriate contract type revolves around the issue of risk allocation and management. In selecting a contract type, it is necessary to assess the risks involved in the project, allocate the risk to the appropriate parties and manage the risks. This section will focus on selecting a contract type that minimizes risk for the owner, and therefore largely the project manager IDOM (although differences will be highlighted). There are three steps in the selection of an appropriate contract type:

4. Understanding the types and phases of risk
5. Assessing the risks of a particular construction project
6. Drawing up a contract type that places risk in those most adept to manage it

There are basically three types of risks: financial, schedule and design. The first kind of risk is financial, where the project may exceed its budget and endangers the financial health of the stakeholders. It should be noted that budget overruns are not always the result of poor construction supervision. Often, budget overruns occur because of bad planning, wishful pricing or poor coordination. The second type of risk is not having the building finished on schedule. Delays can often have devastating financial effects, particularly in projects where the opening date is crucially timed for peak seasons such as hotels and retail outlets. The third type of risk is design related, where the completed building does not meet the organization's needs.

In traditional, design/bid/build projects these three types of risks change as they go from the preconstruction phase of a project to the construction-settlement phase. All three kinds of risks can be addressed in both the preconstruction phase and the construction-settlement phase, although more control of risks exists in the preconstruction phase. The preconstruction phase is often the most grueling and most important for the owner and/or owner's representative. The owner is responsible for making projections about marketing, budget, space and schedule. The risk although seemingly small because construction has not begun yet, is in really quite large because a planning mistake can cause big problems later on. There is a great deal of uncertainty and ambiguity in the preconstruction phase because the design-cost equation is constantly changing. The key to success in this phase, as elsewhere, is picking the right team – then providing coordination and central direction.

In traditional design/bid/build projects, the risk factors move from planning to supervision as the project goes from the preconstruction phase to the construction-settlement phase. The design is mostly fixed in the construcion-settlement phase; time risk no longer depends on creating a realistic schedule but on sticking to it; budget risks are no longer a matter of pricing but of cost control.

In the case of the San Roque Power Facility, jus like in the Guggenheim Case Study, the traditional design/bid/build risks and phasing of risks must be analyzed in light of a fast-track schedule. In this project, many of the traditionally non-concurrent activities were actually performed in parallel due to the fast-track schedule. The fast-track schedule introduces a coordination risk associated with concurrent management of traditionally phased risks.

The financial and schedule risks in the project were substantially reduced for the owner by the use of a guaranteed maximum price contract, with a guaranteed substantial completion deadline. By using a guaranteed price and delivery date, the owner transfers all financial and schedule risks to the design-build team. Selecting a design build team also reduces the coordination risks as well since the coordination of in house activities is always easier and more efficient than the coordination of activities between separate parties. It should be noted however, that in choosing a design-build team with a guaranteed maximum price and fixed completion date, the owner exposes itself to design risks where the design-build team may cut corners in either the design or construction in order to meet project budgets and schedules. Because the owner is not represented in the design equation, there is an obvious risk that the final product is substandard in terms of quality and performance.

In order to alleviate this, the San Roque Power Company chose to hire an agency construction manager to oversee the construction process. Although this would have allowed the owner to control the quality and schedule of the construction process, it introduces an unnecessary and expensive management layer to the organization. The San Roque Power Company could have simply have hired an inspection team to ensure the quality of construction. Should the owner have wanted direct control over the construction process, they shouldn't have selected a design-build team. By introducing a second layer of management on top of the design build team, the owner exposes itself to possible management and coordination conflicts between the two managing entities. Moreover, the use of a secondary management team shows a lack of trust between the owner and the design-build team.

9.5 Award Method

In terms of award method, the San Roque Power Corporation based their selection method first by reputation and past performance. The Corporation selected Raytheon based on the firm's excellent past performance in terms of on budget and timely delivery. See Figure 20 . The Corporation selected Raytheon out of a large pool of international players. A final project cost was then negotiated after the selection process. A similar selection process was performed for the selection of Sithe Engineers as the Construction Manager. See Figure 21 for the Sithe Energies's past performance record.

Table A16.1 Other Raytheon hydroelectric experiences

YEAR	PROJECT	LOCATION	SIZE (MW)	TYPE OF SERVICE
1991	Allegheny Nos. 8 & 9 Units 1 & 2	Pennsylvania, US	30.5	Engineering, Procurement and Construction
1991	Devils Canyon Units 3 & 4	California, US	160	Construction
1989	Karnali (Chisapani) multipurpose project	Nepal	10,000	Feasibility Study
1984	5 rock-fill multipurpose dams	Korea	888	Consulting Engineering
1978	Boundary Units 55 & 56	Washington, US	420	Construction
1970	Kastraki Hydroelectric project	Greece	320	Feasibility study and Construction Management
1960	Tillery Unit 4	Arkansas, US	22	Engineering and Construction
1956	Littleton Units 1 - 4	New Hampshire, US	150	Construction and Construction Management

Figure 20 – Raytheon Past Project History [3]

TABLE A15.1 NORTH AMERICA - HYDROPOWER PLANTS

Plant	State/Country	Avg. Annual Rating (MW)	Technology/ Engine	Operation Date	Steam Output
Montgomery Creek	California	2.6	1-Pelton	1987	NA
Rock Creek	California	3.6	2-Francis	1986	NA
Bypass	Idaho	10.0	2-Pelton	1988	NA
Elk Creek	Idaho	2.3	1-Pelton	1985	NA
Hazelton A	Idaho	8.7	2-Kaplan	1990	NA
Ivy River	North Carolina	1.2	6-Francis	1985	NA
Allegheny (L&D) 5	Pennsylvania	9.5	2-Kaplan	1988	NA
Allegheny (L&D) 6	Pennsylvania	8.6	2-Kaplan	1989	NA
Allegheny (L&D) 8	Pennsylvania	13.6	2-Kaplan	1990	NA
Allegheny (L&D) 9	Pennsylvania	17.9	2-Kaplan	1990	NA
Plant Count: 10	*Subtotal Capacity (MW):*	78			

