

APM Project Management Awards



# WINNER'S

## CASE STUDY



Category **Overseas Project of the Year 2008**

Winner **Arup for The Water Cube, Beijing.**

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### The project **Introduction**

The ambition of the Beijing Olympics was to be "the green games, the hi-tech games, and the peoples' games".

In the short time since its opening, the Water Cube has become an icon of a 'new Beijing'. The venue amazed visitors and inspired athletes at the 2008 Olympic Games, hosting the swimming, diving and water polo events.

Twenty-five world records were set in what is now the fastest pool in world, Great Britain's Rebecca Adlington became a double Olympic Champion, and Michael Phelps set a new Olympic landmark with eight gold medals.

The design was delivered from competition stage

through to a fully approved scheme in just 12 weeks, with the fast-track programme continuing through to the official opening of the Water Cube in January this year.

Arup received a glowing tribute from the client, Thomas Yi, Vice General Manager of China Construction Design Institute (CCDI); "With regard to Arup's performance on the project we felt that the design consortium did an amazing job. We were deeply impressed by the professionalism of the Arup team, who delivered the multi-disciplinary engineering services required for this key venue for the 2008 Beijing Olympics. The project was completed on time and within budget."



APM's judges agreed that the Water Cube made a worthy winner; "Arup has managed to deliver, on time and to budget, a truly inspirational and enduring project for the Chinese people within a complex technical and cultural management environment, by establishing a clear vision and roadmap that all stakeholders aligned to. Clarity of communication was essential and Arup mitigated this key risk via interface management techniques aligned to the technical and commercial interdependencies, in an innovative manner."

The scale of the project was neatly summed up by Joanna Kennedy, Arup, who when accepting the award on behalf of Arup's Australasian practice, described it as a "major collaboration" involving 20 different disciplines over four different countries.

## Background

The Water Cube was the result of an international design competition with 10 short-listed participants, judged by a panel of architects, engineers and pre-eminent Chinese academics. The Arup + PTW + CCDI design was selected as the clear winner of the competition both by the international jury and the people of China themselves, although the outcome could have been quite different but for some tough decision-making by the Water Cube team.

The Aquatics Centre was required to be the best Olympic swimming venue and then a popular and well-used leisure and training facility after the games. It was to cost no more than US\$100M before the Olympics and US\$10M for its conversion to legacy mode.

The Olympic requirements included a 50metre competition pool, a 33metre diving pool and a 50metre

warm up pool. The main pool hall was to have 17,000 seats for the games and then be reduced to 7,000 seats with other facilities added in order to make the Aquatics Centre a viable long-term legacy. The construction was to start before the end of 2003 and to be completed at least six months before the Olympics to allow a sufficient period for trial competitive events.

In 2003, as the fast track development program got underway, the team from Arup, PTW Architects, and China Construction Design International (CCDI) agreed that the Aquatics Centre design should portray the way in which humanity relates to water, and devoted half of the available design competition period developing a design with a wave shaped roof depicting the power of the surf.

Following the unveiling of the spectacular glowing Bird's Nest design for the National Stadium by the team at Herzog & de Meuron and Arup just four weeks before the competition deadline the Aquatics Centre team realised their design could not win and made the difficult decision to scrap the wave design and swiftly agreed the component parts of the Water Cube concept.

The National Stadium is on the neighbouring site to the Aquatics Centre, the two sites separated by a protected historic axis to Beijing's Forbidden City, factors that led the team to develop a complimentary design to the Bird's Nest. They concluded that a cube concept would appeal to the typical Chinese way of understanding beauty – a subtle, thought-provoking design representing the beauty and serenity of calm, untroubled water.

The two opposing shapes sit together in harmony; the Water Cube is blue against the Stadium's red, water versus fire, square versus round, male versus female, earth versus heaven.

While the structural solution based on the formation of soap bubbles is unique, other technical ambitions contributed to its iconic form.

