MAJOR PROJECT REPORT

UK GAMES: A YEAR TO GO

07|2011

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DELIVERING THE VISION
CELEBRATING THE DELIVERY OF LONDON 2012'S OLYMPIC PARK AND VENUES

Foreword

With just over one year to go to the Opening Ceremony of the London 2012 Olympic Games, the construction of the venues and infrastructure remains on time and within budget. Five years ago we said that the summer of 2011 was the point when we wanted the venues available for test events. That is exactly where we are with the first events lined up for August on the Olympic Park.

Success to date has been the result of the hard work and dedication of the whole team working on this project – from the staff at the Olympic Delivery Authority (ODA) and our Delivery Partner, CLM, to the 12,000-strong workforce and the thousands of businesses who have contributed to the construction project from across the UK. The progress is testament to the skill and professionalism of the UK's design, engineering and construction industries. They have delivered a world-class performance.

John Armitt
Chairman
Olympic Delivery Authority

The moment that London was announced as the Host City of the Olympic and Paralympic Games in July 2005 is etched on people's memories. Almost as soon as the President of the IOC finished uttering the word "London", the planning started – and we are reaping the benefits of that now. The Olympic Park is already a spectacular addition to the London skyline which has seen a largely underdeveloped area in east London, roughly the size of Hyde Park, completely regenerated. From clearing and cleaning the site, to constructing state of the art sporting venues and an athletes' village which after the Games will create a whole new community, this development has been a triumph for UK plc. Add in some of the most advanced thinking in terms of sustainability and it is clear that London 2012 has been the catalyst for change in east London and in the wider construction industry, of which we should be very proud.

Lord Coe
Chair, London 2012
Organising Committee

The project to build the Olympic Park has been a remarkable success and tribute should be paid to Olympic Delivery Authority (ODA) staff and all those construction workers involved who have consistently met the challenges set by an immovable deadline and strict budget. They have all played vital roles in the success of the build project that will be held-up as an example of British construction and engineering excellence for decades to come. It has also been an excellent advert for the British businesses that have supplied many of the materials for these venues and are now winning contracts to supply the London 2012 Organising Committee. The impact of the Games has reached far and wide and many communities across the UK have benefitted, be that through sport, culture or business.

Hugh Robertson MP
Minister for Sport
and the Olympics

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Published by Emap Inform
Part of Emap Ltd

Greater London House
Hampstead Road
London NW1 7EJ
www.nce.co.uk
www.cnplus.co.uk

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Building the Olympic Games

Winning combination: The Olympic Park venues with the Stadium in the foreground

Introduction

By Mark Hansford

In exactly one year from today the world's finest sportsmen and women will be assembled in London, ready to compete in what is billed as the greatest show on earth: the London 2012 Olympics.

Getting the Olympic Park in East London and the plethora of venues around the south east designed, built and operational has been an Olympian effort in its own right. And, against all odds and public expectation, the British construction industry has stood up and delivered.

The main venues are all ready and being handed over to Games organiser LOCOG; the Athletes' Village has beaten banking crisis-induced funding issues and is racing towards completion; and the Park itself has shrugged off its industrial wasteland past and becoming a park that will be used for not just three weeks of Games but to be a catalyst for the long term regeneration of East London.

Targets to make the project an examplar for the industry in terms of health and safety, sustainable construction and engaging and training up a local workforce have all been hit; and all this has been achieved without busting the £9.3bn budget.

Driving the whole project from start to finish has been the Olympic Delivery Authority (ODA), led by its chairman John Armitt, and the ODA's delivery partner CLM. Armitt's top team and the CLM team – formed by CH2M Hill, Laing O'Rourke and Mace and led by programme director Ian Galloway – gelled rapidly and spent two years planning, planning and planning some more to ensure that, once the project moved into the main four year build phase, nothing was unexpected, unplanned or unmanageable.

"This project has demonstrated what the industry can achieve if it has unity of purpose," states Armitt.

"We've had some of the best people and best firms in the industry wanting to be involved, wanting to succeed, and wanting to be seen to succeed. This is an example of the industry rising to the challenge and showing that, actually, it has a lot of self-confidence. So, even though everyone on the outside thought we would fail, there was a confidence that we wouldn't."

"Even though everyone on the outside thought we would fail, there was a confidence that we wouldn't"
John Armitt, chairman, ODA

From day one the project has benefited from seven years of broad political support – a rarity for construction projects and no mean feat given the project got off the blocks under a Labour government and a Labour London mayor and is now heading towards the finishing line under a Conservative government and Conservative London mayor.

"It just shows what we can do if you've got politicians all singing from the same hymn sheet," says Armitt.

ODA chief executive Dennis Hone, who stepped up to the top job from financial director last year when previous chief executive David Higgins moved over to Network Rail, echoes

OLYMPIC TIMELINE

START 2005

July 2005 London awarded 2012 Olympic and Paralympic Games

December 2006 Demolition starts on Olympic Park

May 2007 Earthworks start on Olympic Park

June 2007 Power line tunnels completed and vacant possession of Olympic Park

October 2007 Full Olympic Park planning permission secured

May 2008 Construction starts on Stadium, Olympic Village and Sailing venue

July 2008 Construction starts on Aquatics Centre

"Our job was to be seen as a client of choice"
Howard Shiplee, construction director, ODA

30k
Number of people who will have worked on the Park by 2012

6,449
Number of people working on the Park on the busiest day

246ha
Size of the Olympic Park

this view. "Cross party support has been very good and it continues to this day. It is a credit to the parties that no cheap points have been scored," he says. But Hone is also clear that this support has been earned by a transparent approach to costs and decision making.

"Our approach of complete transparency has gone with the grain of the system. We have not been suppressing bad news. When an issue has arisen, all along we have been clear when the latest possible date to make a decision is, and what the consequences of not making it are. It has been completely open," he says.

"If you are closed, that's what leads to negativity."

And tough decisions have had to be made, whether they were ditching the Park's wind turbine, re-engineering the Olympic Stadium to get costs down closer to the £496M budget, going back to the drawing board on the bid stage Olympic Park masterplan, delivering £7M of post-Comprehensive Spending Review savings by dispensing with the Olympic Stadium's aesthetic wrap, or tackling the impact of the banking crisis on plans to build the Athletes' Village and IBC/MBC media centre with private cash.

"Discovering that what had been a dead cert in 2006 was suddenly a major challenge was a significant concern. Where were we going to find the money from?" says Armitt.

The fact that a solution was found – and one that didn't push the project over budget – is testament to the way the project's finances have been run, with £1.3bn of contingency cash set aside from the £8.1bn main pot for, well, contingencies. It sounds simple, but the Treasury-led initiative had not really been used before. Three levels of contingency exist: one for issues within the project, which is handled by CLM; one for programme level issues; and one for issues outside the control of those managing the programme, which is held by government. The Village and IBC/MBC issue went to government and, because of the faith built up in the ODA, a bold move was taken to ditch the private sector and build them from its share of the contingency budget.

"There was a major issue with the IBC/MBC and the Village," says Hone. "Both wanted private sector investors, and both had them lined up before the credit crunch. But bank lending got suddenly more expensive and the loan to value ratio was falling. There was a deal on the table from the banks, but we took a decision that it was not value for money and that there was not enough risk transfer. So we went to government and said it was better if they stayed in the public sector. Maybe it was the harder thing to do, but we grasped the nettle and now the Olympic Park Legacy Company has taken the IBC/MBC to the market and we have got world class property developers bidding for the Village.

"It would have been easy to take the deal, but it would not have been right," he states.

That a successful outcome was reached to such a potentially project-threatening problem stands as testament to the level of confidence in the ODA. That came entirely through the strength of team unity throughout the supply chain, which in turn came from the ODA being an intelligent client, aided by a properly incentivised delivery partner that knew its role.

"Recognising the role of the delivery partner was an essential ingredient," says Armitt.

Galloway agrees it has worked better than he – or anyone else – expected. "What we were told from history is that organisations like ours and the ODA come in, fence with each other for while, it explodes, then someone else comes in and delivers it. Everybody outside expected it, so to prove them all wrong has been extremely pleasing."

Hone says it simply wouldn't have worked any other way. "As a public sector employer there was a risk we would have got bogged down. As delivery partner, CLM could bring in the

November 2008 Sailing Venue complete – first London 2012 venue ready

March 2009 Construction starts on Velodrome

April 2009 Construction starts on Media Complex

July 2009 Construction starts on Handball Arena and White Water Canoe Centre

July 2009 First time trial of 'Javelin' train from St Pancras International arrives in 6 mins 45 secs

October 2009 Construction starts on Basketball Arena

December 2009 Stadium cable net roof lifted in place

April 2010 Velodrome cable net roof lifted in place and Aquatics Centre pools tested

Brownfield site: Location of the Olympic Stadium before work began

expertise as they needed it. There is no one magic bullet to explain the success of this project, but the early decisions were fundamental, including bringing in the delivery partner.

"We also resisted early thinking that we should be a thin client," he adds. "We staffed up so we could manage CLM, but also so we could give them a clear run at it. They are the programme manager and project manager and we can hold them accountable for that. But we are the people that deal with the government, the mayor, the local boroughs and a huge range of other important stakeholders."

This clarity of purpose is also evident through the procurement process. Infrastructure director Simon Wright who is now leading the ODA's Learning Legacy steering group that aims to ensure lessons learned from the Olympics are shared throughout the construction industry (see box) sums up good procurement strategy like this: "If you are talking procurement, it is about major clients taking appropriate risk, getting supply chain involvement early; the whole attribute that is loosely described as partnering; having a set of common objectives that are set out early and don't change; having contracts aligned with that set of common objectives; and then accepting that the contractor wants to make some money. Do all that and you have a team with an enlightened attitude to issues that occur; early warnings are raised and you have a fairly reasonable success in steering contracts to their conclusion," he says.

Getting the procurement right was also vital in simply getting contractors interested in the work. "Back in 2006 the industry was incredibly buoyant and not interested in the Olympics," explains construction director Howard Shiplee, who headed up the ODA's public procurement exercise. "Contractors were quite clear: 'we're very busy, your budgets are a matter of public discussion, and you're always in the media. We don't need that hassle'."

"There is no one magic bullet to explain the success of this project, but the early decisions were fundamental"
Dennis Hone, chief executive, ODA

Notably, the project attracted just one bidder for the Olympic Stadium – the Team McAlpine consortium that had just successfully delivered Arsenal's Emirates stadium.

"Our job was to go from there to being seen as a client of choice very quickly. By engaging with industry we largely achieved that and demonstrated UK plc delivering on time, under budget and building some iconic designs," says Shiplee.

Of course, Team McAlpine remained the only bidder for the Stadium – with the rest of the industry effectively scared off by its success on the Emirates – but competition was keen for the rest of the venues. And all have come in pretty much as expected.

"This has been a very efficient project and we are producing very high quality products as a function of how things rolled off the procurement process. We did not buy the cheapest price, but the best value.

"We allowed people to make a reasonable margin and we used the whole suite of NEC contracts with very few modifications. We absolutely did not change the spirit or the ethos. We combined teams, we had an early warning process and we set timescales to settle and resolve disputes," says Shiplee.

And it's worked: using a target price NEC contract the final account on the flagship Olympic Stadium is already settled, more than a year before the venue hosts the opening ceremony.

"We are clear we want to finish this, and are settling final accounts as work proceeds," says Shiplee.

"And we know they are getting settled down the supply chain, because we are checking."

That's not to say there have not been big risks. Now long forgotten by most, four years ago the Olympic Park

June 2010 Start of Olympic Park planting and Eton Manor construction

August 2010 First Olympic Park flower meadows come into bloom

December 2010 White Water Canoe Centre complete

January 2011 Construction starts on Water Polo venue

January 2011 Velodrome complete

March 2011 Olympic Stadium complete

April 2011 White Water Canoe Centre opens to public

May 2011 Handball Arena complete

"We are clear that we want to finish this and we are settling final accounts as work proceeds"
Howard Shiplee, ODA

was not a park – it was a part-derelict, part-industrial badland, criss-crossed by roads, railways, power lines and a bunch of polluted watercourses.

Remediating 800,000m³ of soil, burying the power lines in two 6km long tunnels, bridging the roads and railways with 120 new or refurbished structures, cleaning up the rivers, and building the Park's own bio-fuelled energy centre and water pumping stations was a massive challenge and one of the biggest risks to the whole project. In effect, 10 years of work had to be compressed into four.