TABLE A15.2 NORTH AMERICA - THERMAL POWER PLANTS
(Not including GT standby units)

Plant	State/Country	Avg. Annual Rating (MW)	Primary Fuel	Operation Date	Steam Output
Gas-turbine cogeneration plant					
Oxnard	California	48	NG	1990	33,500
Gas-turbine combined cycle plants					
Naval Station	California	45	NG	1989	152,000
North Island	California	37	NG	1989	65,000
NTC/MCRD	California	23	NG	1989	40,000
Greeley	Colorado	72	NG	1988	90,000
Kenilworth	New Jersey	26	NG	1989	72,000
Batavia	New York	58	NG	1992	147,000
Independence	New York	1,042	NG	1994	1,040,000
Massena	New York	86	NG	1993	266,426
Ogdensburg	New York	83	NG	1994	163,170
Sterling	New York	58	NG	1991	147,000
Cardinal	Ontario, Canada	152	NG	1995	70,000
West Medway	Massachusetts	175.9	NG/D	Acquired from Boston Edison in May 1998	NA
Framingham	Massachusetts	34.0	D		NA
Edgar	Massachusetts	24.0	D		NA
Mystic	Massachusetts	11.4	D		NA
New Boston	Massachusetts	20.0	D		NA
Thermal plants					
Mystic	Massachusetts	953	#6FO(all) NG(#7only)		7,105,000
New Boston	Massachusetts	700	NG/#6FO		5,280,000
Plant Count: 19	*Subtotal Capacity (MW):*	1,947			

Figure 21 - Sithe Energies Past Project History[3]

TABLE A15.3 OVERSEAS PROJECTS

Plant	State/Country	Avg. Annual Rating (MW)	Primary Fuel*	Operation Date	Steam Output
Diesel-combined cycle plant					
Dongguan Houjie	China	66	#6FO	1995	NA
Thermal plant					
Tangshan	China	100	PC	1997	485,000
Diesel-fired plant					
Tapal	Pakistan	126	#6FO	1997	NA
Gas-turbine combined cycle plants					
Smithfield	Austrailia	162	NG	1997	521,970
COCO I & II	Thailand	300	NG		NA
Gas-turbine cogeneration					
COCO III	Thailand	210	NG/D		NA
Plant Count: 6	*Subtotal Capacity (MW):*	964			

Total Plant Count: 35 *Total Capacity (MW):* 4,690

Note: #6FO - No. 6 Fuel Oil, NG - Natural Gas C - Coal
DF - Diesel Fuel Oil D - Distillate PC - Pulverized Coal

Figure 21- Sithe Energies Past Project History (continued)

9.6 Conclusions

In selecting both a design-build team and a construction manager, the San Roque Power Company was attempting to ensure the budget, schedule and quality of the final product by using the two delivery methods to negate the disadvantages associated with each delivery method. The San Roque Power Company was also looking out for the interests of its investors, the sponsor companies, by using a subsidiary of one of its sponsor companies to serve as construction manager. By using two delivery methods in a hybrid however, the Company introduced unnecessary coordination conflicts and management premiums. Two alternative delivery methods that could have easily have accomplished the same task without the premiums or conflicts are discussed below.

Should the use of a design-build team been crucial to the owner, the replacement of the agency construction manager with an inspection team would have easily remedied the situation. Having an inspection team perform routine quality assurance tests would have insured the quality of the project. This would require the owner to trust that the design-build team will not cut corners in the design phase. This method has the disadvantage that the Company is unable to control the design process to ensure that the needs of the Sponsors are met. Naturally, the selection of reputable design-build team is crucial. This is true in this project as in any other design-build project.

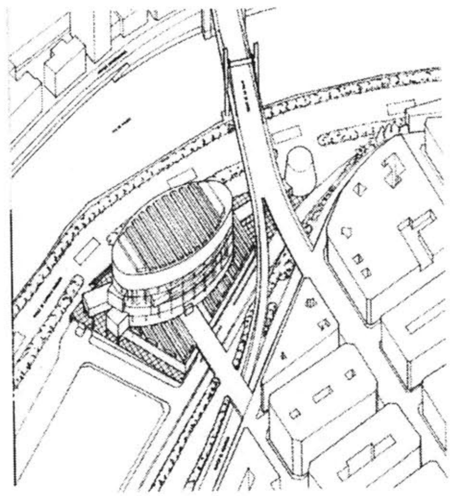
Should the owner not trust that the design-build team will perform its functions professionally, a design-build team shouldn't have been chosen in the first place. The advantage of a design-build delivery method is that one entity will perform all design and construction services. The owner should only have to monitor the process, not manage. Instead of a design-build team, an agency construction manager organization with a separate design team, and subcontractors should have been used. This would enable the owner to ensure the quality of the design and construction phase. However, a guaranteed maximum price and delivery date wouldn't have been possible unless the construction manager was at risk. This however would have compromised the fiduciary relationship between the owner and construction manager. It is for this reason that the first option of having a design-build team with an inspection team is more preferable.

