Destination London Bridge

Redeveloping the iconic station and upgrading the railway

For more than ten years WSP has worked with Thameslink Programme Partners to deliver the Thameslink Programme and a reinvigorated London Bridge Station

Image: Team London Bridge

A transport hub fit for 21st century London

The city of London is in a constant state of evolution. Since Roman times, it has stretched and flexed, expanding out and then up to accommodate its ever-growing population.

Dividing and multiplying so rapidly made the city fertile ground for invention and innovation, and many technologies have been pioneered here, including one of the world's first public railways and its first underground railway. Passenger numbers on London's rail network doubled in the last two decades, and with a customer-led drive to create a better connected and smarter city, enhancing capacity and mobility across this heritage network is a pressing need.

While major infrastructure programmes like Crossrail and HS2 are carving out new routes for rail, their predecessor, the Thameslink Programme is enhancing some of London's oldest lines and stations to transform north-south travel.

A victim of its own popularity, the south-east rail ecosystem has been plagued by congestion issues. It wasn't originally designed to accommodate current demand, and the introduction of the Thameslink network in 1988 only provided temporary relief. To address these capacity constraints and future-proof the network, a substantial overhaul was planned to provide the growing swell of passengers with more frequent and longer trains.

To deliver this, Network Rail (who own, operate and develop Britain's railway infrastructure) needed **to unlock the potential in the existing rail footprint by using the latest technology to redesign lines, reconfigure tracks and redevelop key stations.**

As the fourth-busiest station in the UK, with 15 platforms and c.50 million passengers passing through each year, the redevelopment of London Bridge Station was critical to the success of the £7 billion Thameslink Programme.

The tracks leading into the station needed to be reconfigured to streamline services, and the station itself, much of which dates back to Victorian times, had to be remade fit for the 21st century.

Despite its inherited haphazardness, the station has survived, functioning as a critical connection point for generations of London communities, and providing a link to significant landmarks like The Shard, Borough Market and London Bridge itself. **London Bridge Station deserved to be rebuilt in a fashion that reflected this status – transformed into a destination in its own right.** And, to minimise disruption for its long-suffering loyal users, this five-year redevelopment had to take place while the station continued to operate.

WSP was there from the beginning, helping Network Rail to deliver one of its largest and most complex projects. With rail experience dating back 130 years to the design of New York's first subway, WSP had the breadth of expertise to provide support across the lifecycle of the project. As well as helping to clarify the 'big picture' solution, with early construction planning and systems integration services, and carrying out detailed railway systems and station design, we also provided a myriad of supporting services. This included work on the 'Digital Railway', resulting in the world-first application of Automatic Train Operation technology on a mainline railway.

Through dedication, collaboration and innovative thinking across multiple disciplines and organisations, the project team was able to manage the unique challenges of the London Bridge redevelopment. In May 2018, work was completed and the station was reopened by the Duke of Cambridge, concluding a construction programme first devised in 2009. Its success sets the standard for similar transformational rail projects in the UK and abroad.

DETERMINING AND DELIVERING THE PROGRAMME

How do you ensure success on a project of unparalleled complexity?

The Thameslink Programme needed to perfectly balance and manage time. Due to the lack of progress throughout the 1990s, public perception was that the works were overdue. **This pressure to provide a quick solution, coupled with minimising disruption to passengers, and the impending London 2012 Olympics, added significant complexity to an already complicated project.** Some in the industry even called it impossible. To achieve the ultimate objective of increasing network capacity, while meeting programme and possession constraints, the Thameslink Programme was split into three key outputs.

Key Output 0 consisted of enabling works to introduce service changes. Completed in 2009, it involved the temporary closure of terminus platforms at Blackfriars, the permanent closure of the Great Northern Farringdon to Moorgate Branch, and the introduction of a fleet of Class 377/5 units.

Key Output 1 needed to be completed before the London 2012 Olympics. These works included extended platforms at Blackfriars and Farringdon to enable the Programme to deliver its ultimate ambition of running 24 trains per hour – equal to one train every 2.5 minutes through the central core between St Pancras and Blackfriars – and adding 14,500 peak-period seats to the service found in 2008.