"Remediation was seen as one of the biggest risks on the project because you are always concerned about what you might find," says Wright. "And we found some of pretty much all of it – low level radioactivity, unexploded ordnance, you name it.

"But that's what the team was there for – so that when we had unforeseen events we were able to deal with it." That team comprised ODA, CLM, designer Atkins, contractors Bam Nuttall and Morrison Construction and a whole range of Tier 2 contractors.

It worked, and the project has blazed a trail on the sustainable agenda, says Wright. Ninety per cent of demolition waste has been reused, over 80% of all earthworks has been processed, treated and redistributed on site – and, with more than 1M.m³ out of the 3M.m³ excavated needing environmental treatment, that's some figure.

But the infrastructure challenges didn't end there – there was also the small matter of creating a network of roads, paths and bridges within the Park that can move millions of people around during the Games but also be sustainable, long-term links post-Games.

"We always had this philosophy to design for legacy and make the Games work," says Wright. "If you think of it like that, it's a more straightforward process to get right."

Throw in the letting of a DBFO deal for the Park's Energy Centre and the construction of Britain's first significant black water treatment plant (the treated wastewater is used for irrigation) in joint venture with Thames Water, and that's infrastructure done.

Since then the Park has seen four years of intensive construction activity with more than 30,000 workers employed so far. Yet nothing has been compromised: no-one has been killed (the industry average would suggest four or five should have been by now) and the accident frequency rate across the Park is 0.11 against an industry average of 0.75. So far over 426 apprentices have worked on the project, exceeding the ODA's target of 350, and more than 1,400 previously unemployed people have been placed into work.

Now, with one year to go, the design vision first seeded seven and a half years ago is beginning to be realised. "The thing we should be most proud of is the attention to detail and how it has all come together," says design and regeneration director Alison Nimmo, the longest serving member of the senior team, having actually been in Singapore when Jacques Rogge announced London's selection.

"Everyone forgets what this place was, and if you look back at some of the old photos a lot of the big decisions and big challenges were in those early years, but it is now amazing to walk around and see the strength of the overall design starting to come through and to get a sense of place.

"What we have done will change this part of London for generations to come."

Learning Legacy

The construction of the London 2012 Olympic Park and the off-Park venues has been a truly exemplar project, something that the whole construction industry could, and should, learn from.

As ODA chairman John Armitt puts it: "The British construction industry is the best in the world. Based on this project, I would find it hard pressed to say it isn't.

"Our architects, designers and contractors are very highly regarded, and people will be looking at them and our cost consultants and QSs as something they want."

But Armitt and the rest of the Olympic team are not making it a closed shop; they want the entire British construction industry to benefit, and intend to make this possible through a learning legacy website, due to be launched at the ICE in October. It will have best practice guides, case studies, technical reports, research documents and a whole raft of information provided by the project teams to allow others to learn and emulate what has been achieved on the Olympics.

"It is important to capture what has been done – the good and the bad – and then share it for the good of the profession," says Simon Wright, ODA infrastructure director and the man now charged with the learning legacy project. "Everything that is going live has been peer reviewed and together it forms a comprehensive library."

Given that much of what has been good about the Olympics has already been seized on by government for use in other major programmes, there is much to be gleaned.

"This project has set some real initiatives running," says Wright. "Yes, the government has major public sector constraints, particularly on funding, but our contention is that most of the things we've done – whether its about good procurement, or pressing for top health and safety performance – go hand in hand with best value."

75%
Proportion of budget spent on legacy

£9.3bn
Games budget

"Remediation was seen as one of the biggest risks on the project because you are always concerned about what you might find"
Simon Wright, infrastructure director, ODA

June 2011 Basketball Arena complete	**July 2011** Aquatics Centre and Media Complex complete	**Late 2011** All Athletes' Village accommodation blocks complete	**Spring 2012** Eton Manor and Water Polo venue complete	**July 2012** Olympic Games Opening Ceremony	**August 2012** Olympic Games Closing Ceremony and Paralympic Games Opening Ceremony	**September 2012** Paralympic Games Closing Ceremony	FINISH 2012	LEGACY BEGINS

Stunning and sustainable stadium

Olympic Stadium

The Olympic Stadium will host the athletics and Paralympic athletics events, as well as the opening and closing ceremonies.

It is located in the south of the Olympic Park on an "island" surrounded by waterways on three sides, which spectators will cross using five bridges.

The stadium will have a capacity of 80,000 during the Games: 25,000 seats in its permanent lower tier, and a temporary lightweight steel and concrete upper tier holding 55,000 spectators, which can be removed after the Games.

Facilities for athletes include changing rooms, medical support and an 80m warm-up track. Spectator services, refreshments and merchandise outlets are located outside the arena on a podium surrounding the stadium.

It is the most sustainable Olympic stadium ever built, containing 10,000t of steel – 75% less than most other stadiums. It also features low carbon concrete, made from industrial waste and containing 40% less embodied carbon than traditional concrete. The top ring of the stadium was built using surplus gas pipes.

The stadium is elliptical, with a long axis of 315m and a short axis of 256m. It reaches a maximum height of 60m above the field of play and has a perimeter of 860m.

The 80,000 spectator seats are fixed onto 12,000 precast concrete terrace units, supported by 112 steel raking beams.

Athletics is particularly sensitive to wind conditions: records only stand if there is less than a 2m/s tailwind, while strong crosswinds or headwinds makes it harder for athletes to reach peak speeds.

So it is really important that wind speeds are kept below this threshold, and at an early stage in the design, computation fluid dynamic modelling was undertaken on various roof options to establish the optimum wind performance level.

The optimum design turned out to

"The design and procurement operation was with us procuring major early subcontract packages"
Tony Aikenhead, Sir Robert McAlpine

Efficient structure: The stadium roof is supported from a compression truss running around its perimeter

be a roof that covered approximately two thirds of the spectators' seats. Different support solutions were investigated, including cantilevers, but the amount of roof cover and the elliptical shape of the seating bowl allowed the design team to consider a "bicycle-wheel" roof, which can be extremely efficient in terms of the materials used and the economics.

The design developed with a truss around the perimeter of the stadium, which is pulled into compression by a ring of cables at the inner edge of the roof, and radial cables between the compression truss and the inner ring, all of which are in tension. The overall "wheel" of the roof is in equilibrium and simply needs to be supported from below with any rotation resisted; which is why the columns that support the compression truss are angled in section and elevation.

The compression truss is made up of 28 steel sections, each 15m high, 30m long and weighing 85t.

The 25,000m² roof covering is made of 112 pre-shaped PVC-coated polyester fabric panels, approximately 1mm thick, which are clipped to the cables and tensioned into their final 3D form. They were fitted by a team of 23 abseilers.

To ensure that the action is illuminated to high definition TV standards, the stadium is lit by 532 floodlights housed in 14 towers, each 28m high and weighing 34t. They were lifted into place by a 650t crane over a period of 14 days in March 2010.

The stadium was designed to be flexible enough to accommodate a number of different requirements and capacities in legacy. In February 2011 the Olympic Park Legacy Committee selected West Ham United of the English Premier League as the preferred bidder to assume ownership of the stadium after the Games.

Q&A: Philip Johnson, lead architect, Populous

How did you approach the job of designing the venue?
The Stadium has been designed to ensure that the legacy and post-games use were considered from the outset. The brief also required that the environmental impact of these games would be seriously considered throughout the whole process to realise a more sustainable approach to hosting the Games.

What are you most proud of?
As well as the significant sustainability achievements of the project, I am particularly pleased with how we believe the stadium will perform for ordinary spectators. The experience of arrival onto the venue "island", through the "wrap" enclosure into the spectacular but compact seating bowl will be very memorable and hopefully quite breathtaking. The views to the field of play are excellent and the stadium feels surprisingly intimate.

Which Olympic event would you most like to watch?
As a fan of the athletes that compete in multisport events at the highest level, I would love to see Jessica Ennis win Olympic Gold in the Heptathlon.

"Typically it would take around one and a half years to get from end concept to start of construction, but with the stadium we achieved this in just over six months"
Tony Aikenhead, project director, Sir Robert McAlpine

800k
Tonnes of soil taken away to create the construction platform - enough to fill the Royal Albert Hall nine times over

11km
Of drainage

360
Rolls of turf grown in Scunthorpe and laid in three days in March 2011

50km
The seats lined side by side

Q&A Tony Aikenhead, project director, Sir Robert McAlpine

How did you build the Olympic Stadium?
We began Stage C concept design in June 2007 and by April 2008 had secured the first stage planning approval on behalf of the Olympic Delivery Authority (ODA). Permanent piling started in May 2008.

Typically, with a project of this nature and complexity, it would take around one and a half years to get from end concept to start of construction, but with the stadium we achieved this in just over six months. Design and procurement was fast tracked, with us procuring major early subcontract packages – such as Byrne Brothers for the concrete, Tarmac for precast terracing and steelwork contractor Watson Steel – at the end of concept design. Crucially we had the confidence in our design team, the McAlpine management team and our supply chain to back our ability to control the design development, cost risk, technical challenges and programme surety.

To meet the client brief around demountability we implemented a significant amount of prefabrication of concrete and steel elements. The early design and procurement, plus prefabrication, resulted in the stadium structure up to the roof compression truss being completed

Centrepiece: The Olympic Stadium with the red Arcelor Mittal sculpture taking shape to the right

PROJECT TEAM

Main contractor: Sir Robert McAlpine

Architect: Populous

Engineering design: Buro Happold

Structural Steelwork: Watson Steel

Concrete: Byrne Brothers

Precast terraces: Tarmac

"When you're passionate about sport, and design sports venues for a living, an Olympic Games in your own city is tremendously special"
Paul Westbury, CEO, Buro Happold

within 14 months.

By June 2010 the bowl work was substantially complete, the cable net roof and fabric were complete and fit-out works were well advanced in the west and south stands.

Landscaping and external works continued unabated, with this being the area where we enjoyed the most interaction with others working on the Olympic Park.

We were faced with a number of challenges in terms of the high targets set by the ODA around its priority themes of sustainability, carbon emissions, waste segregation, equality and inclusion, recycled content and potable water reduction. The bar had been significantly raised at the Stadium, in comparison with other major projects, but I'm delighted that we met or exceeded all of these targets.

In particular, the sustainability successes were significant. The embodied energy consumed in manufacturing the stadium's elements was significantly lower than previous Olympic stadiums due to the compact design, and Watson Steel scored a big success by re-using unwanted gas pipeline found in a yard in Yorkshire.

The project has been exemplary, demonstrating collaborative working not only within our own design and construction team but also with our client and their stakeholders. Our engagement with the workforce resulted in us all pushing the boundaries of health, safety and environmental performance.

What are you most proud of?
The fact that the Stadium was handed over two months ahead of time and within budget and quality, with an exemplary health, safety and environmental record. I'm extremely proud that we were able to design and construct the first modern day Olympic stadium without the loss of a single life or a serious accident.

What was the most significant date/event on the job and why?
Other than the completion date?! The "Lights on!" event last December, which signified that all that had gone before had gone well and we were on track for completion under the lights of the Olympic Stadium, and the world's media.

Which Olympic event would you most like to take part in?
Men's javelin final!

Q&A: Paul Westbury, CEO, Buro Happold

How did you approach the project?
For me personally there's not much you can do to best an Olympic stadium in your own back yard, and our target was very much to win the design competition for the stadium.

When you're passionate about sport, and design sports venues for a living, an Olympic Games in your own city is tremendously special.

When the ODA went for team commissions I knew we just needed to get the old gang together. The three of us [Buro Happold, Populous, Sir Robert McAlpine] had just come off the back of the Emirates [stadium], and the ODA was well aware of our team's credentials.

It went back to the early days of the Dome, so teamworking and relationships were very strong.

The brief was very hard because the Stadium had to have the unprecedented capability to change its capacity to

something significantly more modest, and with some pretty big financial constraints.

It was a wonderful opportunity to design a building on an Olympic scale in a very tight site, which was constrained both in the air and on the ground. It needed a very compact solution that was temporary but still looks fantastic and spectacular.

The building is designed in a completely different way to any previous venue of this significance. The bit that costs so much money is not the number of seats, but all the things you put in to support the number of seats – things like the media facilities, toilets and food concessions.

We stripped out everything you traditionally see to support a building like this and put it onto the island in temporary accommodation.

As a result, the stadium becomes a pretty skeletal building that is significantly cheaper and faster to build and far less complex.