- The Water Cube is an insulated greenhouse, which maximises the use of solar energy for both heating and lighting.
- The use of ETFE (ethylene tetrafluoroethylene – a kind of plastic) in lieu of glass creates a superior acoustic environment, reduces the weight of material supported by the structure, improves seismic performance, and is self cleaning and recyclable. The roof collects and re-uses all rainwater that falls on the building.
- Despite the building's apparent complexity because the structure is based on a repetitive geometry, the sub-components repeat across the building. There are only four different nodal geometries, three typical member lengths, and 22 different ETFE pillow shapes, greatly reducing the time and costs of production and installation.
- The design sets a new precedent for engineering approvals for the Chinese Olympic venues. Without performance-based fire engineering (a first for China) the Water Cube as we know it would not exist. The building is the result of integrating the technical requirements of all the relevant engineering disciplines, not the result of a single dominant one.
- Due to its complexity (the structure consists of 22,000 steel members and 12,000 nodes), the entire project had to be conceived and modelled during the last three weeks of the design competition in three dimensions.
- Numerous new techniques and pieces of software were developed specifically for the Water Cube project. This new software was used to generate the geometry, create a physical prototype, optimise the structural performance, analyse acoustics, smoke spread, and pedestrian egress, and to provide construction documentation in a fully automated four dimensional sequence.

## The challenges

In winning, the Arup team had created a significant challenge for itself. The competition concept had enormous wow-factor, and was based on solid engineering principles, but many of the concepts were so cutting edge that multiple streams of research and development were still needed to prove the design both internally and to design partners, and to sell technical aspects to the Chinese approval authorities.

Despite the complexities involved, the Water Cube always had one absolute given – a fixed end date. It was up to Arup's project management team to deal with major timing issues along the way, most notably delivering the physical venue design well in advance of knowing who would operate the Water Cube before and after the games, and how they may want to reconfigure the building.

There were no easy answers to these issues, however the key to success was a combination of involving Arup's specialist designers and project managers with expertise in Olympic sites. These specialists provided a real understanding of how Olympic events will be operated, how the many operational streams must be linked, how to balance the needs of stakeholders, and how the venue sits within the wider Olympic organisational framework.

The design and construction of the Water Cube, while pushing back the boundaries of innovation, is essentially business as usual for Arup. Arup is renowned for taking on large and complex designs and bringing them to fruition. However, the actual project management of an Olympic venue for Arup is anything but business as usual.

## Communication

The binding thread in the success of the Water Cube project was the quality and depth of communication both internally and externally. As well as day-to-day team communication and information management processes, Arup's communication strategy established the vision and key messages, and how these would be integrated into daily project life.

The strategy produced by Arup's project managers went beyond planning the formal internal and external methods of communication – it encompassed the need for the continuous incorporation of lessons learnt in dealing with stakeholders in a different location, and with a different culture and language. In doing so it provided a vehicle for relationship management and stakeholder engagement.

At the implementation plan workshop, Arup's project management team focused initially on the need to articulate and communicate a very clear project vision for the Water Cube design. This was intended to have multiple benefits. Most simply, the vision would provide improved clarity and autonomy to the design team members.

This would help achieve a quality outcome in a very short period of time, by allowing parallel streams of activity to converge quickly and accurately. It was also hoped that having a robust vision would greatly help achieve alignment and buy-in from other project stakeholders.

## International aspects - the management of difference

More challenging for Arup's project management team than the technical aspects of the Water Cube, and ultimately far more rewarding, was learning and understanding the business culture and context in China. It was not only 'foreign' to Arup at the start of the project, but also highly difficult to read, so they held some specific internal sessions with Chinese team members to agree



their approach to the early 'management of difference'. This partly focused on maintaining leverage over commercial arrangements, but mainly looked at how to minimise and manage the risks of the specific differences in norms, practices and expectations through the project lifecycle.