Key Output 2 was the largest and most complex part of the Thameslink Programme. Industry-level and project-level systems integration and early construction planning defined the requirements and developed a feasible solution. Running from 2013-2018, Key Output 2 included track, signalling and station remodelling works at London Bridge Station, a grade-separated junction at Bermondsey, new track-level permanent way and overhead line equipment. This final milestone would open up the Thameslink network to new destinations north of London.

"Redeveloping London Bridge has been likened to undertaking open heart surgery on a patient that's jogging"

Mark Middleton, Grimshaw Architects

Image: Thomas Graham

CONNECTING PEOPLE AND PLACES

How do you meet the needs of a diverse, growing community? How do you integrate urban regeneration into a railway station design?

London Bridge Station is a testament to reinvention – its enormous and stylish concourse is a far cry from the uncovered, four-track station that was a fixture of mid-Victorian London. Its latest evolution is the result of a conscious effort to meet the needs and aspirations of the growing and diverse community it serves – residents, commuters, market traders and city workers. To these people and countless others, the station is more than a familiar landmark, it's part of daily life – one which has hopefully just become easier and more enjoyable.

Today, London Bridge Station is both a truly modern transport hub and a desirable destination. **Passengers and public alike can enjoy its leading-brand retailers, popular eateries and a pleasant and generously proportioned public space flooded with natural light – this is a station that welcomes everyone.** Physically connected to its community via new street-level entrances, and with improved tube and bus links, it provides fluid and straightforward cross-town connectivity. Its large airport-style lifts and escalators provide step-free access to every platform, making it safe and accessible for everyone.

The station's redevelopment has also been central to the success of the London Bridge business district – an area stretching along the Thames between London Bridge and just beyond Tower Bridge. Nadia Broccardo, the chief executive of Team London Bridge, the representative body for local businesses, believes that without the upgraded railway station *"the area couldn't fully flourish"*.

Image: Team London Bridge

Through lively stakeholder engagement, the project team collected and considered the needs and concerns of local businesses and residents. Chief among requests from the business community were better public spaces, many more retail options, reduced congestion, upgraded railway arches, and enhancements to the environs of St Thomas Street – all of which were delivered as part of this ambitious redevelopment.

It was also essential to the client, community and WSP, that London Bridge Station was rebuilt sustainably. Our innovative design achieved remarkable results, including recycling 98% of all waste removed from the site. It was awarded a CEEQUAL sustainability assessment score of 96.6% – the highest of any project in the design phase at that time, and scored 97.3% upon completion – one of the highest scores ever for a transport project.

The new station is world-class – engineering excellence deftly applied to meet the very practical challenge of finding capacity in a busy and confined urban environment. But as a catalyst for development and a blueprint for successful value capital opportunities, its legacy goes much deeper. The new retail and hospitality resources, the abundant public space that complements Hay's Galleria and the iconic Shard Quarter itself, all owe their existence to the station that has never stopped moving with the needs of its community.

"London Bridge is a great example of how transport-led development can support urban regeneration. The whole area has been revived; alongside the Shard, Shard Place and The News Building – there have been more than 11,000 new homes built over the past six years. By applying the same approach to other station redevelopment opportunities, we can help make our cities and infrastructure ready for the future needs of a growing population."

Darren Reed, Managing Director – Rail, WSP

1836
The first London Bridge Station is completed.

1839
It has become two stations in one, serving different train companies.

1923
A hole is knocked into the dividing wall and the two stations are united.

1945
Wartime damage has added to the confusing and congested layout.

1970
With the station at capacity, British Rail undertakes a major redevelopment.

2007-2011
A 30-strong WSP team is appointed by Network Rail to manage the GRIP 3 London Bridge Station solution and rail system designs for Thameslink Key Output 2.

2008
Another transformation is needed as part of the £7 billion Thameslink Programme. WSP carries out early design feasibility and optioneering on behalf of Network Rail.

2010-2013
WSP is appointed to the systems integration team for the Thameslink Programme, contributing to a migration plan that defines the approach to delivering Key Output 2 and London Bridge works.