What was your biggest challenge?
The challenge was to not go down route one – a bland, simple, rectilinear, steel-framed, clad solution filled with temporary terraces that looks temporary and feels temporary. I'm delighted that we put so much effort into it.

It is functionally correct, it looks great, was buildable and was built to a very tight budget.

What are you most proud of?
There was a certain level of achievement when we handed over the keys and we'd done something that is very, very different after Beijing.

In recent history the Olympics had become something that costs cities tremendously dear.

If you get these things wrong, it costs the city and the country a huge amount of money.

This should be about the athletes and about human endeavour, and not about building huge buildings.

We have delivered similar capacity, but with a fraction of the materials, and we are thinking more appropriately of the event and the legacy of what comes next.

> **"There have been many challenges, but underpinning them all was the fixed deadline"**
> Ian Crockford, ODA

Q&A: Ian Crockford, project sponsor, ODA

What was your biggest challenge?
There have been many challenges, but underpinning them all was the fixed deadline.

The start of the Games was never going to move, so we always had that at the forefront of our minds. But it also ensured that everyone was focused and pulling in the right direction.

The site itself was a huge challenge at the start of the project. It is very compact and surrounded by water on three sides, so we had to design a very compact venue to fit on the island site.

Plus the area was neglected and contaminated, and we had to demolish 33 buildings and take away over 800,000t of soil before construction could begin.

Which Olympic event would you most like to watch?
I am a keen swimmer, so to see the 1,500m swum in circa 15 minutes is always a thrill to me – I am more than 10 minutes off that pace!

16ha
The area the Olympic Stadium site covers, it is 62.7m high – half the size of the London Eye and the equivalent to the central span of Tower Bridge

56
Vomitories, entry points for spectator access to seating areas

80k
Capacity of stadium

32
Separate buildings at podium level house spectator toilets covering 4,610m²

Taking shape: The Stadium bowl rises from the ground

Swim in a sweeping wave of success

Aquatics Centre

The Zaha Hadid-designed Aquatics Centre is located in the south of the Olympic Park and will be the main "gateway into the Games".

It will host swimming, diving, synchronised swimming, water polo finals and the swimming discipline of the modern pentathlon.

It will have a capacity of 17,500 during the Games, reducing in legacy to a maximum of 2,500, with the ability to add 1,000 for major events. The capacity is boosted during the Games using two temporary seating stands either side of the roof.

Inside the centre are two 50m

"The team has delivered a unique building with by far the most unique field of play on the Olympic park"
Ian Crockford, project sponsor, ODA

Flying fish: The sweeping, wave shaped roof is embraced by two massive temporary stands that will boost spectator capacity to 17,500

swimming pools with moveable floors and separator booms, a diving pool and dry diving area.

The sweeping wave-shaped roof, is 160m long and 80m wide at its widest point.

It is an innovative steel structure weighing over 3,000t and resting on three supports, with a striking and robust aluminium covering, half of which is recycled.

The curved ceiling is formed from over 30,000 sections of sustainably sourced Red Lauro timber, and sweeps outside the venue and around the external roof supports.

A 250m long, 45m wide land bridge, which forms the main entrance to the Olympic Park, spans the Aquatics Centre and forms the roof of the training pool.

Following five months of laboratory and on-site trials, the distinctive and unique Zaha Hadid-designed curved 462t concrete six-board dive tower was built using reinforced plastic moulds, computer cut from a 3D model, around a skeleton of steel bars.

Q&A: Ian Crockford, project sponsor, ODA

What was your biggest challenge?
The biggest challenge has been successfully designing, engineering and delivering a venue that is capable of being the second highest capacity venue on the Olympic Park during the Games and converting to the smallest capacity venue on the Park in legacy.

Achieving this unprecedented transformation, while retaining the core elements of the unique original competition design, and focusing the investment in the permanent legacy building, is a testament to the world-class team designing and delivering the Aquatics Centre.

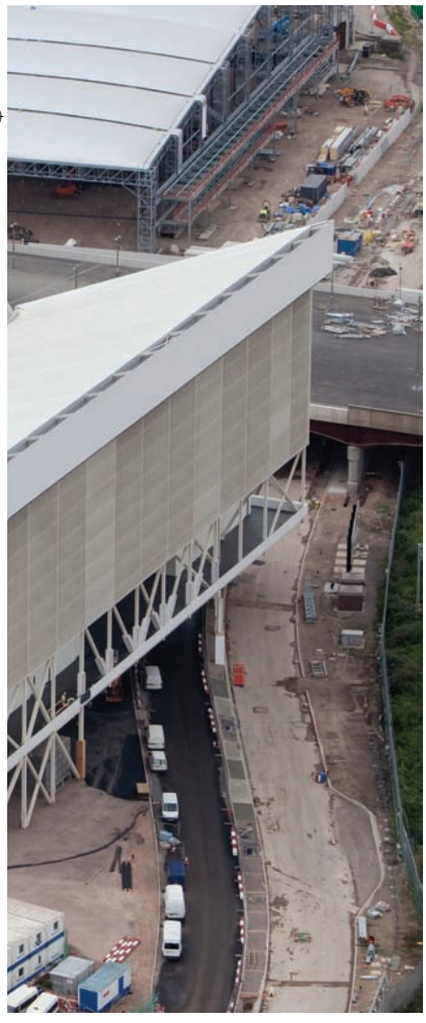
What are you most proud of?
Delivering together and safely. It has been a long and hard road and together the team has kept its sights on the destination and has delivered a unique and complex building, with by far the most complex field of play on the Olympic Park, some of the greatest engineering and construction challenges, and an outstanding health and safety record.

What does sustainability mean to you in the context of this venue?
Alongside the use of recycled, recyclable and other sustainable materials and innovations – such as the reuse of pool water to flush the loos – the most powerful sustainability measure for the venue is its legacy. The focus of the investment is in the permanent building, and the use of cost efficient and recyclable temporary seating stands to boost games-time capacity, as well as designing to reduce long-term maintenance costs. Building in the moveable floors, separation booms, dry diving-areas and a variety of changing rooms before the Games to create the flexibility and functionality that will ensure that the pool is busy and well used by a whole range of local people and elite swimmers after the Games.

Q&A: Stuart Fraser, project director Balfour Beatty

How did you build the Aquatics Centre?
We knew from an engineering perspective that this building was going to be extremely challenging, and it's a credit to everyone here that it was delivered on time.

The main difficulty was that, because of the complexity of the



10M.l
Of water in three tanks.

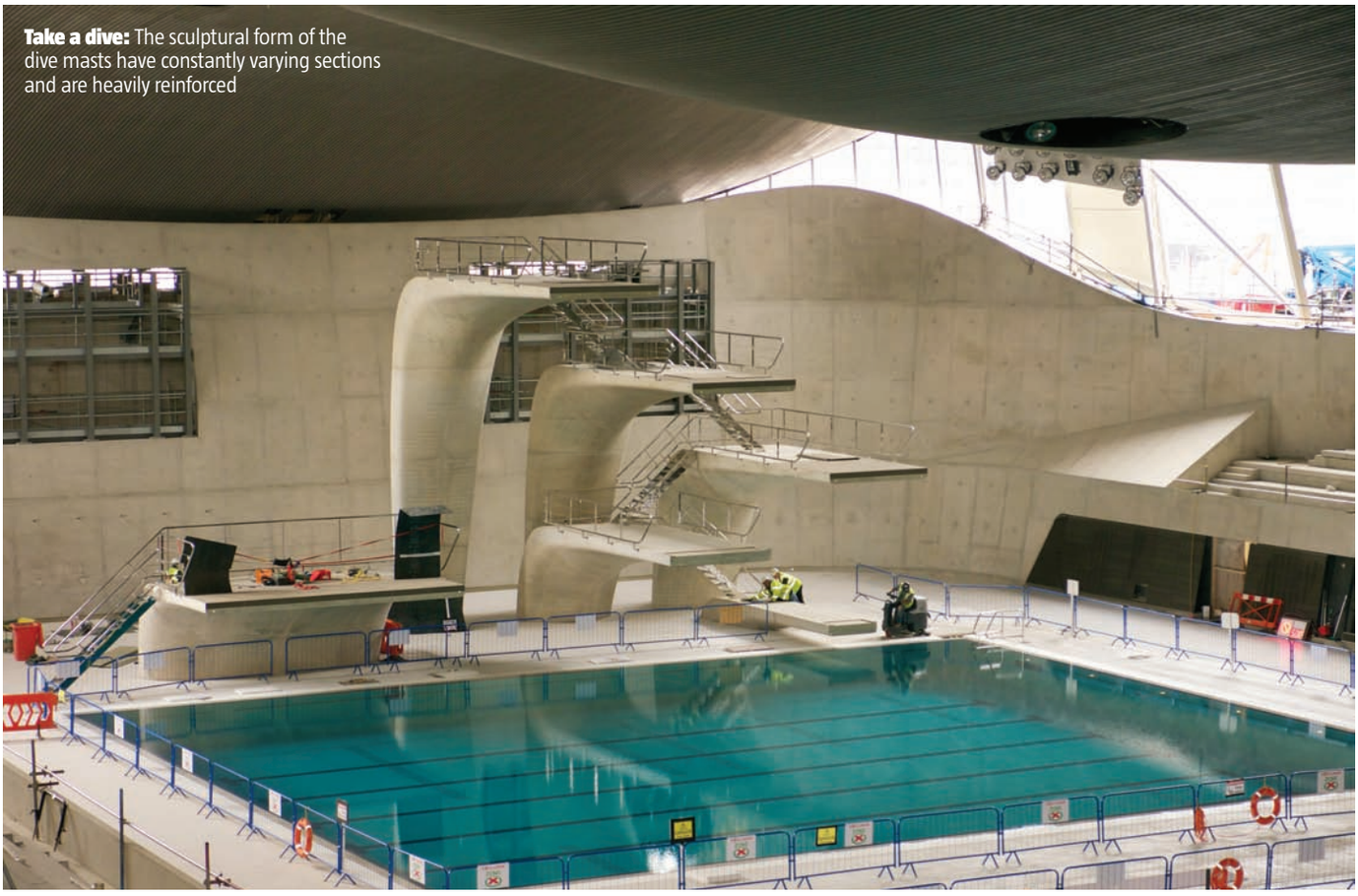
3,200t
Weight of roof structure

4
Skeletons discovered and removed from a prehistoric settlement on the site

"We knew from an engineering perspective that this building was going to be extremely challenging"
Stuart Fraser, project director, Balfour Beatty

Still waters: A swimmer's eye view of the Olympic Pool

Legacy: How the centre will look after the games



Take a dive: The sculptural form of the dive masts have constantly varying sections and are heavily reinforced

building, the programme has been linear. We had a period of nine months to prepare the foundations for the structural steel, then we worked on the roof structure for nine months, and while we were doing that we couldn't do anything else. Only in November 2009 could we start building the main structure and the pool tanks. Until they were done we couldn't do the seating.

On major projects you usually have some flexibility, but we genuinely could not start the pool tanks until the roof was up. We worked with the architects to improve the performance of the temporary stands. We came up with a steel structure that is fully demountable and can be reused elsewhere.

Beneath the building there are massive transfer structures over the cable tunnels. There is a tunnel directly below one of the roof cores, so we used CFA piling from a very low level for the foundations.

One of the major challenges was the roof, which spans 120m. When we were appointed there was still a lot to do in terms of the detailed design, and working out how to construct it properly. We took lot of time to make sure roof structure was correct, for example the quality of the steel and the welding.

That put pressure on the reinforced concrete structure, which has an amazing 3D shape. The venue has an amazing reinforced concrete structure and the majority of the high quality finish comes from a complex shutter design made by Peri.

The big challenge with the shutters was around the quality and consistency of the concrete. It was very much like baking a cake and finding the perfect mix and took a lot of samples to get it right.

This was the first time I've used self-compacting concrete, and it is a completely different process, because you pump from the bottom.

We used it for the dive towers as well. There's a tremendous elegance and serenity about those structures.

Precision is everything in a venue where world records could be set – the pool really needs to be exactly 50m. The pools are concrete tanks with render applied to the surface, then tiles. Now that it is finished you can see how amazing the building is. Looking back across the pool tanks towards the dive towers is remarkable – it's such an enormous chasm of space. I'm so proud of it.