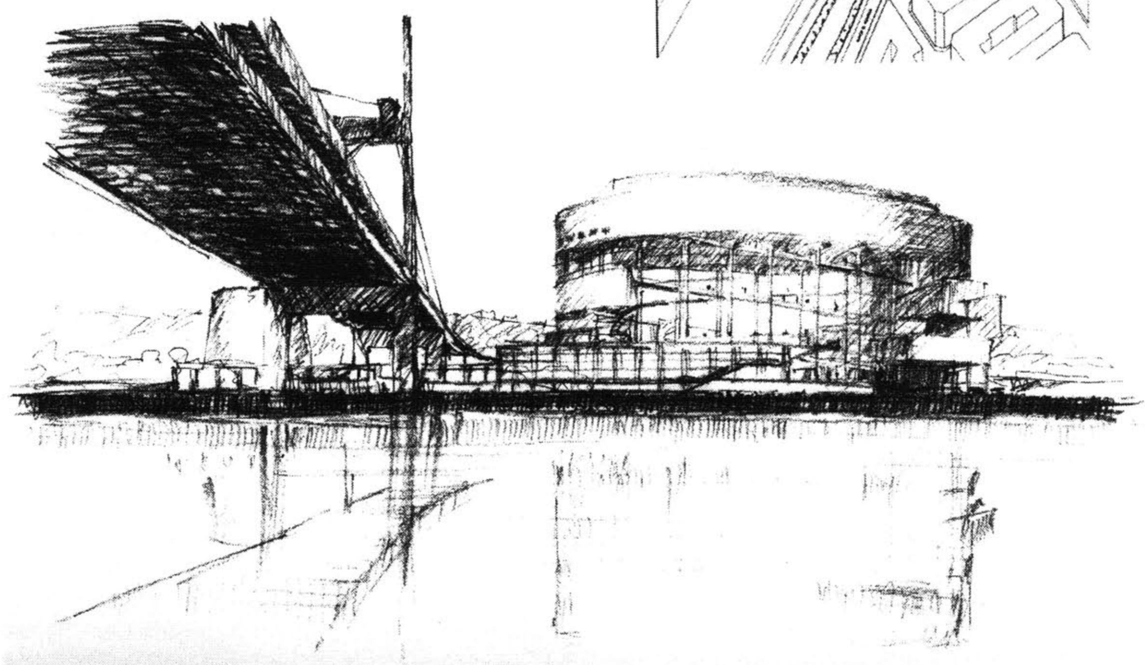
APPENDIX A

9.7 APPENDIX A1

Bilbao Guggenheim Museum Design Competition

Arata Isozaki Entry(1)

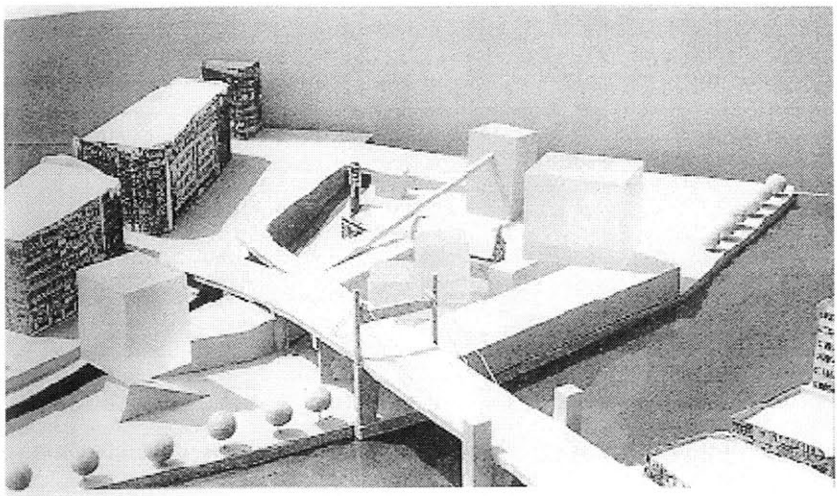


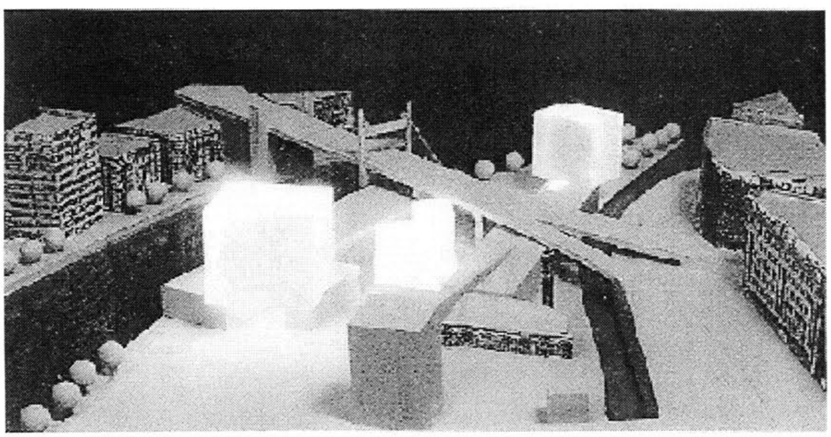


9.8 APPENDIX A2

Bilbao Guggenheim Museum Design Competition

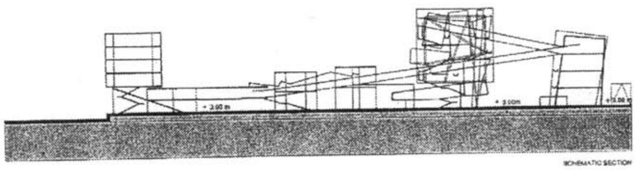
Coop Himmelblau Entry[1]

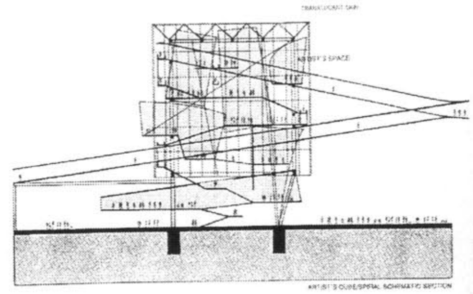




Bilbao Guggenheim Museum Design Competition

Coop Himmelblau Entry (continued)