2010-2013
WSP is appointed by Network Rail to provide early designs of the depot connections and the Approval in Principle design for seven stabling sites.

2011
WSP is appointed to provide detailed design services for the electrical track equipment, delivering every stage on time to support Balfour Beatty Rail's track remodelling.

2011
WSP is appointed as lead designer for the station, responsible for reconfiguring all the platforms and creating better access for passengers.

2012
WSP and JV partner Hyder (now Arcadis) provide design support to Costain during construction.

2012
WSP's bus station design is finalised, integrating with the station, the Shard, Shard Place and the News Building.

2013-2014
Also designed by WSP, construction on the Shard Building and the News Building is completed.

2014
The first new platforms at open on schedule at London Bridge, following the programme concept devised in 2009.

2018
The new station officially opens, marking a new beginning for London Bridge and one of the final steps of the Thameslink Programme.

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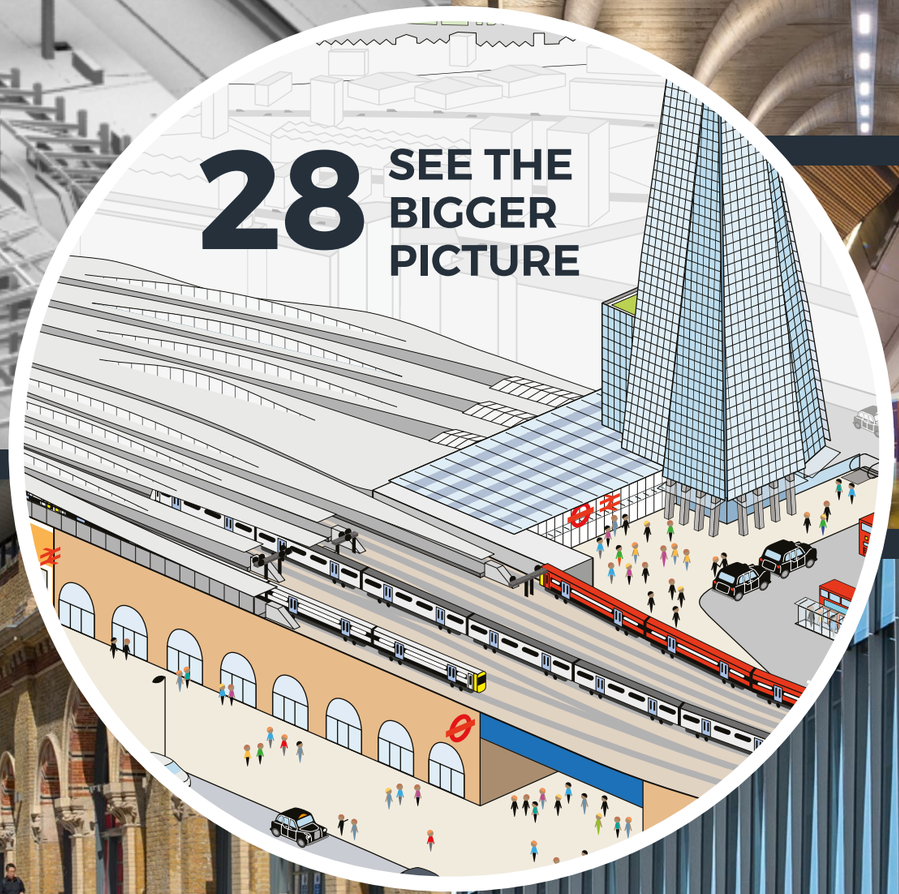


RAIL SYSTEMS

A new track layout to untangle the lines

Designing the rail system for the UK's most ambitious rail and station programme meant introducing a completely new track layout and signalling infrastructure.

This solution would enable 92 trains per peak hour in each direction over the 11 approach tracks to one of the busiest mainline railway stations in the UK. It would also mean untangling a cat's cradle of lines near Bermondsey. And with the East London Line destined to pass beneath lines to the east, our civil engineers and permanent way design teams would have to contend with spatial constraints and react to a last-minute change to the concourse area, some of which had been sold as part of the London Shard development project.