"On major projects you usually have some flexibility, but we genuinely could not start the pool tanks until the roof was up."
Stuart Fraser, project director, Balfour Beatty

PROJECT TEAM

Architect: Zaha Hadid

Engineering design: Arup

Contractor: Balfour Beatty

Roof covering: Kalzip

Readymix concrete: London Concrete

Engineering design software: Oasys

Drainage software: Microdrainage

Steel frame: Rowecord Engineering, Watson Steel

What was your biggest challenge?
On reflection, thinking through the detailed design and the erection method for the roof structure was probably the most important challenge. The second was recovering from some of the delays that occurred around the roof construction in 2009.

What are you most proud of?
Having done something so technically challenging with a great team of people – suppliers and the design team – and an extremely enlightened client. They've been set some tough challenges, they set us come tough challenges and we've delivered. It's been the complete all round job. Nobody wants to look back and say we could've done it better – and I don't think we could.

What was the most significant date on the project?
18 October 2009, when we strand jacked the roof.
Which Olympic event would you most like to watch or take part in?
I wouldn't want to take part in 10m diving but would love to watch Tom Daley doing it.

Q&A: Gordon Mungall, associate director, Arup and Philip Stevenson, lead structural engineer, Arup

How did you approach the job of designing the Aquatics Centre?
I think we all started with an understanding of how fortunate we were to be involved and influence the design of a signature building which assisted in winning the Olympics for the UK.

The venue will be the centre of attention to millions of people around the globe during the Games – which adds a certain level of pressure!

The Aquatics Centre is an iconic piece of architecture – its stunning, distinctive long-span roof was a major challenge for our design team, and we worked closely with Zaha Hadid to make sure the design could be delivered. Handling the complex geometry involved in the design for the main roof and the concrete building, we made extensive use of 3D modelling, with models shared across different specialisms.

> **"The venue could be the centre of attention to millions of people – which adds pressure!"**
> Arup design team

The starting part for the design was to determine the key constraints of the site in relation to the form of the new facility. The site's location and restrictions due to the existing railway, proposed adjacent road, below ground tunnels and realigned river quay wall – along with soft surface alluvium deposits and high ground/floodwater levels – all had to be understood and considered to determine the form of the key structural components.

What was your biggest challenge?
One of our greatest challenges was the need to fix the design of the cores that support the roof, so that the floors and the "bowl" of the entrance area (or welcome zone) could be constructed around them 18 months later.

They are 20m high free standing structures, which need to support the 3,000t roof structure.

We used temporary ties to help the cores resist the thrust from the roof arch, and also designed inclined core-capping slab bearing blocks to achieve this.

A 15,000t temporary tie was installed between the cores, just below the roof support positions.

A further challenge was the analysis and design of the dive masts. The constantly varying section required that we had to rewrite many of our software analysis and design tools to achieve the required solution while ensuring that it was technically achievable and constructible.

The biggest challenge for the substructure was to develop the foundations within a tight budget, and with the added challenge posed by underlying power tunnels.

We selected long-span transfer structures, utilising lightweight fill materials, together with state of the art soil structure interaction analysis, to overcome the technical challenges.

What are you most proud of?
The first thing that comes to mind is how the caps to the cores and the inclined bearing plinths came together in design, detailing and finally construction on site.

Similarly the dive masts: the evolution of the design and technical solutions, and then the development of reinforcement scheduling to allow their construction.

Then there is the complex geometry of the welcome zone bowl, the training pool roof which is also a road bridge, the sculptured roof over the external stair – I could go on!

Making an entrance: Spectators coming into the Park will sweep past the Aquatics Centre on their way to the main stadium

200m
Length of the building, the second largest Olympic Park venue

17,500
Capacity during the Games reducing in legacy to a maximum of 2,500, with the ability to add 1,000 for major events

1,600t
Weight of steel in temporary seating stands

Tracking the Velodrome

Velodrome

The 6,000-seat Velodrome sits in the north of the Olympic Park and has a 250m indoor cycling track that has been designed to be the world's fastest. After the Games, the legacy Velodrome will be the main hub within a VeloPark that also includes a BMX track, a one mile road circuit and over 7km of mountain bike trails, used by elite athletes and the local community.

The Velodrome has a distinct double-curved roof designed to reflect the geometry of the cycling track. Not only does this create a striking piece of architecture in the north of the Olympic Park, but the lightweight double curving cable net structure is also extremely efficient, helping make the Velodrome the most sustainable Olympic Park venue.

The design team of Hopkins Architects and structural engineer Expedition says the concept for the Velodrome was inspired by cycling: "The bike is an ingenious ergonomic object, honed to unrivalled efficiency. We wanted the same application of design creativity and engineering rigour that goes into the design and manufacture of the bike to manifest itself in the building – not as a mimicry of the bicycle but as a three dimensional response to the functional requirements of the stadium."

A striking double curved roof shape evolved as the form that would best answer the needs of the stadium, but simultaneously provided the biggest challenges – particularly when it came to the roof, and the choice of a cable net, which lent itself well to the form and 130m span, while providing programme and construction safety advantages.

Typical cable nets support lightweight fabric and work like a tennis racquet, using a grid of cables in tension with a large compression ring at the perimeter to isolate the net's tension forces.

The Velodrome cable net is not typical, and presented two major challenges: the indoor venue needed a weathertight, heavily insulated roof (the building exceeds Part L 2006 thermal requirements by 30%); and the graceful lines of the building form — combined with the desire to reduce steel usage – required a roof design without a large perimeter ring beam.

High tension forces in the cables were resolved by engaging the whole of the stadium bowl structure below to avoid a chunky ring beam.

The wider design and construction team was involved in designing the steelwork bowl – which not only transferred the cable forces, but also supported stadium seating, housed M&E plant and carried the façade. This approach is unusual, as the roof is traditionally designed as a separate, self-contained object perched on the seating structure.

By integrating roof and bowl, the Velodrome takes full advantage of the structural and material efficiencies that come from the geometrical strength and stiffness inherent in the curved track and seating.

For the design team, however, the cross-relationships between roof and seating bowl generated complex

Curved air: The timber-clad Velodrome has a lightweight cable net roof that helps make it the most sustainable permanent venue in the Park

PROJECT TEAM

Architect: Hopkins Architects

Engineering design: Expedition

Contractor: ISG

Steelwork: Watson Steel

Concrete: FDL

Piling: Rock & Alluvium

Cladding/Roof Cassettes: Wood Newton

Track design: Ron Webb

Cable net roof detailed design: Schlaich Bergmann

Cable net contractor: Pfeiffer

"We built the Velodrome like a clock – starting at 12, with one crew going in each direction"
Tim Sullivan, design manager, ISG

1.2M
Working hours

1,000
Timber cassettes

94%
Of construction waste reused or recycled

15km
Of roof cables

structural responses that proved "educational".

Q&A: Tim Sullivan, design manager, ISG

How did you build the Velodrome?
We started working with the designers in June 2008, when we got the Stage C design report – which consisted of six drawings. When Stage D was issued we had to get to an initial tender price, then, when E/F came out, we had to agree the final price – which could not be more than Stage D.

The Olympic Delivery Authority (ODA) wanted a collaborative approach; they wanted early contractor involvement, and access to our supply chain. For us that was brilliant – we could help the designers by bringing our supply chain to them, and influence them to help us build it sustainably and to the client's budget.

We said we wanted to finish a year – even 18 months – before the Games, and we've actually beaten our own initial programme. The Velodrome is one of the "big five" venues; it was the one of last of these to start and the first to finish, and is the most sustainable. The programme was 118 weeks, including pre-construction. That was one of the benefits of getting involved early – we were appointed in June 2008,

"We wanted to finish a year before the Games and we've beaten our programme"
Tim Sullivan, design manager, ISG

and the ODA wanted us on site in February 2009, so we had time to plan and get it right.

We built the Velodrome like a clock – starting at 12, with one crew going in each direction. The structure has huge pile caps, and on every cap there is a truss that varies in height to take on the geometry of the building.

The terracing is precast, but every single unit is more or less different, so all of the shutters were done in timber.

We said from the start that it was all about the track, and we had to look at ways of getting the roof on as quickly as possible so we could focus on the track. The design team had a desire to investigate a cable net roof, but it hadn't been done before on this scale in the UK. When we started working collaboratively with the design team we looked at various options, including a cable net going one way, a cable net going two ways, and steelwork – and we did programme, cost, sustainability and materials analysis of all the options. We recommended that the ODA and CLM go for the cable option, which could cut the programme from 118 to 95 weeks and still allow the venue to be built on budget.

The roof net is formed of two 36mm diameter cables connected together by a node. We had to order the cables one year in advance, because 15km of cable does not just come off the shelf. When the time came, we lifted the roof in 40 minutes. The success of this project can be put down to a number of things, and the cable net roof is definitely one of them.

The whole idea of off-site manufacture was big for us – for example using driven piles, precast terracing, roof

High speed: Conditions inside the Velodrome have been designed to produce world records

"The design team's aim was to reflect the efficient design of a bicycle"
Richard Arnold
project manager, ODA

23
Months to construct

panels, rooflights and cladding panels that could be made months before we needed them. Because we had a long lead-in period we could procure a lot of elements knowing that when we needed them they would be there.

We did a lot of things on this job that we haven't done before when it came to workforce management. In the site canteen we gave the operatives access to the internet and Sky TV on plasma screens – with time off to watch England World Cup matches. With two years to go, Sir Chris Hoy came to ride round the track. That was very special.

What was your biggest challenge?
The cable net roof.

What was the most significant date?
The day the roof went up.

Which Olympic event would you most like to watch/take part in?
Table tennis – I used to play as a kid.

Q&A: Richard Arnold, project manager, ODA

What was your biggest challenge?
Sorting out the design and deliverability of the legacy VeloPark that met all of the aspirations of British Cycling and local cycling groups. Initially we met with opposition.

But by working with the various parties and changing the layout of the road circuit and mountain bike trails we were able to achieve a solution that the key stakeholders were delighted with and will provide a fantastic facility after the Games.

What are you most proud of?
Working with a group of very talented professionals that have delivered the best venue on the Olympic Park.

What does sustainability mean to you in the context of this venue?
From the early part of the Velodrome project, the design team's aim was to create a lightweight and efficient venue to reflect the efficient design of a bicycle, so sustainability has always been at the heart of the project. The lightweight cable net roof, water saving fittings and collection of rainwater, the use of abundant daylight and almost entirely natural ventilation, have helped create a highly efficient building and one of the most sustainable venues on the Park.

Which Olympic event would you most like to watch and/or take part in?
Unsurprisingly, it's watching track cycling in the Velodrome.

Q&A: Ruth Hopgood-Oates, Andrew Weir, Ed McCann and Chris Wise (Expedition) with input from Chris Bannister (Hopkins)

What are you most proud of?
The Velodrome is a great example of collaboration and has set the standard for a new generation of buildings that are beautiful, good value, buildable and blaze a trail in sustainability.

As ever, the proof is in the pudding. Olympic gold medallist Sir Chris Hoy described the Velodrome as "magnificent – better even than it looked on the drawing board". A response like that makes us proud.

Which Olympic event would you most like to watch or take part in?
Most of our team are cycling fans, and even the ones that aren't have been caught up in the buzz surrounding the Velo Park. I think we'd all love to see Victoria Pendleton or Sir Chris Hoy doing a sprint finish to win gold.

Creating a new landscape

Olympic Park

When the International Olympic Committee announced that London had won the right to stage the 2012 Games, the site earmarked for the Olympic Park was still occupied by a myriad of businesses housed in almost 200 buildings.

The full legacy of centuries of industrial activity on the site was not fully understood; and the detailed planning process was just getting underway. And yet, the London organising committee had promised to deliver the most sustainable Games ever.

Since then, the site has been transformed. Gone is the dereliction, and in its place is a 246ha parkland criss-crossed by new roads and bridges, threaded through with waterways, and alive with trees, plants and wildlife habitats.

The ODA has managed this transformation, appointing Atkins as the project manager, and dividing the main contracts up into three tranches – remediation, bridges and highways, and landscaping – as well as procuring a green "energy centre" and moving power lines underground.

