



UNSW
A U S T R A L I A

Project 3 Final Report

**Designing the Water Cube, a project
management case study analysis**

Group 26 | GSOE9820 | 30/05/2018

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Executive Summary:

This case study analysis discussed the challenges in managing the design of the Water Cube in an international joint venture project and the strategies used by the design team to overcome them posed in the case study: "Arup: Building the Water Cube". The difference in culture was the key challenge in this project, along with communications and technical challenges arise due to the complexity and time limitation of the project. The design team from Arup used different management techniques including signature parallel inter-disciplinary design approach: "total design" along with sustainability management tool SPeAR to manage technical issues. Management of cultural risks, interfaces and detailed implementation plan are among the practices used to tackle the communication challenges both internally and externally. Through designing the Water Cube, Arup gained valuable lessons in both management and technical aspect on working in a construction joint venture projects in China.

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I. INTRODUCTION

Beijing National Aquatics Center, or Water Cube is one of the most famous landmarks in Beijing. It was built to host the aquatics games at the 2008 Beijing Olympic. Known for its unique design, the Water Cube was designed and built by consortium of award winning design firms Arup, PTW Architects and China's largest construction architecture and engineering firm CCDI. Arup and PTW Architects oversaw the design part of the project [1]. The case study analysis will focus on Arup side of the project and how the team from Arup used project management techniques in a high-profile international joint venture project.

II. ACCOMPLISHMENTS AND INNOVATIONS

Innovations:

The design's effort in convincing the Olympic committee to change the Olympic pools requirements for the better was an innovation. The pools themselves were designed to be the fastest pool. The pool is deep enough coupled with the water filtration system that allowed reduced water turbulence without compromising vision [2].

The Water Cube's bubble design and blue color contrast with the close-by National Stadium's nest-like shape and red lighting create a yin-yang relationship in atmosphere between the two stadiums. The design heavily inspired by Chinese culture and philosophy allows it to not only serve as an Olympic stadium but as a landmark of Beijing [1].

Besides technical innovations, managerial innovations were also made. The team used of management of interfaces helped make sure seamless transfer of design to CCDI [1]. The design team's commitment to show the fire-safety of ETFE and documented risks during the construction and maintenance phase helps to minimize future unwanted accidents and hazards.

Using ETFE for the building was an innovative choice, even though Arup had used ETFE for another high-profile project, the Eden Project, but that was a green house [1]. The use of a new tool BIM to design then techniques like Rapid Prototyping for fast 3D prototype was ground breaking.

Accomplishments:

As a project management group, the project accomplishment can be seen under the paradigm of Economical, Reputational and Capability enhancing achievements:

Economic:

The design surpassed all the requirements set out by the Beijing Olympics committee while keeping it on the calculated \$US110 million budget [1]. Its optimized sustainability and pools with wave machines and rides allow it to serve as a generally non-profit public destination after the Olympics. The project was a financial success for Arup despite its tight schedule and many challenges met during the design process.

Reputational:

The use of ETFE to reduce construction cost (much lighter than the equivalent glass panel) and maintenance cost (self-cleaning while being recyclable) revolutionize the way sustainable buildings are built [3]. The Water Cube is the largest ETFE membrane structure. As a beacon of sustainability and architecture design, the Water Cube project helps promote Arup's reputation as a design firm.

Though the Water Cube project was not the first project that Arup worked in China, this project helped to solidify Arup's reputation with its professionalism under a cross-cultural management. This would open more project opportunities for Arup in one of the largest yet most conservative market.

The Water Cube has, since then, won many design awards in Australia and internationally, as a proof of its innovative and iconic design.

Capability:

The project management team at Arup was able to utilize their "total design" model to its fullest potential. It was able to lead diverse team of 20 different disciplines from offices all around the world to work on a fast-track project with prototype designs being supervised by international partners.