PUTTING THE PROJECT FIRST

The 27-strong team charged with finding a cost effective, robust solution blurred the lines between client and consultant, with over half of its resources coming from WSP.

WSP Project Manager Daniel Mayhew knew that to earn Network Rail's trust – which would eventually see us deliver the bulk of the station's deliverables – we would need to instil confidence in our design, *"We showed Network Rail that its preferred option would be constructable and deliverable within the cost and time limits we were working to, and helped it to articulate this with confidence in its business case to the Department for Transport (DfT)."*

An intense two-week review of all design options – one of the most thorough design reviews conducted on a Network Rail project – secured the funding for this transformative project against a backdrop of austerity cuts. For the first time, the Thameslink Programme and London Bridge Redevelopment, including the complex and comprehensive rail system design, had the agreement of the Department for Transport and the project team.

REBUILDING REQUIREMENTS

Large infrastructure projects can be 'stop-start' by nature, affected by political and economic events that are beyond their control. Programme-level requirements that had been agreed almost a decade earlier (as part of 'Thameslink 2000') were scattered and, up until our involvement in Key Output 2, lost to history. Our iterative review process sought to agree on those requirements that could be rediscovered and include new ones following our capability assessment studies.

Image: Thomas Graham

CONSTRUCTION PLANNING
A railway built in phases

On such a massive construction project, where do you start? Early and integrated construction planning confirmed the project's viability and directed the work of engineers, architects, contractors and operators as the project progressed.

Early collaboration with WSP's operations, constructability and systems engineering teams gave Network Rail certainty that the Thameslink Programme could be delivered while keeping London Bridge Station operational for the 50 million passengers who use it every year.

EXPLORING STAGING OPTIONS

Initiating the construction staging strategy process as early as the feasibility stage (GRIP 2) was unusual at the time, but necessary to confirm that the project could be completed within the required five-year construction period. Working with Network Rail's timetabling, passenger demand forecasting and pedestrian modelling teams, our track experts, systems engineers and constructability consultants explored construction staging options to see how different scenarios would affect passengers. This included adjusting the operating schedule, stopping patterns, and train dwell times to optimise the construction programme with features like 'non-stopping' platforms. This simplified the interim staging requirements and improved safety while maintaining a robust train service.

The resulting solution was a railway and station built in phases with a synchronised construction programme organised into nine strategic stages and over 70 sub-stages. Progressive handback enabled old platforms and the arches below them to be demolished and the tracks progressively reconfigured, reducing the number of closed platforms to three out of 15 at any time. By reversing the platform configuration of nine terminating and six through platforms we enabled more journeys further in and out of the city centre.

The constrained and complex construction sequence that took place from 2013 to 2018 remained true to the original programme concept WSP devised in 2009. The completion of Key Output 2 and the redevelopment of London Bridge Station met every major milestone along the way.

Our programme organised the work into three 18-month slots, delivered in a tightly planned sequence of possessions and blockades. Any break in the sequence would severely disrupt the schedule.

Using virtual design and construction in the early construction stages enabled us to integrate the station design, development sequence and track construction to reduce the costs and the schedule duration. This was critical for the safe and timely reconfiguration and progressive release of the 15 platforms at London Bridge, along with new viaducts on the approach to the station and enabling works like Bermondsey Dive Under.

LESSON LEARNT
The importance of unanimous support for the programme

"An unexpected yet significant part of the construction planning role was managing stakeholders to ensure everyone was committed to delivering the highly synchronised programme. By creating and circulating the staging strategy from the early design stages, stakeholder challenges were assessed and incorporated early. As new staff started on the project, we ensured they understood the ramifications of moving or missing even the smallest milestone."