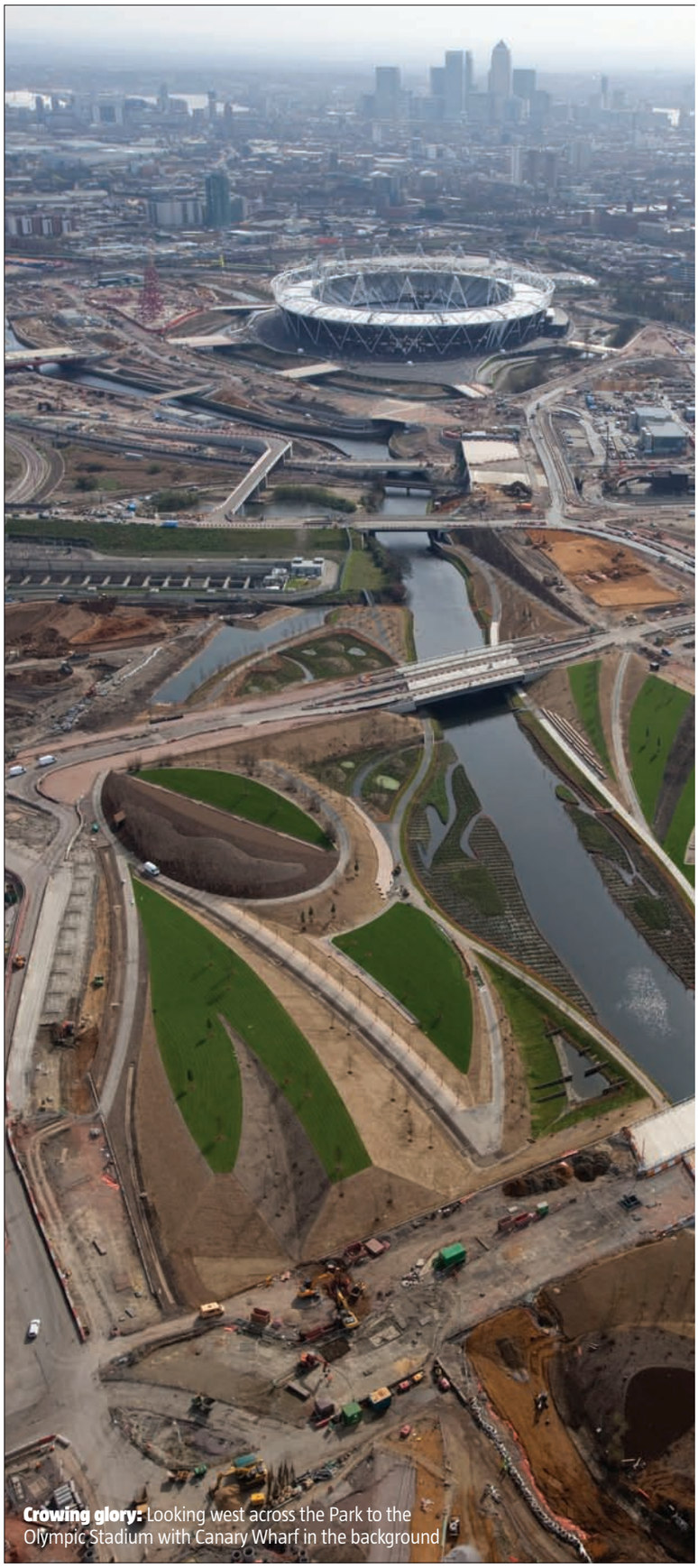
Q&A: Simon Wright, director of infrastructure and utilities, ODA

What was your biggest challenge?
The initial challenge was to pin down the baseline scope and budget. Securing the very significant private sector finance in the combined cooling heat and power plant and the other utility concession contracts was also a great milestone. The legal negotiations leading towards closing these deals were tortuous but ultimately successful, I am pleased to say.

What are you most proud of?
Most attention is, quite naturally, on the venues, but the completion of the contaminated land treatment, infrastructure and utilities has provided the backbone for not only the Olympic and Paralympic Games but also for the future legacy development.

I am particularly proud that we managed to design the works to provide for both phases with only

"Most attention is on the venues, but completion of the land treatment, infrastructure and utilities has provided the backbone"
Simon Wright, infrastructure and utilities director, ODA



Crowing glory: Looking west across the Park to the Olympic Stadium with Canary Wharf in the background

In bloom: Trees blossoming in the Parklands area of the Olympic Park

Winning through: Trials proved that planting in coir matting would be best

2.1M.t

Contaminated soil cleaned

2,700

Number of boreholes, trial pits and window samples

"The design of the utility works was central to reducing carbon emissions by 50% and reducing potable water use by 40%"
Simon Wright, infrastructure and utilities director, ODA

PROJECT TEAM

Project manager/designer: Atkins

Remediation contractors: Morrison Construction (North Park), BAM Nuttall (South Park)

Bridges and Highways contractors: Skanska (Lot 1), BAM Nuttall (Lot 2), Balfour Beatty (Lots 3 & 4)

Landscaping and Public Realm contractors: BAM Nuttall (North Park), Skanska (South Park)

Aggregate supply: Aggregate Industries

Engineering data management: Bentley ProjectWise

minor modifications post Games, so the investment only needs to be made once.

What does sustainability mean to you in the context of the Park?
There were many aspects of the infrastructure works which were vital to the achievement of the sustainability targets. The design of the utility works was clearly central to the reduction in carbon emissions by 50% and reduction in consumption of potable water by 40%.

Another central element was the reuse of demolition waste within the follow-on works. Less than 5% of all demolition waste was taken off the site, and the vast majority of treated contaminated soil was re-used on the park following soil washing.

Which Olympic event would you most like to watch and/or take part in?
I love all sport, so it is difficult to choose. I was lucky enough to see the 100m final in Beijing in 2008, so that evening will take some beating, but I would love to see some of the finals in the Velodrome. The venue is absolutely spectacular and the atmosphere, I am sure, will be electric. To be honest I would be delighted to see any event!

REMEDIATION

Before any of the new venues could be built the Olympic Park had to be transformed from a polluted, post-industrial wasteland into a clean, clear site ready for construction. This involved demolishing 190 buildings, relocating four buildings in their entirety, 2,700 boreholes, trial pits and window samples, and treating more than 2M.t of contaminated soil.

The sustainable element of London's Olympic vision included keeping as much material on site as possible, and remediating it on site for re-use. For the demolition the ODA set a target that 90% of materials should be reclaimed, and on the remediation side the team committed to keeping 80% of soil on site.

In the end, 98% of demolition materials were recovered, and the challenging clean-up targets were also met.

As the consultant managing the enabling works, Atkins has acted as project manager and designer for the remediation, which was split into two

First aid: A 'soil hospital' was set up to clean the most contaminated soil

contracts, with Bam Nuttall carrying out the work in the south of the Park and Morrison Construction in the north. Both firms used a variety of techniques, including bioremediation, soil washing, chemical and geotechnical stabilisation.

Q&A: Richard Prime, project director, Bam Nuttall

How did you approach the remediation of the South Park?
We commenced demolition and remediation in 2006. Our work included the main stadium remediation and earthworks, which comprised 460,000m³ of excavation and associated remediation in 20 winter weeks from November to March. We handed over to the stadium contractor three months ahead of programme.

In total we excavated 1.3M.m³ of spoil and placed 1.1M.m³ of fill to create the required landform.

We established two separate soil treatment plants and a treatment centre that included three soil washing plants with a combined capacity of 7,000m³ per week, treating a total of 620,000m³ of material. Also in the centre was a soil stabilisation plant with a capacity of 2,000m³ per week, which treated 30,000m³ in total, and bioremediation treatment beds that were used for 25,000m³of material.

In all, 620,000m³ of contaminated material in the south of the Park was treated for re-use on site, exceeding the ODA's 95% re-use target.

We also set up our own site laboratory to test soil samples, which gave a fast turnaround that speeded up the process of deciding on the right form of soil treatment.

BRIDGES AND HIGHWAYS

Before work started the Olympic Park site was made up of fragmented pockets of land, with poor connections between local communities.

The programme to build new structures, bridges and highways has created new connections across the Olympic Park that will leave an open and accessible area in legacy.

The infrastructure project was divided into a number of contract packages, which included the construction of more than 30 new bridges and underpasses.

The largest of these contracts went to Balfour Beatty, Skanska and Bam Nuttall. Skanska's contract in the north of the Park included 5km of roads, two land bridges, one road bridge and two underpasses, included Underpass U01, running beneath the busy A12, to connect the training area with the stadiums.

Skanska proposed and developed a scheme to construct the 50m long x 11.5m wide x 8.05m high underpass using jacked box techniques to minimise disruption to the main arterial route into London.

The 3,500t reinforced concrete box was constructed in three sections to the north of the A12 above a reinforced concrete jacking slab, which transferred the jacking force into a reaction wall. Jacks were located at the back of the box and at intermediate jacking stations at the joints, with a jacking capacity at each location in excess of 5,000t.

During the drive 5,000m³ of material was excavated, over 90% of which was mined mechanically using excavator-mounted rotary cutting heads.

The jacking phase took 28 days of 24-hour working, and the underpass was successfully manoeuvred to within 25mm of its design position with a maximum vertical displacement on surface of the A12 of 65mm.

The original scope of Bam Nuttall's roads and bridges contract included 5km of loop roads and their associated deep and shallow drainage networks, numerous outfalls, five permanent bridges across the waterways, one temporary bridge, an outer perimeter fence encapsulating the southern half of the Olympic Park, and a major underpass beneath the Northern Outfall Sewer Barrels.

Later additions to the contract included a bridge linking the Stadium and the warm-up track for the athletes, a temporary bridge that crosses Stratford High Street, and three more underpasses.

"This was a complex and challenging project, due to the interfaces with the waterways and the railways, as well as working adjacent to other contractors' boundaries," says Bam Nuttall project director Richard Prime , who adds that communication was vital to ensure that different contractors' programmes were aligned and work impacts well understood.

Balfour Beatty landed two major infrastructure contracts: Lot 3 – rail overbridges, which included three land bridges, two road bridges and retaining walls; and Lot 4 – the main stadium area bridges, which included one road bridge and four footbridges.

The contractor engaged consultant Tony Gee to design the six temporary bridges providing access to the Stadium and the Aquatics Centre, and the team decided to go for a simple, uniform design that would reduce the cost of deconstruction when the bridges come to be removed after

"This was a complex and challenging project, due to the interfaces with the waterways and the railways"
Richard Prime, project director Bam Nuttall

30
New bridges and underpasses were built for the Park

3,500t
Weight of one of an underpass which was jacked into position

45ha
Area of wildlife habitat created within the Olympic Park

the Olympics.

The template for the footbridges was a steelwork single span bridge supported on concrete pile caps over CFA piles, with some minor variations for different spans and heights. The steelwork is covered with easily removable precast concrete slabs and timber decking.

The spans are all around 43m, but widths range from 11 to 28m, and two of the footbridges had to take additional ambulance loading.

Q&A: Neil Farmer, executive director, Tony Gee and Partners

What was your biggest challenge?
Producing economical designs that could be built on a congested site close to other structures, whilst catering for the requirement of the Olympic Games and being suitable for incorporation within the post-Games transformation works.

What are you most proud of?
Producing designs that were not only functional but could be built safely, economically and maximised the use of recycled materials.

Which Olympic event would you most like to take part in ?
When golf is re-introduced into the summer Olympic Games in 2016, Tony Gee would love to represent Team GB. Unfortunately this day is a fair way off. So we'll save our strokes for a team event in the pool, where we've been helping prepare the roof for the last three years.

"The wet woodlands, ponds and river banks have advanced superbly over the last 12 months with very few plant failures"
Mike Vaughan, Atkins principal engineer

LANDSCAPING/PUBLIC REALM

When the Games are over, 101ha of the site will become the Queen Elizabeth Olympic Park – the largest new urban park in the UK for over a century.

The southern section is being turned into a "festival" park, with riverside gardens, wildflower display meadows and walking and cycle paths along restored and previously inaccessible waterways, as well as areas for markets, events, cafes and bars in legacy.

The north uses green techniques to manage flood and rainwater, and will provide quieter public space and habitats for existing and rare species, from kingfishers to otters.

Within this area a former landfill site has been remediated to create a wetland bowl with 15,000m² of riverside spectator lawns, timber seating, frog ponds, loggeries, wetlands, woodlands, tree-lined footpaths and the largest man-made wet woodland in the UK.

The Park will boast 4,000 new 4m-7m high semi-mature trees, over 2,000 of which have been grown in Hampshire and already planted. These include wild and bird cherry, ash, hazel, white willow, crack willow, alder, aspen, holm oak, English oak, rowan, lime, field maple, sweet gum and silver birch.

The Park has seen an extensive transformation in the last 12 months. Summer 2010 saw the installation of the wetland plants in the North Park – a project that wasn't without its challenges, according to Atkins principal engineer Mike Vaughan.