This was possible by the effective usage of new design paradigm BIM which allowed the design team to produce high quality models under tight deadline. Easy extraction of parts within the whole project allow seamlessly collaboration between sub-teams which lead to less error prone and fast 3D prototype [1].

III. PROJECT CHALLENGES

Time constraint:

The team had only 12 weeks to come up from concept work to complete design and budget estimation. Since this was a competition and the construction had to start at the end of 2003, there was no flexibility to the deadline. Strict short time constraint would intensify all other challenges results in higher risk

Budget constraint:

The 100 million USD construction budget with 10 million USD for transition post Olympics is a limited amount for such a big project. For a comparison, the London Aquatics Centre, which was used for the 2012 Summer Olympics and with Arup as structural engineer, had a cost of over 360 million USD with basically the same requirements.

Technical/design Challenges:

Choice of materials, structural design, prototyping for the competition. These were all part of the technical challenges. The technical challenges were an integral part of the project and the complexity and ambition of the design is huge with the limited time and budget. Technical challenges come with the choice of ETFE combine with a new market (China) means that the team had to test the material under a new set of regulations [1].

Project environment challenges:

As the project was a joint venture between 3 parties from East and West the unfamiliarity in project environment within Arup team as well as between each company made it one of the biggest challenges.

+ Communication:**- Internal:**

Since Arup's team was comprised of specialists coming from a variety of different disciplines, ensuring the collaboration in between the team easily so that to not waste resources and to produce complex design was a challenging task.

- External:

There were multiple stakeholders and authorities for the project as well as this is a joint venture project between 3 different companies. Getting consensus views would prove to be a hard problem for the management team.

+ Cultural differences risks:

The unfamiliarity of China's regulations and relationship-based business culture affect both technical and management part of the project. Lack of regulatory transparency means that any technical decision had to be researched under China's market inter-personally and not with widely available resources. Misunderstandings and disagreements would be hard to resolve without comprehending business culture from all sides. In the beginning of the project, Western architects and China architects were working on 2 completely different design without agreement first on the concept which leads to huge waste of limited resources.

IV. MANAGEMENT PRACTICES

1. *Arup's management as a firm*

At the core of Arup's operation is its philosophy and mission which are best understood through Ove Arup's Key Speech in 1970 which is required reading for new employees. Stated by Ove Arup, the firm's aims are: "Quality of work, total architecture, humane organization, straight and honorable dealings, social usefulness and reasonable prosperity of members". And at the core of operation is the "total architecture" or "total design" philosophy [4].

The implementation of these philosophies lies mainly in Arup's organizational structure. Instead of a traditional bureaucratic organization structure, Arup opted for a network-oriented organizational structure where Arup is a holding company that consists of several subsidiaries. For each subsidiary, instead of a core team, it is consisted of different engineering disciplines that cover all aspects relate to construction. Arup's smallest unit of business is small project team in which project managers will lead team of specialist drawn from all the disciplines within the company. The company's growth is through the incorporation of more discipline/field into its network.

This type of organizational structure used by Arup is called network governance in the literature. A definition proposed by Jones et al (1997), network governance comprises of a set of independent firms engaged in "creating products or services based on implicit and open-ended contracts to adapt to environmental contingencies and to coordinate and safeguard exchanges". The contracts are socially and not legally bound [5]. There are conditions under which network governance thrived: the unpredictable environment of industry, customized exchanges, project complexity and frequent exchanges among parties [6].

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- **Unpredictable environment with stable supply:** Construction industry involved many variety of fields of engineering and arts. With the fast changes in knowledge and technology, the industry is also changing but there will always exist demands for construction projects. Firms that do not able to keep up with the ever-changing requirement of the industry will be rendered obsolete. That's why the network governance structure thrived when it is more focus on expanding the coverage of fields (both in skills and geographical) using partnership [5].
 - **Customized exchanges:** The network structure allow the freedom to exchange knowledge both specialized and social across multiple global offices. Arup's project managers can tap onto a customized combination of different specialists for the specificity of the projects they are working on. This flexibility allows Arup to involve in many unique projects.
 - **Project Complexity:** For high complexity projects under tight schedule, the sequential flow of project is normally impossible. Network governance allows complex projects to be worked on simultaneously by specialists then comes together under the direction of project managers.