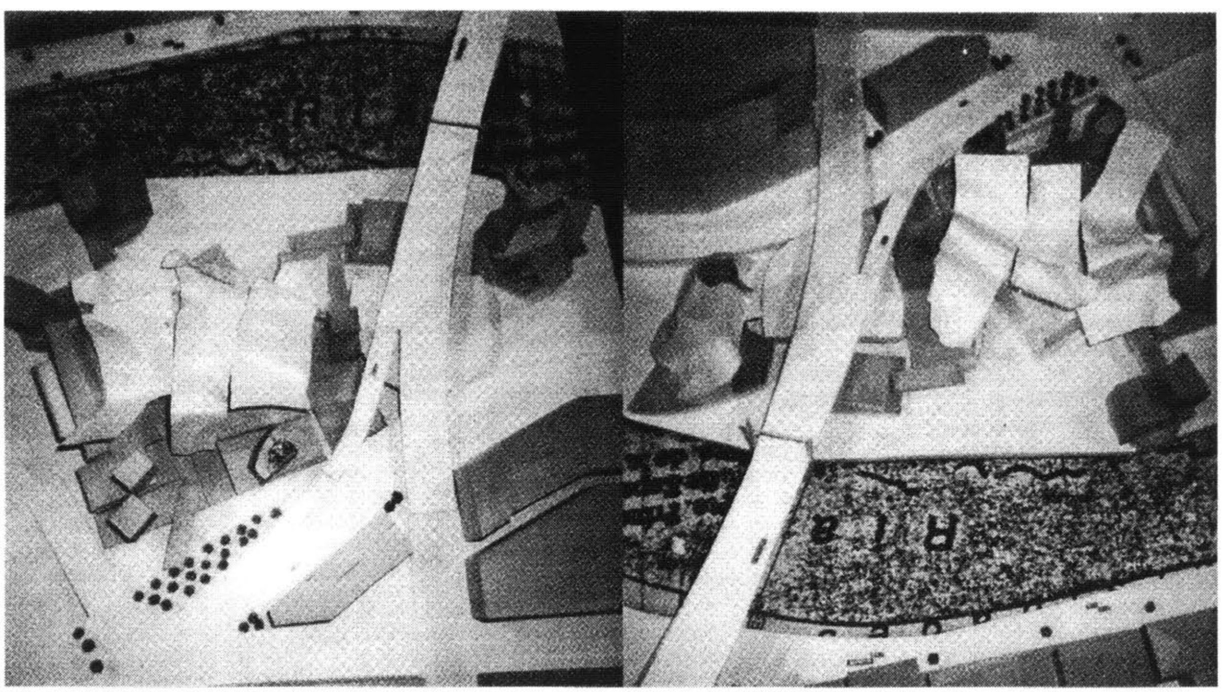




9.9 APPENDIX A3

Bilbao Guggenheim Museum Design Competition

FOG/A Entry[1]



9.10 APPENDIX A4

List of Nominal Member Sizes Used in the Primary Steel Structure[4]

- Vertically inclined columns: standard, rolled European HD 310mmx310x97 kg/m (approximately the cross section of an HP12x63) and HD 260mmx260x73 kg/m (slightly larger than the cross section of an HP 10x67)
- Corner vertical members: 250mm diameter x 10 mm wall thickness seamless pipe section (42 ksi yield)
- Horizontal members: 160mmx160x6mm wall thickness square tube (42 ksi yield)
- Diagonal members: 155mm diameter x 66 mm wall thickness seamless pipe section (42 ksi)

9.11 APPENDIX A5

IDOM – Initial Project Cost Model[2]

idom

PREVIOUS BUDGET FOR GEGGENHEIM MUSEUM

(M Ptas)

Construction and architectonnic elements	7.724
Mechanical Engineering	2.258
Legal formalities and endorsements	762
Architecture and Engineering	1.700
Other items	925
	13.369
Unforeseen items (20%)	2.660
TOTAL	**16.043**

idom

1. **COST BREAKDOWN FOR CONSTRUCTION AND ARCHITECTONIC ELEMENTS (Mptas)**

A. MUSEUM AND PARKING

CONCEPT / AREA	1 Atrium	2 SW.Gal.	3 SE.Gal.	4 T. Gal.	5 Tower	6 Parking	TOTAL CONCEPT
EXTERIOR WALLS	659.55	549.22	582.08	484.67	189.25	--	2,464.77
INTERIOR WALLS	444.62	85.49	129.50	193.57	11.64	4.37	869.19
PAV. EXT - ROOFS	266.10	238.20	203.00	384.64	9.25	--	1,101.19
FLOORS	117.39	62.08	110.56	211.44	5.60	67.97	575.04
CEILINGS	104.94	65.41	224.94	47.88	--	--	443.17
STAIRS	7.85	5.86	3.90	2.40	--	2.40	22.41
STRUCTURE (H & V)	78.82	161.29	97.00	212.20	10.30	112.70	672.31
EXCAVATION& FILLING	--	--	--	23.86	--	45.00	68.86
PILE & FOUNDATIONS	63.00	87.50	150.50	52.50	10.50	--	364.00
CAPS & BEAMS	18.00	25.00	43.00	15.00	3.00	--	104.00
DEMOLITION							127.50
URBAN PLANNING							29.65
TOTAL / AREA	1,760.27	1,280.05	1,544.48	1,628.16	239.54	232.44	6,842.09

B. EXTERNAL WORKS

CONCEPT / AREA	1 Atrium	2 SW.Gal.	3 SE.Gal.	4 T. Gal.	5 Tower	6 Parking	TOTAL CONCEPT
PLATFORM							690.00
WATER GARDEN							191.96
TOTAL / AREA							881.96