The complex and dynamic nature of the Chinese market, particularly in the context of the Olympics, meant that the risks associated with delivering the Water Cube could not be underestimated. Beijing's lack of regulatory transparency and regional differences, as well as a relationship-based business culture were among the factors Arup identified that made China a challenging project environment.

Arup's project management team looked at a diverse range of risks, trying to understand and plan their approach to the project in the unfamiliar context of China's legal, social, cultural, economical and technological environment. Other than the commercial risk of delayed payment, the key risks identified were social – how China's business culture might affect the relationships and dynamics within the international Water Cube team, and with the external stakeholders involved in approving the design concept.

Social risks such as cultural misunderstandings could have completely derailed or significantly delayed the Water Cube project. Relationship building is fundamental in Chinese business, so understanding Guanxi – a form of social networking – and how to authentically cultivate and manage it was vital to the Arup project management team.

Other important factors in the approach included:

- Emphasising Arup's international reputation and the depth and diversity of its activities and locations.

- Ensuring that all interactions with Chinese stakeholders involved giving them the highest possible quality of service, both in terms of the material issued and the Arup staff directly involved with them.

It was important to involve well-respected senior engineers from Arup's Beijing and Hong Kong offices at key stages of the approvals process. Their influence and local knowledge of the Chinese legislation, coupled with Arup's involvement in other high profile Olympic projects in Beijing, were leveraged to convince some conservative authorities to accept a range of innovative approaches to the engineering design that didn't follow the prescriptive rules of the Chinese building codes.

This was the number one risk in the early stages of the project, and the formal approval of the engineering design in early 2004 set a major precedent and direction for other Olympic projects.

Arup's specialist project managers were very specific during contract negotiations to clearly define the scope of services and the interfaces with Chinese design partners, and were robust in contract negotiations that removed some of the post-Olympic payment milestones that were unrelated to Arup's scope. The result was a financial success despite the considerable risks of working on such a fast track project, with international partners and stakeholders, on a project involving such groundbreaking design techniques and materials.

By deliberately resolving any potential conflicts early, Arup were able to sign a contract and facilitate a smooth and seamless handover to their Chinese partners with clearly understood and accepted interfaces.

## Interface management

Some of the challenges faced included the integration and the coordination of the many interfaces for the project involving multiple stakeholders with conflicting demands. Coordinating the requirements for athletes, officials, VIPs, written press, broadcasters, workforce, sponsors, spectators, and of course the operator, is complex and requires delicate balance.

Arup's project management team had the challenge of coordinating 20 specialist Arup engineering disciplines, ensuring they were properly integrated, and that the complex interfaces of the Water Cube were properly understood and documented.

Developing on previous Arup project management work at London's Heathrow Terminal 5, the project management team introduced an interface management strategy which divided component parts of the Water Cube into volumes defined by physical and time boundaries which were described in a project volume register and each volume assigned an owner.

An interface occurred when anything touched or crossed a boundary. Initially all high (key) and low level interfaces were identified and captured on a register, and regular interface management and coordination meetings held involving all parties. The principle began working very well internally, and was quickly expanded to include external interfaces where Arup required information from another team or third party – e.g. the interior designers, or utility supplies from off site. These external interfaces were classified as:

- Physical – a point or plane common to two or more parties at which a physical interdependency exists, e.g. the location of an underground service or duct route.
- Functional – a relationship between two parties at which performance interdependency exists, eg power requirements or data connectivity.
- Organisational and contractual – a relationship between two parties in which a delineation in scope or contractual responsibility exists, e.g. the development of details by Arup's Chinese design partners CCDI based on Arup's scheme designs, or interfaces between civil engineering and architectural landscaping documentation.
- Operational – a relationship between two parties at which delineation in operational responsibility exists, e.g. maintenance for equipment under warranty with the ongoing maintenance and replacement by the operator, and the short term responsibilities for Olympic overlay compared to pre-Olympics mode and then legacy mode.

The management of interfaces became one of the most important functions of the project management team during the Water Cube design and in the longer term, Arup believes the results will also generate significant savings in construction cost compared to current practice.