"The lack of rainfall throughout the summer created a tough environment for the immature plants, and the River Lee was being held at an artificially low level to accommodate other riverside works," he says. As a result the wetland features had to be irrigated every day.

Over the winter, however, the North Park wetlands have blossomed into a lush, dense environment, with common reeds standing nearly 2m tall – well beyond what designer Atkins had hoped for after only one year on site.

"The wet woodlands, ponds and river banks have advanced superbly over the last 12 months with very few plant failures, and the design has created a viable and sustainable habitat that will not only provide a backdrop for the Games but will form a lasting legacy beyond 2012," says Vaughan.

This year will see the rivers and wetlands adjacent to the Athletes Village and in the South Park being planted, including the 600m wetland alongside the Aquatics Centre, where a reinforced reed mat is being used to counter the effects of boat wash and scour. Once the wetland is installed, the temporary sheet pile wall that lines the river will be cut down to reveal the 8m wide margin and widen the waterworks river beyond its industrial canalised form. The result will be a rural landscape of much-needed green space in this once-neglected part of east London.

As had previously been done with the remediation contracts, the Park was divided in two for the landscaping work, with Skanska winning the contract for the South Park and Bam Nuttall the North.

Skanska's contract includes 27,000m² of soft landscaping and 200,000m² of hard landscaping. In conjunction with subcontractor Willerby the firm contracted out Palmstead Nurseries to source, germinate, culture, harness and grow 30,000 plants from all corners of the world sourcing seeds and cuttings from far and wide to meet the demanding brief.

Skanska identifies "change – and the management of it" as key to the

Post Games: How the park will work in legacy

4,000
Number of new, semi-mature trees planted in the Park

"The lack of rainfall throughout the summer created a tough environment for the immature plants, and the River Lee was being held at an artificially low level"
Mike Vaughan, Atkins principal engineer

Materials Supply

The ODA specified at the outset that 50% of all materials used on the Olympic Park construction should be brought on to site using sustainable transport – ie by rail or water. Aggregate Industries, which won supply agreements with the ODA for aggregates and ready-mixed concrete, brought in 90% of aggregate for both agreements by rail.

At the height of construction up to 24 trains per week were delivering aggregate products to the Olympic Park, each carrying 1,200t.

To date over 1M.t of aggregate fill materials have been supplied to the contractors on the Olympic Park, as well as aggregates for over 400,000m³ of ready-mixed concrete.

Sustainable: 50% of materials were brought in by rail and water

The company has calculated that the products supplied through the Olympic Park railhead have saved over 100,000 vehicle movements.

While the majority of aggregate materials have been delivered to the Olympic Park by rail, some of the waste has been taken away by water.

After a new lock was constructed at Three Mills in 2009, 350t freight barges were able to access the Park to deliver construction materials in and carry waste out.

Aggregate Industries modified a barge to transport containerised waste, and containers were loaded onto the barge at a temporary wharf near the Aquatics Centre.

project's success, which encompasses everything from challenging previously held buildability preconceptions to changing the scope of works – including the decision to position the 130m high ArcelorMittal Orbit sculpture on a concourse that the contractor was about to build.

BAM Nuttall project director Richard Prime says one of the main challenges in the North Park was phasing work to integrate with other projects.

"In total we planted 1,400 trees and 350,000 wetland plants, and our highlights to date include the finished landscape of the wetland bowl, and planting the last semi-mature tree in May 2011," he says.

The soft landscaping is now substantially complete and, slowly but surely, the vast 2012 park is starting to resemble something more than just a construction project – a glimpse of what it will be like in Games time and beyond.

Q&A: John Hopkins, parklands and public realm project sponsor, ODA

What was your biggest challenge?
Creating a park that delivers a green and colourful atmosphere for the Games and can be quickly and simply transformed into a new public park that works for people and wildlife in legacy. We also wanted to set new standards and create a new kind of park to put Great Britain – the inventors of the public park – back at the forefront of park design.

> **We wanted to set new standards and create a park to put Great Britain – the inventors of the public park – back at the forefront of park design"**
> John Hopkins, parklands and public realm sponsor, ODA

What are you most proud of?
Attracting an A-team of UK and world-leading landscape and garden designers, horticulturists, soil specialists, ecologists, tree and plant growers, and seeing their shared commitment to creating this very special park.

We invited members of the public for a picnic in the park and took them on a walk in the just-completed northern half.

I asked one or two of them what they thought of it – they loved how the park looked and felt, but more importantly, they really loved learning about how it worked, and that all the different bits were working landscapes.

What does sustainability mean to you in the context of the park?
Creating new public green space and wildlife habitats out of former industrial land.

Building a park that manages and utilises rainwater and flood water and is designed to deal with the increased temperature and wind associated with climate change.

Creating and encouraging biodiversity, including specific habitats aimed at specific targeted species, and leaving a legacy for all the existing and future communities to enjoy for hundreds of years.

Q&A: Mike Vaughan, principal engineer, Atkins

How did you approach the job of transforming the river edges?
Slowly. The prospect of a brief with such vast scope was exciting but a little daunting.

We started by modelling the hydraulics of the river, which gave us a better understanding of how the water behaved, and then worked in collaboration with the landscape architects to conceptualise how we could integrate the rivers into the masterplan. The result was a model for restoring the rivers and surrounding wetlands and ponds to create a central feature.

What was your biggest challenge?
Understanding how the river system worked, which meant examining the way water flows towards the Thames and measuring velocities.

We also had to predict how the river would behave after the construction of a new lock at Three Mills Island: we knew the Lee would become tide-locked during high tide but we didn't know how much.

Factors like this could potentially affect many aspects of the rivers on the site – the Park layout, the drainage, the wetlands and ponds, and the river bank restoration.

Our solution was to undertake computer modelling of the river, looking at daily flows and tides and then confirm the analysis over the following 12 months, taking recorded level, tide and flow data and passing it through the hydraulic model.

The range of fluctuating river levels that we identified led to the need to select plants and design the wetland features to cope with these conditions – or to limit them through clever design.

Our ecologists tested various plant species for growth performance, trialling them at different elevations and with different planting techniques. The outcome was a solution of installing plants in a coir mat, which traps sediment from the tide and prevents the plants being washed away or swamped.

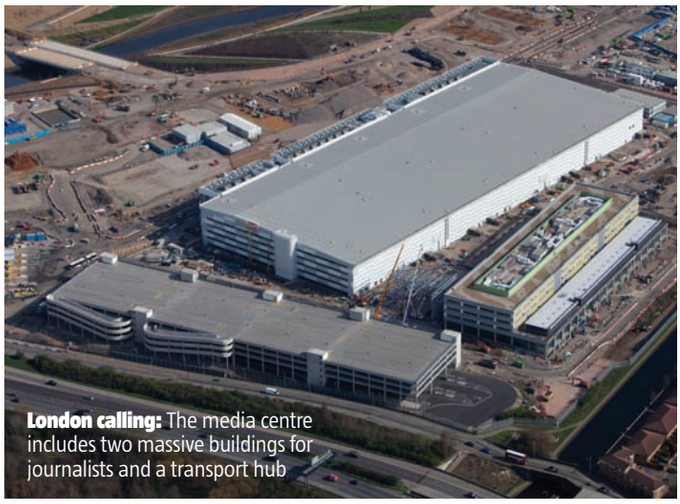
What are you most proud of?
The efforts and collaborative working of all parties during the design and construction of the wetlands. This enabled the experts to innovate, integrate and operate in an unrestricted way.

Which Olympic event would you most like to watch and/or take part in?
I'd most like to watch track cycling in the velodrome – partly because we have a good chance of winning, and partly because the building itself is magnificent.

As for taking part, I'd enjoy an attempt at the white water canoe course, although perhaps as a river engineer I might be a little too analytical of the hydraulics involved!

The world is watching

Media Complex



London calling: The media centre includes two massive buildings for journalists and a transport hub

107
Apprentices employed

12km
Total length of ductwork

100%
responsibly sourced timber

PROJECT TEAM

Design & build contractor: Carillion

Architect: Allies & Morrison

Engineering design: Buro Happold, RPS

"Broadcast deals make up a significant proportion of Games revenue, so this is one building we have to get right"
Tony Coyle, project director, Carillion

More than 20,000 journalists will be based at the main media complex in the north west corner of the Olympic Park at any one time during the Games.

The £300M complex consists of two main buildings: the 56,000m² International Broadcast Centre (IBC) and the 30,000m² Main Press Centre (MPC).

The IBC can be split into different configurations depending on market demand after the Games, while the BREEAM Excellent-rated MPC will offer flexible office and commercial space beyond 2012.

Also within the complex is a 12,000m² catering village, which will serve 60,000 meals around the clock, and a 200m long high street with shops, banks, newsagents, travel agents and a post office. There will also be a temporary press conference room that can cater for up to 700 journalists at a time.

Media will also be able use the Media Transport Mall – a multi-storey car park with a coach drop-off, car parking, accreditation and security.

Q&A: Tony Coyle, project director, Carillion

How did you build the media centre?
Without the Olympic Park Media Hub the 2012 Games would only be seen by the thousands of lucky ticket holders. With it, 4bn people will get to join in. Broadcast deals make up a significant proportion of Games revenue, so this is the one building that we have to get right.

We applied for detailed planning permission in February 2009, with start on site just a month later. We were initially working from planning drawings rather than detailed design, but this formed the basis of a project that was born out of partnership and built on collaboration.

With 50 Tier 2 contractors and 50 Tier 3 contractors, plus a host of specialist designers, it was essential to develop effective and efficient ways of working.

We met tough targets to produce a quality project built using lean construction techniques and within challenging environmental and diversity parameters.

I am proud to say that, with our contractors, we have gone above and beyond the targets and we are on course and within budget to complete this month.

The 56,000m² IBC, which has room to park five jumbo jets on the ground floor alone, was handed over in April ready for fit-out.

There have been a lot of hurdles to overcome. With just two entrances for the whole park, the logistics of labour transportation into and around a high security environment was a significant challenge, made all the more interesting by a constant stream of visitors, inspections and tours.

In 45 years in the construction industry I have never been involved in a project with such a significant safety agenda. With an accident frequency rate of 0.04, we are among the leaders on the Olympic Park and industry leading in comparison with a UKCG average of 0.35.

What was your biggest challenge?
Getting 58 massive air handling units onto the three-storey cantilever that runs along the length of the IBC. The units weighed several tonnes each and had to be winched carefully into place by crane.

What does sustainability mean to you in the context of this venue?
The IBC and MPC are innovative buildings and incorporate technology that will provide a sustainable facility during and after the Games.

Their design will deliver substantial water savings, through rainwater collection facilities and the extraction of underground water through bore holes.

Additionally, the MPC will have a brown roof, and there are plans for photovoltaic cells to be installed on the MPC to deliver renewable energy to the Park. The MPC will also encourage wildlife through the use of bird and bat boxes.

What was the most significant event on the job and why?
The most significant event was erecting the International Broadcast Centre frame in nine weeks.

This was achievement that attracted appreciative comment from our peers on the Olympic Park and set us up for the rest of the project.

Wrapping it all up

Basketball and Water Polo

Creating tension: The Basketball Arena is shrouded in a PVC membrane

The Basketball Arena was the fourth Olympic Park venue to be completed and is one of the largest temporary venues ever used in an Olympic Games.

It will stage the basketball preliminaries and quarter-finals, wheelchair basketball, wheelchair rugby and the handball men's quarter-finals, all semi-finals and medal matches.

The arena was built by a collaboration of companies which were brought together to deliver different aspects of the bespoke venue, from the 1,000t steel structure to the 12,000 black and orange seats – representing the colours of a basketball.

It was delivered through a series of package contracts, with the Olympic Delivery Authority's delivery partner CLM acting as principal contractor.

The venue is wrapped in 20,000m^2 of recyclable white PVC, with the tension created by stretching the fabric over three different variations of steel arched panels.

During the Games, the membrane can be used as a canvas onto which an artistic and innovative external lighting design can be projected.

After the Games the building will be dismantled and elements potentially used at other UK and overseas events.

Q&A: Richard Arnold, project sponsor, ODA

What was your biggest challenge?
I took on the project when it was halfway through construction, so the main focus was on ensuring it was successfully delivered. The biggest challenge was making the fourth largest venue on the Park entirely temporary and capable of being completely dismantled after the Games. We don't believe that this has ever been achieved before for a venue of this size, and the International Olympic Committee is now very keen to see this model being rolled out in future Games.