David Carter,
Construction Planning Manager

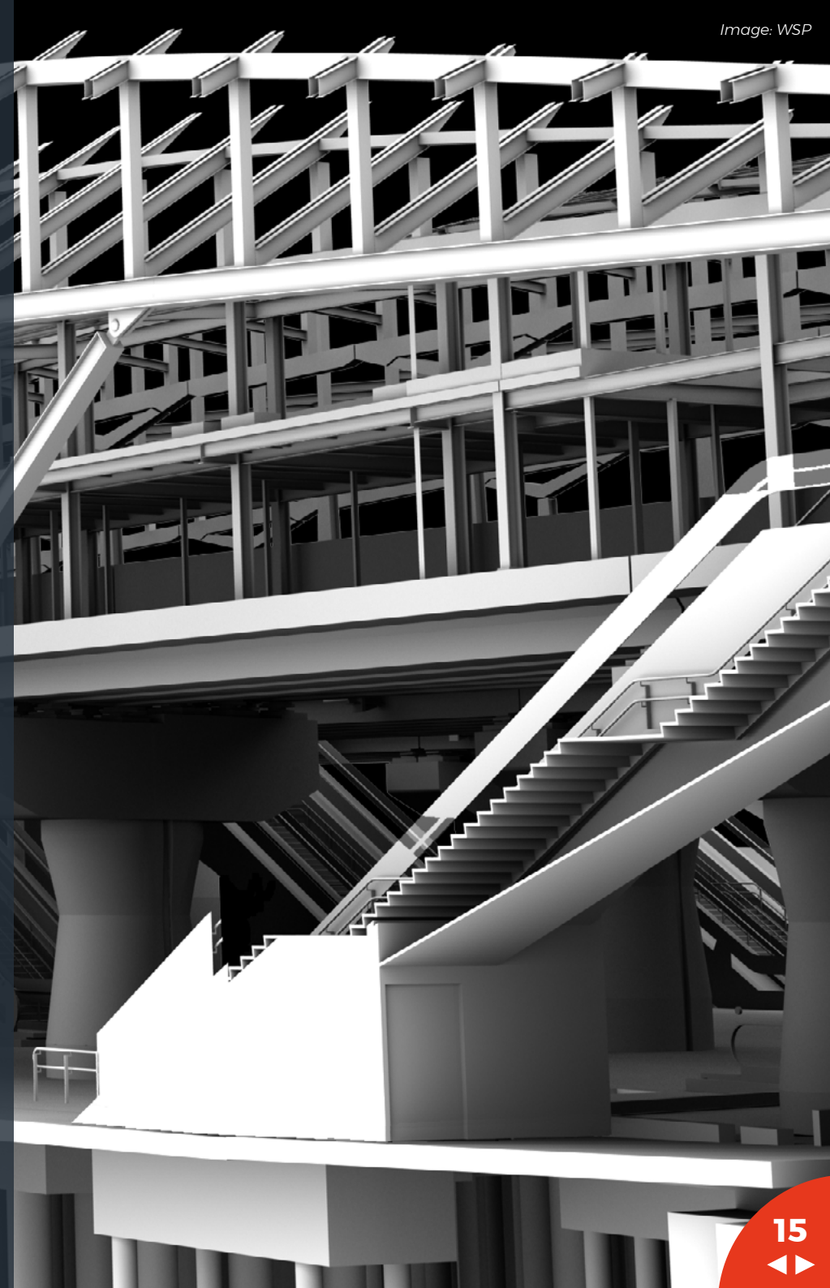


Image: WSP

SYSTEMS INTEGRATION

Innovative systems thinking

As well as enhancing key infrastructure, including the rail systems and stations works, the Thameslink Programme involved procuring new trains and a major franchise change. That meant one of the biggest challenges in the early days of the scheme was aligning all the partners, operators and stakeholders to achieve the promised increase in passenger capacity.

In 2009, to ensure success Network Rail and the Department for Transport (DfT) had to closely integrate the various aspects of the Programme that they were separately responsible for. As Network Rail's largest programme of works to date, the sheer complexity and lack of useful project precedents meant coordination and agree ment on key elements with the DfT, including strategy, governance and planning, was critical.

Appointed as technical consultant for the Thameslink Systems Integration (SI) team, WSP's role was to set up a bespoke systems integration management methodology to support Network Rail and the DfT. WSP worked with these organisations to plan and execute the first strategic stages for the integration of the Thameslink Programme and helped them form an innovative body, the Thameslink Systems Integration Authority. This celebrated model has since been replicated on to other major rail programmes, including Northern Hub, Great Western and East Coast Main Line programmes.