## Safety in design

Measured by international standards, construction site safety records in China are poor. At the implementation plan workshop, Arup's project management team made a strong commitment to explore the risk-prone activities likely to occur in the construction of the Water Cube, and to potentially improve safety by following a 'Safety in Design' approach. This included producing documentation that would improve safety awareness, suggesting planned and logical methods for construction and maintenance.

Using the UK Construction Design and Management (CDM) Regulations, and draft NSW legislation, this approach was intended to ensure that unusual hazards and risks (such as post-Olympic alterations to the internal fit-out, and working-at-height hazards involved in maintenance of light fittings or adjusting broadcasting equipment) were eliminated or controlled at the design stage wherever possible.

The final hazard risk register was included with tender documentation along with recommendations that it be incorporated into the safety management plans for the various package contractors on site.

## The people factor

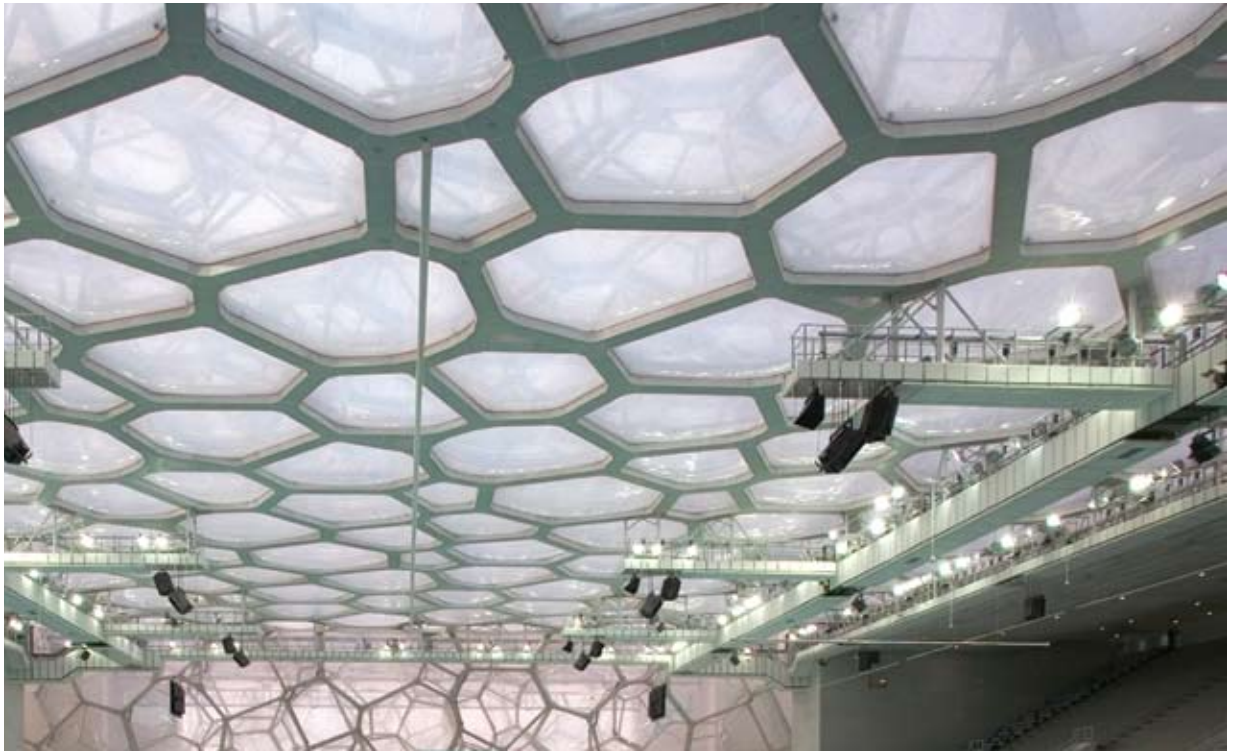
To remove potential pinch points from specific key staff becoming overloaded, and to allow technical staff more freedom, Arup's project managers established semi-independent teams with their own leadership, to progress in parallel streams.