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2. **COST BREAKDOWN FOR MECHANICAL ENGINEERING (Mptas)**

A. MUSEUM AND PARKING

CONCEPT / AREA	1 Atri.	2 SW.G.	3 SE.G.	4 T.Gal.	5 Tower	6 Park.	TOTAL CONCEPT
CO EXHAUST AND DETECTION PARKING	--	--	--	--	--	11	11
AIR CONDITIONING	164	180	390	293	13	--	1,040
ELECTRICITY	23	25	55	41	4	3	151
PRECINT LIGHTNING	24	27	58	44	3	14	170
EXTERNAL LIGHTNING	7	8	18	13	2	--	48
STRUCTURAL WIRING	--	--	25	--	--	--	25
SPEAKER SYSTEM	3	4	9	7	2	--	25
TV / FM	2	2	4	3	1	--	12
TELEPHONY	1	1	7	2	0	--	11
INTEGRAL MANAGEMENT SYSTEM	12	13	30	22	3	--	80
ELECTRICAL UNIT	4	4	10	7	2	3	30
POTABLE AND SANITARY HOT WATER	4	5	10	8	2	1	30
ELEVATORS	20	21	32	14	1	12	100
SECURITY	29	32	67	52	5	15	200
FIRE PROTECTION	31	34	73	55	5	26	224
PARKING LOT MACHINERY	--	--	--	--	--	20	20
AUDIO-VIDEO FOR AUDITORIUM	--	12	--	--	--	--	12
TOTAL / AREA	324	368	788	561	43	105	2,189

B. EXTERNAL WORKS

CONCEPT / AREA	WATER GARDEN
ELECTRICITY	2
LIGHTNING	52
DUATER TREATMENT	15
TOTAL	69

IDOM – Initial Project Cost Model (continued)

3. **COST BREAKDOWN FOR LEGAL FORMALITIES AND ENDORSEMENTS (Mptas)**

CONCEPT	COST
ENDORSEMENT OF PROJECT	
College of Architects	3,5
College of Industrial Engineers	2
College of Technical Architects	1
END OF WORKS CERTIFICATE	
College of Architects	0,01
College of Industrial Engineers	2,5
BUILDING PERMIT	750
OPENING PERMIT	2,2
ENDORSEMENT FOR MECHANICAL ENGINEERING (INDUSTRY DEPARTMENT)	1
TOTAL	**762,2**

IDOM – Initial Project Cost Model (continued)

4. **COST BREAKDOWN FOR OTHER ITEMS (Mptas)**

CONCEPT	COST
SAFETY AND HYGIENE	450
WORKS GUARD	150
CONTROL	150
STAFF TRAINING	10
CUSTOM DUTIES	30
FENCES + ENVIRONMENT ADAPTATION	20
TEMPORARY ELECTRICITY	5
ADVERTISEMENTS	10
LEVEL RISING (FLOODS)	100
TOTAL	**925**

9.12 APPENDIX A6

IDOM – Revised Project Cost Model Summary[(2)]