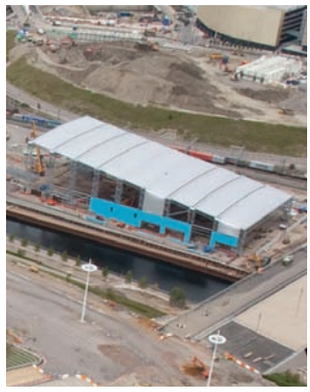
What are you most proud of?
The whole team is very proud to have delivered a unique temporary venue that still provides a "wow" factor when you walk inside.

PROJECT TEAM

Structural engineer: Sinclair Knight Merz
Architect: Wilkinson Eyre/KSS
Principal contractor: CLM,
Structure contractor: Barr Construction
Seating: Slick Seating
Membrane cladding: Base
M&E: Mitie
Steel erection, toilet blocks and internal fit-out: Volker Fitzpatrick

Water Polo venue

The 5,000-seat Water Polo Arena is a temporary venue, easily distinguishable by its silver wrap and an inflatable roof made from recyclable plastic. The wedge-shaped building rises from 12m to 25m, and contains a 37m competition pool and a warm-up pool. It will stage the men's and women's water polo competitions during the Games, and will then be taken down, with elements reused elsewhere in the UK. Construction incorporated materials available through the rental market to promote reuse and reduce construction waste.



Q&A: Andrew Best, group director, Buro Happold

How did the design team approach the Water Polo venue?
With a great deal of excitement and commitment. The team had a great opportunity to design a building that was going to be seen on the world stage, that had to function perfectly and look great, yet we had to do it within a budget appropriate for a temporary venue.

What was your biggest challenge?
Enclosing a large volume of space in a very efficient way, using components that could be taken down at the end of the useful life of the building and fed back into the supply chain.

What are you most proud of?
Working together with the architect to come up with a few deft touches to turn a cost effective temporary building into a very nice piece of architecture.

Which Olympic event would you most like to watch or take part in?
Water polo of course!

PROJECT TEAM

Architect: David Morley Architects
Engineering design: Buro Happold
Main structure: ES Group
Substructure: Jackson

To the manor born

Eton Manor

Facilities at Eton Manor are being built on a site that is steeped in sporting history.

In the first decade of the 20th century a community sporting facility was established on the site, followed by the Eton Manor Boys Club, which gained a reputation as an elite sporting association in east London.

During the Olympic Games Eton Manor will be an aquatics training venue, including three Olympic-size swimming pools, a synchronised swimming pool and a water polo.

During the Paralympic Games, it will host the wheelchair tennis competitions with temporary seating for 10,500 spectators.

It is the only new purpose-built permanent Paralympic venue to be built in London

The site houses five temporary swimming pools, which have been designed such that the plant and structure can be dismantled and split to form smaller pools.

These can then be used at another site in the future.

After the Games it will be transformed into a hockey centre with two competition pitches, a tennis centre with four indoor and six outdoor courts, and provision for five-a-side football pitches.

The building has a reinforced concrete frame, red cedar timber cladding, precast concrete seating terraces, exposed concrete with a woodgrain effect finish, and a mix of roofing types, including sustainable brown, single ply and paved.

Q&A: Richard Arnold, project sponsor, ODA

What are you most proud of?
The site has a long and colourful history of sport, and I am proud to have been part of securing the future of this historical site with a mixed sport facility for many more years to come.

> **"The site has a long colourful history of sport, and I am proud to have been part of securing the future of this historic site"**
> Richard Arnold, project sponsor, ODA

Which Olympic event would you most like to watch?
Watching track cycling in the Velodrome would be top of my list, but it would also be great to see wheelchair tennis during the Paralympics at Eton Manor.

Q&A: Joanne Lamour, project manager, Arup

What was your biggest challenge?
The biggest challenge was the level of transformation and integration required for each of the phases.

The challenging ground conditions on the site required a variety of foundation solutions to suit each different type of structure, including a permanent sports building, temporary tents for the swimming pools, and large temporary spectator stands.

What are you most proud of?
The permanent building is a favourite. The naturally ventilated concrete and timber structure uses recycled and sustainable materials to create a functional yet beautiful building.

Which Olympic event would you most like to watch?
The design team are all very keen to watch a wheelchair tennis event. The opportunity to soak up the atmosphere in the venue we've designed would be fantastic.

Q&A: Graham Beach, senior project manager, Mansell

What was the biggest challenge?
One of the most significant challenges entailed planning the logistics for the delivery of 10, 42m long glulam beams, weighing 8t.

PROJECT TEAM

Architect: Stanton Williams

Main contractor: Mansell Construction Services

Civil/structural engineer: Arup

Drainage software: Microdrainage

3m
Height venue has been raised from existing site levels

5,000
Seat main show court is entirely temporary. It was constructed within the legacy hockey bowl

112
Paralympic athletes will compete for six medals in wheelchair tennis

Copper challenger

Handball Arena

The 6,500-seat Handball Arena has been designed and constructed to ensure a straightforward transition into legacy as a flexible, sustainable multi-use sports and entertainments arena.

Bright thinking: A natural lighting system feeds daylight into the venue via 88 rooftop sun-pipes

Events being staged at the venue include the men's and women's preliminary stages and the women's quarter finals of the handball competition, the fencing discipline of the modern pentathlon, and goalball during the Paralympic Games.

Designer Arup says its mantra for the Handball Arena was "design for legacy and overlay for games", and the response was a simple, cost effective, flexible building with the viewing area stacked as tightly as possible around the field of play to produce a small building with minimum facade area.

The BREEAM Excellent-rated building is cubic in shape and clad in 3,000m² of copper. It was designed and built with sustainability as a priority: the copper cladding has a high recycled content, the building uses water harvesting and has waterless urinals, and a natural lighting system feeds daylight into the venue via 88 rooftop sun-pipes, resulting in energy savings of up to 40%.

Q&A: Colin Naish, project sponsor, ODA

What was your biggest challenge?
Cladding the top half of the venue in copper. We had to source around 3,000m² of copper from the manufacturer and carefully fit it, strip by strip. The process took some time as it needed to be perfect.

What are you most proud of?
I think my proudest moment was at project completion – when the keys to the venue were handed to LOCOG in May. For me the job was done. I had been managing the project since work started and it was a great feeling that it had gone successfully.

Which Olympic event would you most like to watch and/or take part in?
Handball (of course)

Q&A: Arup design team

What was your biggest challenge?
A key concept was the open interconnectivity between the concourse and the main arena, when traditionally the concourse is a fire separated space, used as the first point for escape in the event of a fire.

We used a risk-based analysis to show that all occupants would be able to safely evacuate, by considering the use of the concourse, the materials present, the spectators likely to be using the venue and the high levels of management present when the building is used for large events.

Which Olympic event would you most like to watch?

Goalball – a sport played by blind athletes that was devised in 1946 to help the rehabilitation of visually impaired World War II veterans. There is a bell in the ball to guide play, and the building's mechanical systems had to be designed to achieve theatre-like noise levels at the field of play.

Q&A: Rob O'Brien, senior project manager, Buckingham Group Contracting

How did you build the Handball Arena?
We took possession of the site in early June 2009, with the piling works commencing in late July.

As the design progressed through the autumn of 2009, and construction on site continued, we faced a construction sequence obstacle that would determine the success of the project: a late change to the Stage D design forced a rethink with regard to the erection of the roof trusses. In the original scheme the roof trusses were to be erected from outside the building footprint. The new scheme meant that erection of the roof trusses had to be undertaken from the field of play.

The project progressed at a pace during 2010, and the 60m long, 4m deep roof trusses were erected during late May and June 2010. During the latter phase of roof truss erection the field of play was home to two crawler cranes, two medium-sized mobile cranes, one mobile tower crane, two forklifts and six cherry pickers; space was at a premium. On a footprint of just 67m x 46m these works were a major challenge with regards to safety.

> **"On a footprint of just 67m x 46m these works presented a significant challenge with regards to safety"**
> Rob O'Brien, senior project manager, Buckingham Group

PROJECT TEAM

Main contractor: Buckingham Group Contracting
Architect: Make Architects with PTW
Engineer: Arup
Design software: Oasys

Riding the rapids

White Water Canoe Centre

Rapid construction: (top) White Water Canoe Centre main building; (bottom) The course includes movable obstacles that create the white water features

Olympic canoe slalom events will take place at the new Lee Valley White Water Centre, located 30km north of the Olympic Park in Broxbourne, Hertfordshire on a former landfill site.

Two new canoe slalom courses have been built for the Games: a 300m competition course and a 160m intermediate/training course. The courses are fed by a 10,000m² artificial lake that is fed from borehole water and cleaned up to swimming pool standard by an on site treatment plant.

The courses and the facilities building will remain in place once the Games are over, and the centre will become a venue for canoeing, kayaking and white water rafting.

Q&A: David Mutter, project director, Galliford Try

How did you build the White Water Canoe Centre?

Our challenge was to construct two slalom courses and associated facilities by Christmas 2010 to allow athletes to start training in January 2011. A further challenge was to open the venue for public use ahead of the Games.

The Olympic course is constructed on a landform of imported WRAP recycled materials over the landfill, which was surcharged to compress the fill material, then formed the channels with step drops and eddy pools of precise geometry. Hyder and specialist course designer EPD modelled the course at 1 to 30 scale and proved the course geometry prior to construction.

> **"Obstacles can be configured anywhere on the course to provide a constantly changing white water experience"**
> David Mutter, project director, Galliford Try

The 300m competition course has a drop of 5.5m and is fed by five pumps drawing water from the lake at a rate of 13.5m³/s, which would fill the Olympic swimming pool within two minutes! The Intermediate course provides a gentler experience, with a drop of 1.6m over 160m.

The real innovation on the course is the Rapidbloc moveable obstacles, which create the white water features. This system was developed specifically for the White Water Canoe Centre by Andy Laird of EPD, but is now being used on other UK and international courses. The obstacles can be configured anywhere within the course to provide a constantly changing white water experience, which should allow the venue to remain the foremost white water centre for years to come.

The venue's multi-purpose facilities building, which includes changing facilities, a cafeteria, water treatment centre and storage for rafts and canoes, was awarded a Ceequal Excellent rating due to the high degree of sustainable construction incorporated in the design. Features include solar panels for secondary water heating, and primary heating from heat pumps drawing energy from the lake water.

PROJECT TEAM

Architect: Faulkner Browns

Landscape architect: MVVA

Course designers: Whitewater Parks International/Cundall

Detailed course design: EPD/S20 Design & Engineering

Contractor: Galliford Try

Lightweight aggregate fill: Leca

13.5m³

Speed per second at which pumps deliver water down the course

What are you most proud of?

Hearing world class athletes from the world over stating that this is the best artificial course they have experienced.

Which Olympic event would you most like to watch and/or take part in?

Having just taken up canoeing late in life I would like to have competed in Olympic Slalom and I will be coming to watch the event at Broxbourne.

Pushing the boats out

Sailing Venue

The Olympic and Paralympic sailing competitions will take place at the Weymouth and Portland National Sailing Academy (WPNSA) and the adjoining Portland marina.

In 2008 work started to enhance the existing facilities at WPNSA, with the construction of a new permanent 250m slipway and race-boat parking, lifting and mooring facilities. Work was completed on time and on budget in November 2008, making the WPNSA the first 2012 venue to be ready – more than three years ahead of the Games.

Q&A: Mark Stanyon, project manager, Balfour Beatty Regional Civil Engineering

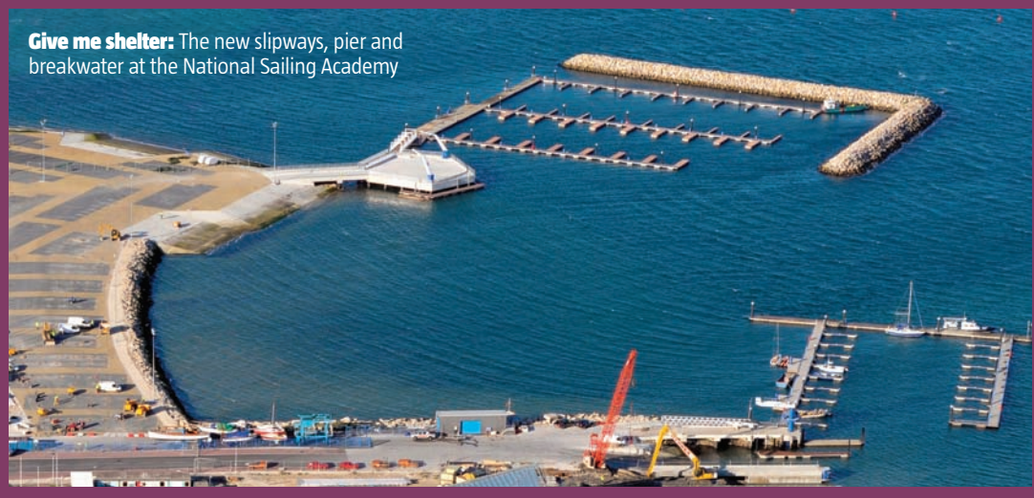
How did you build the sailing venue?
Dean & Dyball had built the sailing academy a few years before, so the company knew the site very well. I live in Weymouth and a lot of the guys live in Weymouth or Portland. They can look out of their windows and see the site in the morning, so it is very close to the company's and the workforce and staff's hearts.