This organizational structure allows Arup to fulfill its missions that help them provide good services/projects throughout its history.

“Total design”: Arup elevates the regular dedicated project team with the organizational structure into its signature design approach called “total design” where all disciplines assigned to a project work on them simultaneously [7]. The approach's successes can be described by its processes:

- **Conceptualization:** the design will be created by the architect but with the contribution from engineers while incorporating any knowledge on construction, building technology, financial and material [8]. This first phase with early involvement of all members allows the specialists to have access to the concept of the design.
- **Preliminary:** The concept will then be examined again by all the team members, now at a more sophisticated level. Any challenges in any given discipline would be detected by the specialists and the implementation of the design would be seamlessly and coherent as all parts of the team have knowledge on the conceptual design.

This approach, if done correctly, will produce high quality results in shorter amount of time with more design freedom as the project is executed simultaneously by all sub-teams and everyone has all the knowledge of the design from start to finish.

Extensions of disciplines: With a wide coverage of disciplines under its structure, Arup can combine these disciplines to create different strategies and frameworks that can work for more variety of projects. An example of this was SPeAR which was developed by the software and sustainability team of Arup [9]. With the increasing demand in sustainability solutions for constructions due to increasing sophistication of technology, SPeAR framework provides a tool for managing a generalized sustainability project.

Organizational culture: Arup recognized that employee satisfaction underpinned the success of Arup the brand and individual project outcomes - emphasizing the “humanitarian” attitude. Arup also tries to keep the work for its employees both “interesting and rewarding” and this is evident in the wide variety of ‘modern’ and ground-breaking project ventures which the company has undertaken [4]. With the profit from projects being distributed to its members, everyone in the firm is united under the same purposes [5].

2. Practices and Processes in the Water Cube project

Project execution approach: recognizing the challenges in completing a project of this scope in 10 weeks with a very limited building budget. A sequential approach would take too long so the parallel multi-disciplinary “total design” approach was a natural choice for Arup. The Arup design team drawn its human resources from 20 different disciplines across 4 offices around the world [1]. Also, with the sustainability requirement of the structure, the incorporation of the trademarked SPeAR tool was logical.

Focused Implementation Plan Strategy tailored for the project

The key strategies for Arup in achieving great success in this project was through the detailed implementation strategy that covers communication both internally and externally, risk management strategy that focused on the difficulties arise from working in an international joint venture:

- *Management of Volumes and Interfaces*

To deal with the complexity arises from the use of the “total design” approach, the work was breakdown into four parallel streams: designs, product research, stakeholder engagement, and commercial issues. This work breakdown help ensuring technical specialists did not have to deal with any business issues and vice versa. The

choice of streamlining the processes into independent, simultaneous streams was a great benefit in saving time and scheduling of resources.

Furthermore, to help with transparency when working in such complex project boundary of each project volume must be identified. Management of interfaces: physical, functional, organizational & contractual, and operational helps document the project clearly and avoid any overlap of works which result in waste of resources hence generate possible savings during the construction phase. The number and type of volumes teams into which the project was split was optimal and appropriate for the size of the project. Communication was seen in the use of a register for the levels of the interfaces and the use of 'regular interface co-ordination meetings' which included all necessary stakeholders.

- *Management of cultural differences risks:*

Arup planned to ensure the services both in terms of materials and staffing are at the highest quality when presenting, interacting with the Chinese stakeholders and Olympic committee. Senior engineers from the Beijing and Hong Kong offices were put in charge of/involve in any of these processes. Meetings focused on maintaining contractual agreements to ensure the scope of the project as well as responsibilities of the Arup's design team. Moreover, implementation workshops were held at the begin phase to keep everyone up to speed and internal sessions between the Chinese and Western team members to establish approaches and bridge the cultural gap [1].