idom

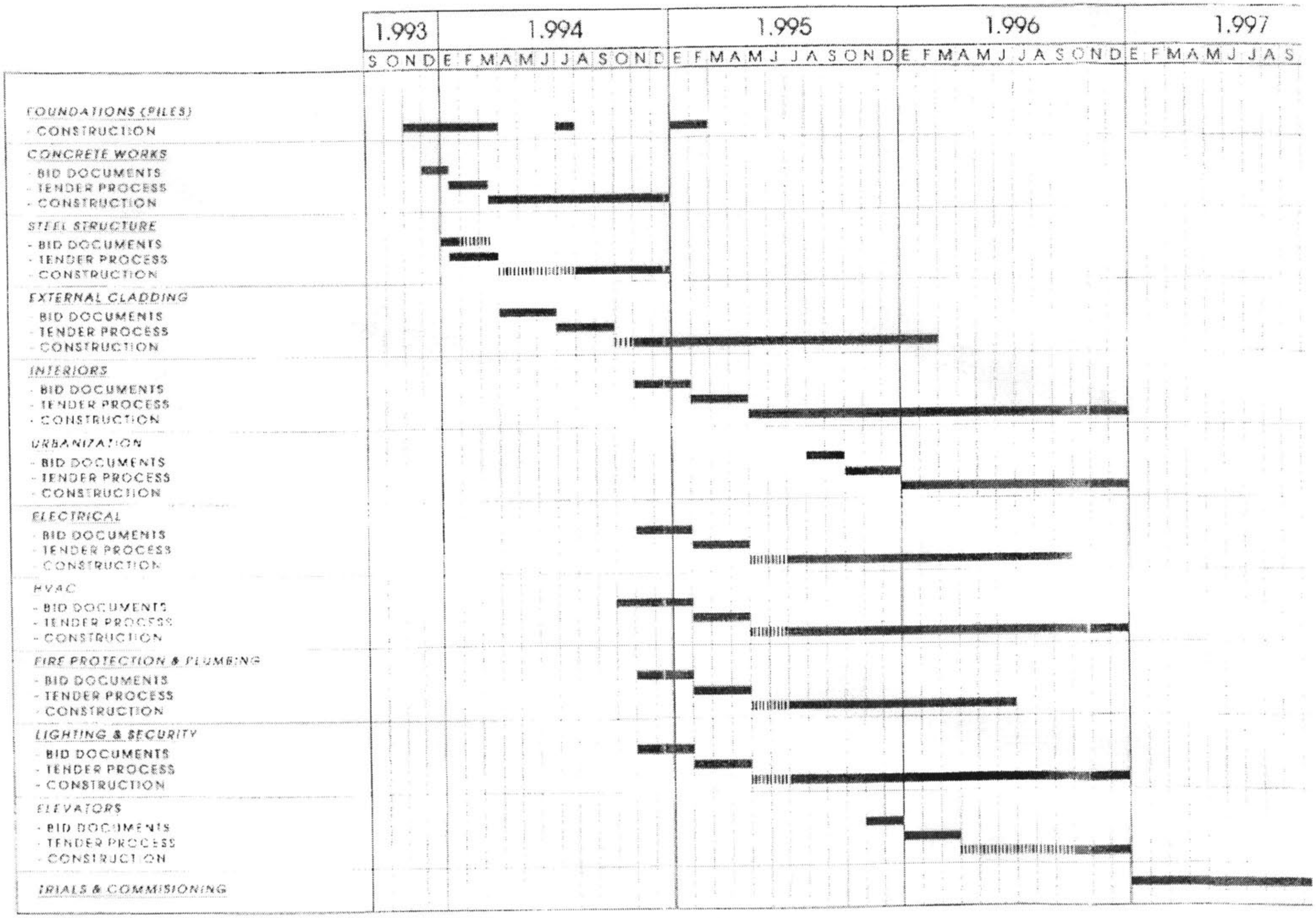
COST PLAN SUMMARY - MARCH 1996

- BUDGET -

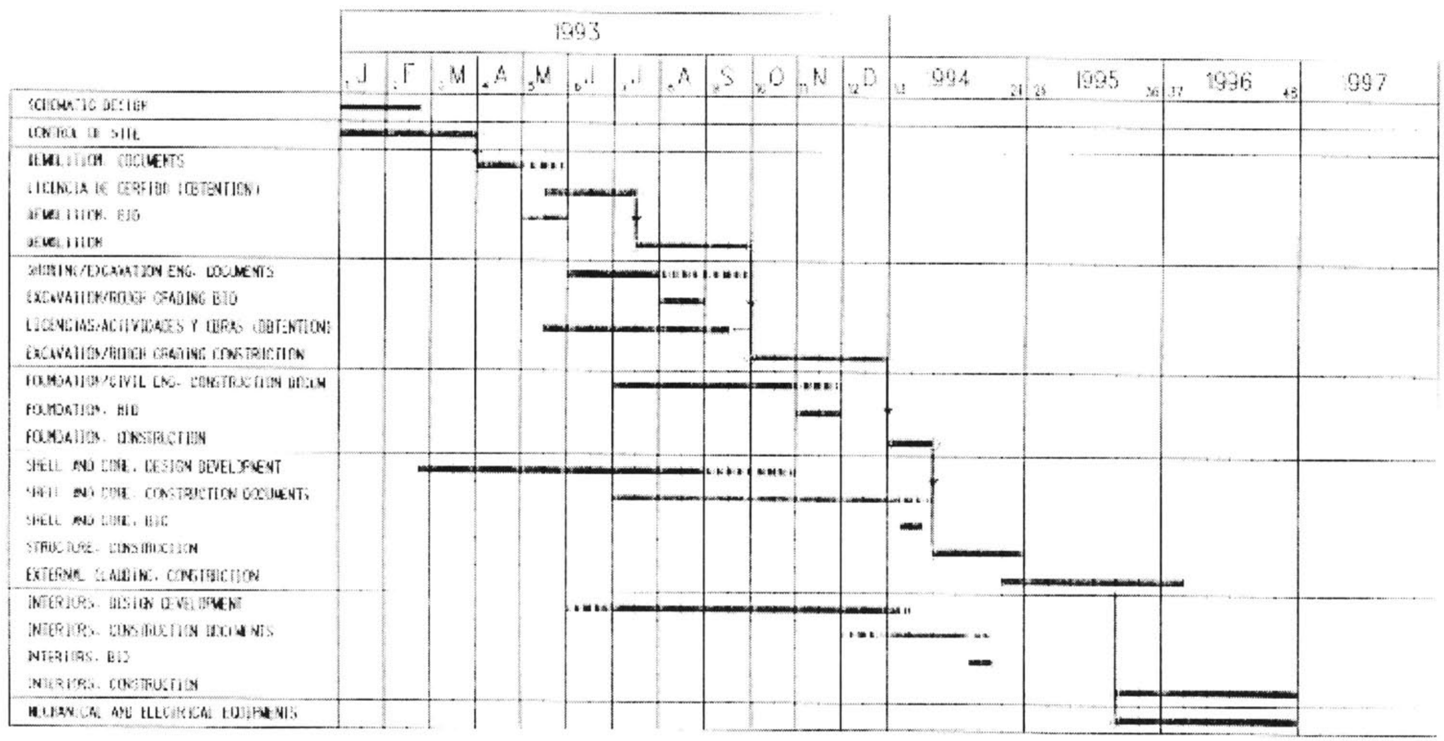
ITEM	COST (M Ptas)
BASE BUILDING COST	10.106
TOTAL	**10.106**
GENERAL EXPENSES	
Mobilization	423
Contingency (8%)	676
TOTAL	**1.099**
FIXED COSTS	
Legal	12
Fees	2.013
FF&E	798
TOTAL	**2.823**
TOTAL MUSEUM COST	**14.028**

9.13 APPENDIX A7

IDOM – Construction and Design Schedule[2]