The four teams included design, product research, stakeholder engagement and commercial issues such as scope, contract and fees. For example, Arup established clean interfaces that would allow the finalisation of the structural geometry and research into the ETFE facade performance to proceed without holding up the general space planning of the building. Leadership for key stakeholder meetings was separate from commercial negotiations, so that one did not compromise the other.

Following the success of the Water Cube implementation model, it has now become standard practice on all of Arup's major projects. Having specialist project managers providing leadership, while still providing freedom to technical staff, significantly improved the design process and embedding project management into the business was more easily accepted as the specialist project managers on the Water Cube also had technical engineering backgrounds. In this way the specialist project managers were able to contribute at all levels, rather than ever being perceived as a 'non-technical' overhead.

## Developing the tools to deliver

The Water Cube was a catalyst for the development of a range of bespoke project management planning and monitoring tools. Such tools were needed to deliver such



a large multidisciplinary project, delivered across different offices, and with a program that demanded reporting, monitoring and action to happen in real time.

A range of project management tools established for the Water Cube have since been developed further through internal funding and are now being rolled out on all major Arup projects in the Australasia Region. These include simple protocols for shared servers and email filing between multiple offices, technical management of project interfaces, safety in design and construction sequencing, through to more complex programming applications that interface with Arup's global cost monitoring system to provide detailed forecasting and performance reporting capabilities such as resource management and earned value management.

In fact, following on from the momentum and success of the Water Cube, there is now a dedicated systems development & integration team based within Arup's Brisbane project management team that services both internal major projects and also successfully provides these services direct to external clients, through licensing agreements and tailored systems development.

## Conclusions

Stretching with their involvement in the design competition in 2003, through to the emerging dynamics of working between Chinese and Australian teams, the Water Cube has been an incredible learning and development experience for Arup. The Water Cube has acted as catalyst in advancing and codifying Arup's approach to a number of key areas of project management knowledge.

In particular, these included:

- Establishing and leading winning teams,
- Managing relationships with stakeholders across cultures,
- Project management processes required on major multidisciplinary projects,
- Technological improvements in modelling capability.

These have since been used to great effect on many other Arup projects internationally. Watching the Olympic events in the Water Cube has been a rewarding and humbling experience for the Arup team. There is a genuine sense of authorship with the team members, and there have been many presentations and discussions about why the project was so special.

Of all the key messages though, the one that has emerged above all others is the total, equitable and transparent partnership between Arup, PTW Architects, and CCDI.

The Water Cube is a unique project brought about by a set of circumstances that perhaps may never repeat themselves. Olympic venues are always special, but the nature of Beijing's aspirations to emerge on the global stage meant that the Water Cube became a representation to four billion viewers of a new Beijing.

The fact that Beijing invited international designers to be part of the Olympics at all was unusual, and set the tone for a genuine collaboration on the Water Cube where western and eastern perspectives worked together with mutual respect and openness.

The project management of the Water Cube has created a lasting legacy for Beijing, and a lasting legacy for Arup's project management team.

The **APM Project Management Awards** have been celebrating project management excellence since 1993 and the broad range of categories is designed to make entry possible for projects and companies of all sizes and complexity.



Joana Kennedy OBE, Director of Ove Arup & Partners Ltd collecting the 2008 Overseas Project of the Year Award for the Watercube, Beijing

The awards reflect the invaluable contribution project managers make in all sectors of society and the event provides an opportunity for industry professionals to meet with colleagues and entertain guests as well as celebrate at one of the year's most exciting events.

Highly regarded in the project management industry, the awards reflect the dedication and talent that helps to shape the project management community and the world around us. The finalists, winners and sponsors of the awards attract national publicity for their achievement and involvement. Winning an award provides invaluable recognition and kudos to the careers of winners.



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