CLARIFYING COMPLEXITY

The real complexity was in designing the migration path – a sequence of seven interim 'configuration states' and transitions that culminated in the final Key Output 2 system. To choreograph this intricate dance, we carried out system integration activities at programme and project levels, integrating key interfaces for routes, rolling stock, performance targets, operational concepts and other infrastructure projects.

In 2011, WSP developed a System Migration Plan (SMP), to show how the construction sequence at London Bridge would interact with the new depots, rolling stock and train control equipment. Used up until the project's completion – unprecedented for so complex a project – our SMP successfully identified every key state through which the programme would transition to reach its final configuration.

A NEW BLUEPRINT FOR PROGRAMME SUCCESS

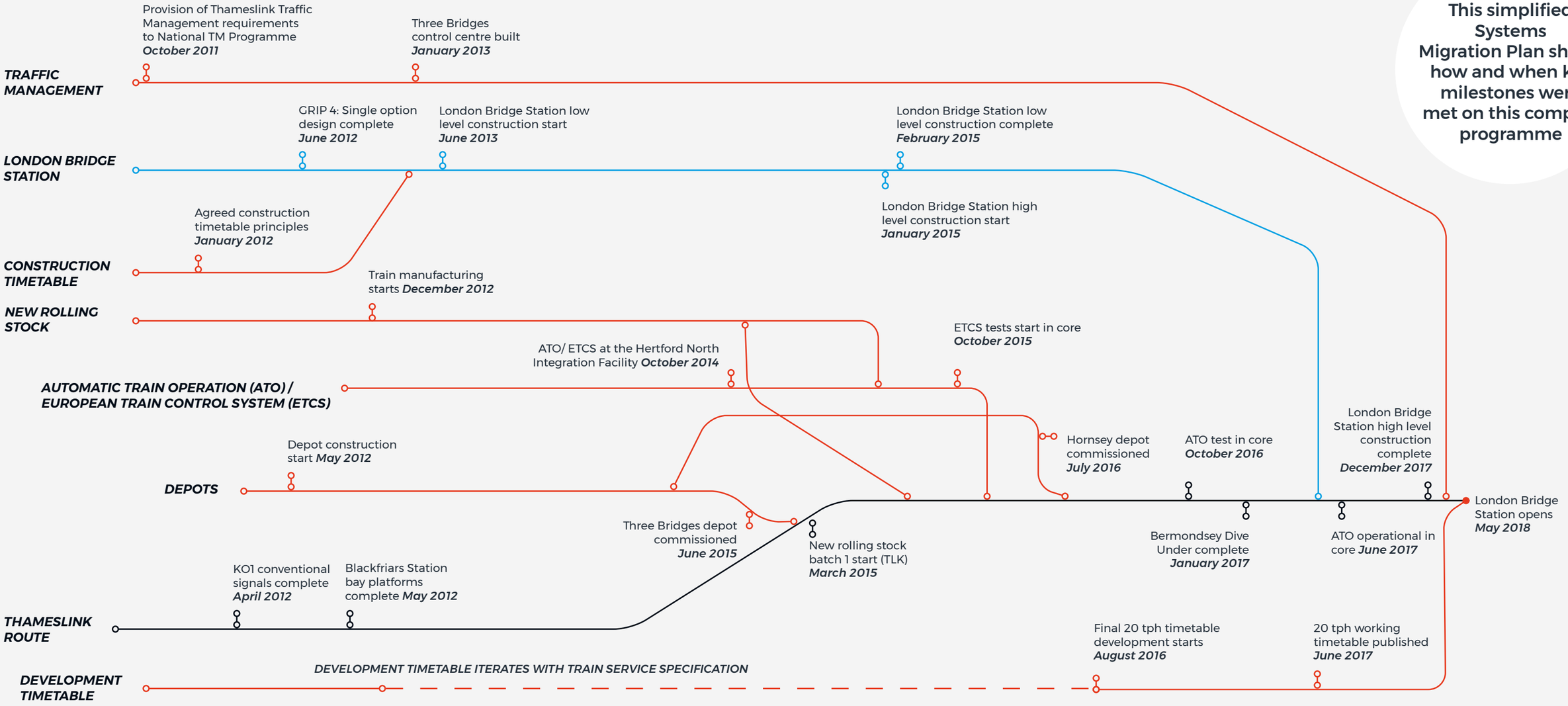
The vertical integration between key stakeholders in the rail industry, like train and track operators, took a step forward when WSP's approach to systems engineering and integration engendered a singular vision of the Thameslink Programme. Recognised in the 2011 McNulty Report 'Realising the Potential of GB Rail', our approach – known now as SI:D^3 (System Integration: Develop the strategy, Define the system, Deliver integration), helped to define the many requirements, manage interfaces and deliver outputs in a constrained timeframe.