Even though we had built the academy, this did feel like a different job. Apart from anything else, this was going to be the first Olympic venue to be completed.

There were several challenges: working in the sea was one of them, and another was keeping the academy running while we built 250m of new slipway frontage. We built one new section first and a parking area for boats, while they used the old facilities, then we were able to let them onto the new slipways and do the other half of the work.

We also built a 40m long pier to launch boats from, with a linkspan bridge onto the pontoons where boats are moored. The pier structure is made of tubular steel piles driven 10m into the seabed, with in situ concrete beams between the piles, precast concrete planks spanning the beams and an in situ concrete topping.

There is also an L-shaped rock breakwater with a total length of 200m, built 150m offshore.



Give me shelter: The new slipways, pier and breakwater at the National Sailing Academy

PROJECT TEAM

Project Manager: Olympic Delivery Authority

Planning/Design consultants: WYG/Royal Haskoning

Contractor: Balfour Beatty Regional Civil Engineering, through its Dean and Dyball civil engineering division

80,000t
Imported crushed Portland stone

"Construction was held back to avoid disrupting over-wintering birds"
Ralph Luck, ODA

Q&A: Ralph Luck, director of property, ODA

What does sustainability mean to you in the context of this venue?
At one level it is about creating a facility that is user friendly and financially viable before and after the Games.

Completing this venue early has helped because the place has been established in the sailing fraternity's mind.

On a second level it is about how the enhancement works were carried out. The initial set-up on site for the enhancement works took place in January 2008 but the start of construction was deliberately held back and programmed to start in May 2008 to avoid disrupting the nesting season of over-wintering birds around the local coastline.

What are you most proud of?
It being the first 2012 venue the ODA finished, creating an early legacy for people to use and to start creating economic benefits for the area.

Which Olympic event would you most like to watch and/or take part in?
It has to be the sailing, as it is my passion outside work.

Homing in on the future

Athletes' Village

Coming home: The Athletes' Village will become a sustainable community once the Games are over

The Athletes' Village has been designed for legacy but adapted for the Olympic and Paralympic Games, when it will house 17,000 athletes and officials.

Therefore it has been imperative that design initiatives and quality of product are key in the successful delivery of the overall project.

The 24ha site contains 11 residential plots, with 2,818 homes, a state of the art education academy, a three-storey multi-use health facility and a multi-story car park for high speed rail line High Speed One, as well as 6km of road networks and over 10ha of landscaped public realm and courtyard spaces.

Lend Lease was appointed as the design, development and construction manager for the Athletes' Village back in March 2007, and has seen the project from initial planning stages, with a small start-up team, through to a peak workforce of 6,000 in spring this year.

Following the handover of the multi-storey car park in late 2010, the company is now progressively completing residential buildings, and has so far delivered close to 10,000 bed spaces ready for Games organiser LOCOG's final fit-out.

To date the project team has worked in excess of 18M hours and delivered 1M hours without a reportable injury on six separate occasions; in two of these periods the 2M hour milestone was reached. "Health and safety is absolutely the highest priority, and the strong safety outcomes have been put down to relentlessly revisiting simple, effective initiatives across the team," says Lend Lease project director Mark Dickinson.

"With the rate of progress we have achieved, and the huge growth in the workforce, the logistical challenges have been onerous," he adds.

The site has received around 900 to 1,000 delivery vehicles each day for the past year, with about 300,000 vehicles passing through the site in 2010.

The Village will set new standards in sustainability, being the first development of this scale to achieve Level 4 of the Code for Sustainable Homes.

This has been achieved by considered design, high levels of energy efficiency, extensive biodiversity and use of certified responsibly sourced materials.

This year has seen the landscaping at the Village change dramatically. "The first tree was planted in January, and we will eventually see the introduction of 3,000 new trees on site, including herb gardens and orchards," says Dickinson.

The focus for delivery in the final months before handover in February 2012 will be managing the interface between the 63 buildings on site and completing the landscaping.

This will be done while maintaining safe access across and through the site and facilitating LOCOG's requirements as it prepares for the Games.

Q&A: Mark Dickinson, project director, Lend Lease

What was your biggest challenge?
Maintaining exceptional standards of Health and safety to ensure every worker is sent home safely at the end of each day has been the biggest focus and has consistently been the most important challenge on site. It has required relentless focus and we're working to ensure complacency doesn't set in as we push forward through the last few months of the job.

What are you most proud of?
The intensity of this project can be tiring, with tight deadlines and high expectations across the board. Many of the team joined the project at the start – others for just a few months, but everyone's focus remains the same. We have some exceptional talent in the team and just looking at what has been achieved makes me proud of everyone involved in the delivery.

What was the most significant date/ event on the job and why?
Each time we have a new visitor to the site, their reaction reminds me of what has been achieved to date. World famous athletes have visited the site and openly talked about how impressed they are with what's being delivered at the Village – the quality of product, design and landscaping are always commented on.

Which Olympic event would you most like to watch?
Any – I didn't get any tickets!

> **"Strong safety outcomes have been put down to relentlessly revisiting simple initiatives"**
> Mark Dickinson, project director, Lend Lease

24
Tower cranes in operation at peak of construction

340m
Of high speed railway running through the centre of the site had to be enclosed before construction work could commence

1M
Working hours without a reportable injury on six separate occasions

Creating an identity

Public art

Iconic: Monica Bonvicini's installation Run

By integrating arts and culture initiatives into the public spaces across the Park, the Olympic Delivery Authority (ODA) hopes to create a unique area that gives existing local communities a sense of ownership.

It also hopes the area will make new communities want to live, and help make east London a world class visitor destination.

"We wanted arts and culture to be part of the new landscape and not just an add-on, so a programme of permanent commissions has been developed over the last three years and integrated into the high quality architecture, landscape, design, construction and engineering of the Park," explains ODA head of arts and cultural strategy Sarah Weir.

These diverse commissions include artists' designs on bridges and underpasses, security fences incorporating artwork, planting schemes, large-scale walls and facades, and artist-led community projects in the five host boroughs.

Some of these projects are already visible and demonstrate the ingenuity and imagination that artists have brought to the look and feel of the Park and the surrounding area. For example, the fence around a key building in the north of the Park showcases Carsten Nicolai's commission "Ifo spectrum"; the "Cloud Bridge" by RCA design students Oscar Bauer and Nazareno Crea is already installed on Angel Lane bridge in Stratford; Hackney-based artist Martin Richman's distinctive "One Whirl" design can be seen on one of the main footbridges in the middle of the Park; and "The Floating Cinema" by artists Nina Pope and Karen Guthrie with UP Projects and Studio Weave is currently navigating the waterways surrounding the Olympic Park.

Future projects, which will become as much a part of the Park as the venues, include poetry on transformer enclosures and walls across the site, numerous "fantastic facts" on bench plaques by local artists Klassnik Corporation, Riitta Ikonen and We Made That, and Monica Bonvincini's landmark lightpiece "RUN" outside the Handball Arena.

"We wanted arts and culture to be part of the new landscape and not just an add-on"
Sarah Weir, ODA

ArcelorMittal Orbit

The most prominent artwork on the Park is the 115m high ArcelorMittal Orbit, named after its sponsor, steel giant ArcelorMittal and designed by artists Anish Kapoor and Cecil Balmond with consultant Arup, and Ushida Findlay Architects. It sits within the Olympic Park between the Olympic Stadium and the Aquatics Centre.

The sculpture – the tallest in the UK – is being constructed from a continuous looping lattice of tubular steel, and will be painted deep red. It incorporates two viewing platforms at 76m and 80m above the ground.

Arup's advanced geometry unit took the Orbit's design through conceptual development, with bespoke parametric tools allowing a team of software scripting designers to sculpt and optimise its form.

Advanced geometry: The Orbit

The design team claims the structure "crosses the boundaries between art, architecture and engineering, fusing them into a complete piece – and a very large one at that".

The sculpture is intended to be experienced in many different ways: from a distance it will pop up in different views all over London, while close up, the power of the complex form will be revealed. "It has been designed to be a journey of amazing experiences, ranging from quiet contemplation into vertiginous excitement," says the design team, adding that the biggest challenge was "taking a concept sketched as a single flowing line and translating it into a very large three dimensional form which human beings could inhabit".

So far the design team has spent more than 30,000 hours on the project. Construction started in October 2010 and completion is due in early 2012.

Q&A: Pierre Engel, chief engineer, ArcelorMittal

What are you most proud of?
The collaborative effort needed to realise the vision of Anish Kapoor and Cecil Balmond has been inspiring to be a part of. At every stage of this incredible process we have been able to call upon brilliant minds and craftsmen – everybody from the architects in London, to the steelworkers in Luxembourg, through the welders in Bolton and the onsite team of four that are constructing the ArcelorMittal Orbit.

Getting to the games

Transport

"The main constraint with all the transport works is carrying them out with minimal disruption"
Hugh Sumner, ODA

13.87
Frequency in second of train arrivals at the Olympic Park during the Games

London 2012 is set to be the first "public transport Games", with 100% of spectators able to travel by rail, Tube, bus, coach cycle, river or foot.

What needed to happen to make this possible – particularly for accessing the Olympic Park – was opening up routes to more people so that people could get there and back no matter which mode they decided to use.

A concentrated effort was made between the Olympic Delivery Authority (ODA) and its partners to improve London's networks, and across the UK £6.5bn has helped to fast-track existing enhancement plans to improve travel before, during and after the Games.

Just under 50% of visitors to the Olympic Park will travel via Stratford station, where peak time capacity has been increased from around 35,000 in the mornings during 2006 to around 120,000 by next year.

Improvements at Stratford station include a new Docklands Light Railway (DLR) extension from Stratford International to Canning Town, new platforms on the North London Line, refurbished subways and new lifts, a new Northern Ticket Hall serving the Westfield Stratford shopping centre, a mezzanine-deck ticket hall and new station entrance. Establishing the Javelin service at Stratford International will also help meet demand, as will investment in improving capacity at West Ham station.

Substantial progress has been made on improving rail, Tube and DLR services, while contracts have been drawn up to create national coach and bus networks for the Games.

There will also be a Park & Ride service for spectators wishing to use their cars for part of their journey to the Olympic Park. Transport infrastructure along the River Thames is being improved to raise the profile of water as a transport option, and more than 100 walking and cycling schemes on eight routes across London are being upgraded, as well as paths linking to outer London venues

"The main constraint with all the transport works is carrying them out with minimal disruption," says ODA director of transport Hugh Sumner, who cites the example of the town centre link bridge being slid into place above live tracks to avoid temporary rail closures.

The Games-time requirements for additional capacity have already created a long-term legacy, with the Olympic Park served by 10 lines and three stations – Stratford, Stratford International and West Ham. Stratford has always had good rail links, and the Games-related investment will make it one of the best connected parts of London.

Q&A: Hugh Sumner, director of transport, ODA

What was your biggest challenge?
Next summer everything will be much busier than usual.

The biggest challenge for us was getting the balance right between how we get spectators around with the continuance of background demand.

We have worked closely with stakeholders and operators to ensure that roads, rail networks and other routes continue to operate as close to normal as possible.

The Olympic Games are being held at a time when service demand is at its lowest, because of holiday season, and we have worked with Transport for London to inform businesses of the need to plan their travel and deliveries around this increased demand so that they can continue to operate as efficiently as possible.

What are you most proud of?
I'm particularly proud of the way the transport industry rose to the challenge of the bid.

It has done so again to help deliver the infrastructure, and is running a fast last leg to bring the operations on line next summer.

In terms of achievement, we've done it safely, we've saved money and we're within a few days of where we should be.

We also don't suffer from hubris!