- *Technology Application*

The Arup team used a technique called Building Information Modeling (BIM) and structural optimization tools to design also contributes to the success as one of the practices & processes. 3D digital model was given to engineers to iteratively perform multiple specifically analyses to determine suitable sizes of the beams, columns, and related structural components. The design would then be produced into a real 3D model for the competition using Rapid Prototyping technology [1].

3. *Lesson learnt by Arup*

- *Working in international joint ventures project*

The gained experience from working in this joint venture is massive. Throughout the project, one of the main challenges was managing the difference in culture both internally and externally. Arup would learn a lot about the nature of doing business in

China. The strategies used for internal cultural difference can even be used to improve Arup's overall effectiveness as a firm. For future projects, project managers can bring in specialists from any office without much concern about cultural conflicts.

Also, international joint venture projects are the best way for a firm to enter a new market [10]. The reputation and trust Arup get from designing such an impressive structure such a big event as the Olympics would lead to new projects in China.

- *Efficiency in communication and collaboration processes*

The conflict during the conceptual design phase of the project indicated that there was room for improvement for communication and collaboration processes with Arup and other stakeholders/project partners. In future, it would be better to overcome culturally specific barriers and ambitions in design in an earlier phase as a consensus about design concepts was not reached in the initial discussions

- *Technical advancements*

The Water Cube tested the boundaries of engineering possibilities. The use of techniques like rapid prototyping, computational methods for developing unconventional structural designs and the use of BIM for cross-functional data exchange communication worked for complex structures. It also broke down previously held ideas in the industry surrounding cost, quality project time and sustainability. Arup has earned this knowledge which can be taken away from this project and applied or modified in future projects.

- *Business in a new culture*

Any management strategy used to bridge the cultural difference can be learned and improve from for future projects in China or in other foreign countries where the business culture and regulations are vague.

To be able to participate in the supervision of the construction as the designer and structural engineer is crucial for any construction project. It is to make sure that the construction follows what the designer envisioned. Learning from this experience, Arup would know more of the interpersonal-based business culture in China which in turn helping them make better lobbying strategies for future projects in China.

V. CONCLUSION

The case study analysis discussed the challenges in managing the design of the Water Cube in an international joint venture project. The challenges arise mainly from the difference in culture between the parties involved and the complexity of the project under a tight schedule and budget. The team at Arup was able to utilize project management strategies to overcome these challenges and succeed in designing one of the best aquatics centers for the Olympic Games as well as an iconic landmark in Beijing. This project helped established Arup's reputation as a structural design firm in China which open the door to future opportunities.

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LESSONS LEARNT

The major challenge in coordinating this project was studying the Case provided and analyzing each task mutually within schedule. A detailed schedule outlining daily tasks was of benefit to the team. Individual work and discussion made it easy to accomplish every task in a better way. There was more learning about project management techniques with respect to real world example of a world-renowned firm like Arup which was quite knowledge giving. The case study demonstrates what the necessary components a firm needs to own and the actions they have to carry out to face the challenges. Strict adherence to the schedule and minor flexibility (where necessary) ensured consistent progress by the team.

Additionally, sticking to deadlines helped to carry on discussions overcoming all disagreement and summarizing each task made it easy to carry on project with support of everyone. Additionally, it also enhanced the quality of the discussion and analysis of every task and helped evaluating it in the best way. Compromise, communication as well as cooperation are the most significant mission among the project.

PEER MARKS

Team Member	Total Marks
Shrey Srivastava	9
Cheng Lu	9
Trong Tu Do	9.5
Shilpa Kala	9.5
Per Christian Wibe Due	9
Siwei Lin	9
Hongyu Zhang	9