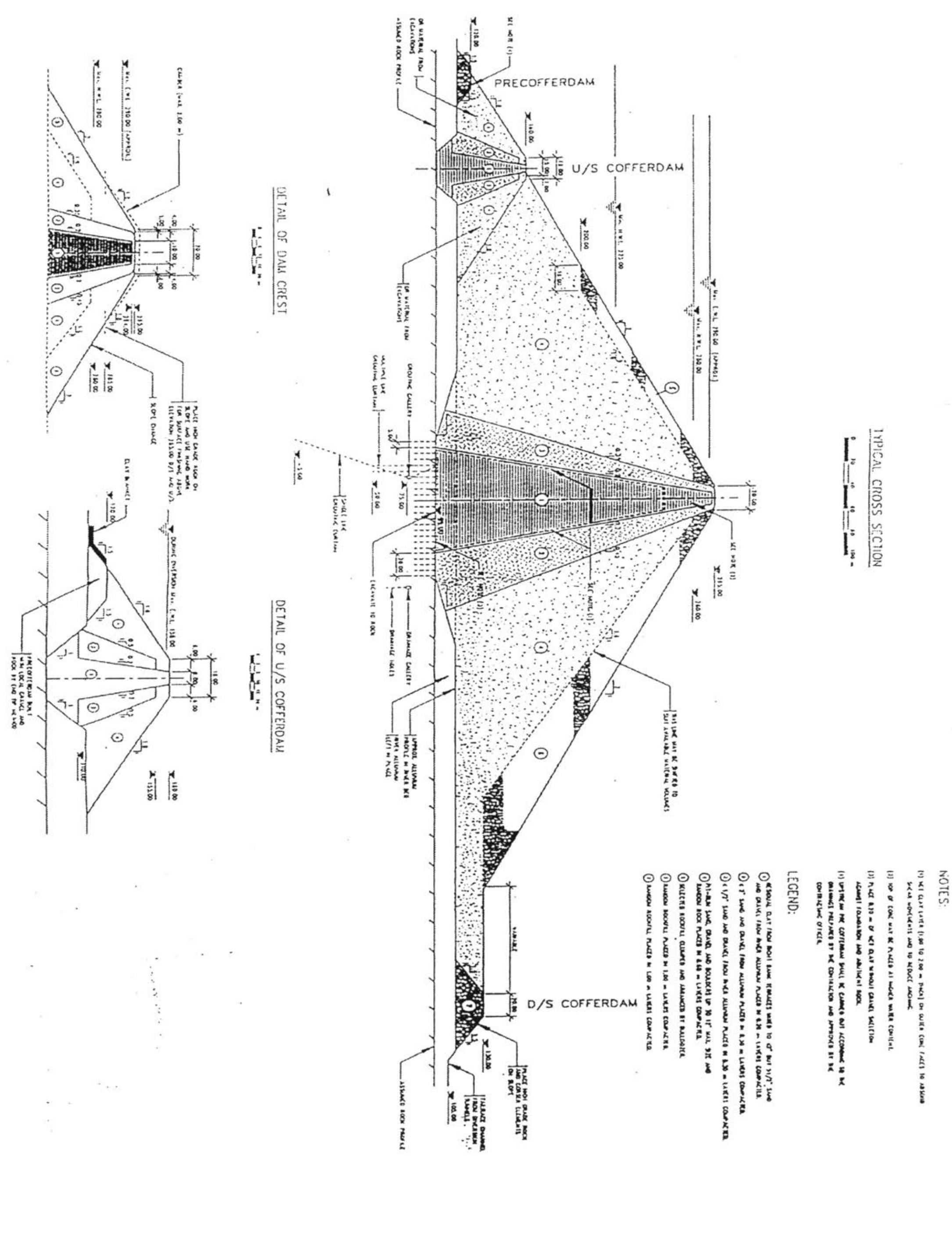
DEVELOPMENT SCHEDULE



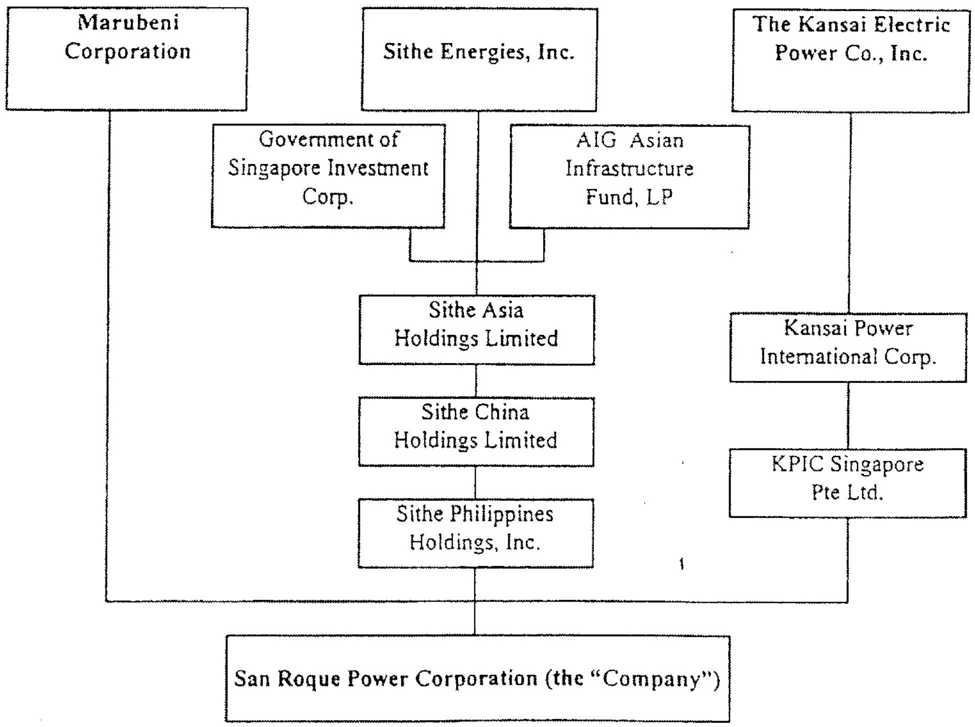
APPENDIX B

9.14 APPENDIX B1

San Roque Power Station Design[3]



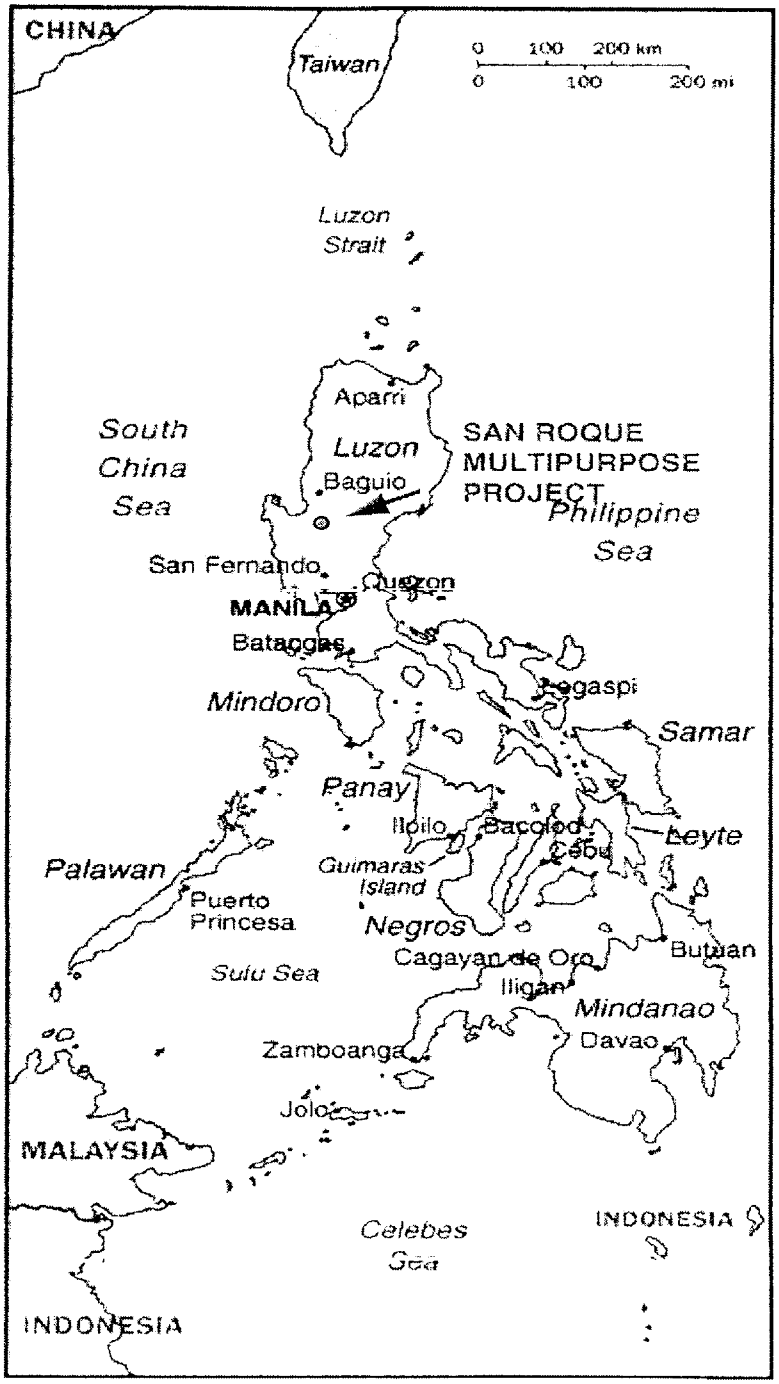
9.15 APPENDIX B2



Shareholder Structure(3)

9.16 APPENDIX B3

Site Location – Philippines[3]



REFERENCES

GUGGENHEIM CASE STUDY

1. Bruggen, Coosje van, Frank O. Gehry Guggenheim Museum Bilbao, The Solomon R. Guggenheim Foundation, New York, 1997.

2. Case Studies in Project Management, Bilbao Case Studies A-C, Case Studies in Project Management, Harvard, March – April, 1999.

3. Gordon, Christopher G., "Choosing Appropriate Construction Contracting Method," Journal of Construction Engineering and Management, Vol. 120, No. 1, ASCE, March, 1994.

4. Iyengar, Hal, Framing a Work of Art, Civil Engineering, ASCE, March, 1998.

5. Iyengar, Hal, The Guggenheim Museum, Bilbao, Spain, Structural Engineering International, November, 1996.

6. Iyengar, Hal, Steel Flower, Modern Steel Construction, July, 1998.

7. Iyengar, Hal, Unique Steel Structures in Spain, Journal of Constructional Steel Research, Volume 46, Nos. 1-3, 1998.

8. Macomber, John D., "You Can Manage Construction Risks," Harvard Business Review, March – April, 1989.

9. Rodriguez, Luis, Guest Lecture, Case Studies in Project Management, Harvard, March-April, 1999.

10. Slessor, Catherine, "Atlantic Star," The Architectural Review, December, 1997.

11. Tishman, John L., "Construction Management – A Professional Approach," Robert B. Harris Inaugural Lecture, April 13, 1988.

12. Vidarte, Juan I. Et. Al., Guest Lecture, Case Studies in Project Management, Harvard, April, 1999.

REFERENCES

SAN ROQUE POWER FACILITY CASE STUDY

1. Gordon, Christopher G., "Choosing Appropriate Construction Contracting Method," Journal of Construction Engineering and Management, Vol. 120, No. 1, ASCE, March, 1994.

2. Macomber, John D., "You Can Manage Construction Risks," Harvard Business Review, March-April, 1989.

3. San Roque Power Corporation, Summary of Terms and Conditions, San Roque Power Corporation, August, 1998.

4. Tishman, John L., "Construction Management – A Professional Approach," Robert B. Harris Inaugural Lecture, April 13, 1988.