WHY DO MEGA PROJECTS NEED A DEDICATED SYSTEMS INTEGRATOR?

Major rail programmes are notoriously difficult to manage due to their size, duration, number of contract interfaces and staged delivery. Systems integration is a method which can help manage this complexity by:

- Clearly setting goals and defining the resulting benefits
- Establishing an overall governance structure with lines of accountability
- Planning the progressive introduction of the system's capability to minimise the technical, operational and programme risks of 'big-bang' introductions
- Developing system architecture views to better understand the affected system
- Developing concepts for future operations and maintenance regimes
- Identifying and mitigating 'whole-system' risks and issues

This simplified Systems Migration Plan shows how and when key milestones were met on this complex programme



2011	2012	2013	2014	2015	2016	2017	2018

DEPOTS

Designing facilities for new Thameslink trains

The Thameslink Programme introduced new rolling stock requiring maintenance depots and stabling facilities. Our innovative designs for seven depots and stabling sites drove health and safety, constructability and sustainability while keeping the programme on track.

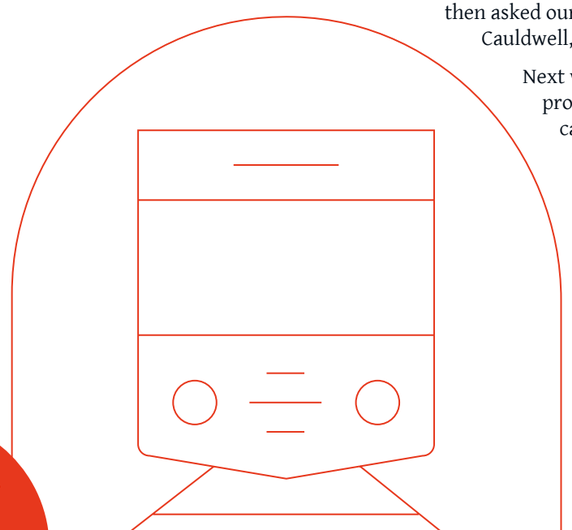
Once the Department for Transport (DfT) had defined the train service and our systems integration work had identified the rolling stock requirements, it was possible to map the precise location, capacity and requirements of the depots and stabling facilities. Our multidisciplinary team responded fast to keep the programme on track. For example, it took us just three weeks to deliver our report on options for a new Selhurst stabling facility that would enable the London Bridge Station upgrade to proceed.

DELIVERING AGAINST A TIGHT TIMESCALE

We delivered the option selection reports for Brighton and Horsham stabling sites in less than three months – a tight timescale mandated by the DfT. Network Rail then asked our multidisciplinary team to assess design options at: Bedford Cauldwell, Cricklewood, Cambridge, Selhurst and Peterborough.

Next we developed the single option designs for six depots, providing the designs and surveys – including topographical, cable management and ground investigation surveys, to avoid damaging utilities – and the all-important Approval in Principle. Four separate and independent audits demonstrated that our team applied the same high level of service across all sites.

Our early design of the Cricklewood stabling emphasised safety-by-design principles by keeping operators, maintainers and other users of the facility as far from the busy West Coast Main Line as possible.



UNEARTHING LONDON'S DARK PAST

In preparing the ground for an enlarged stabling facility at Selhurst, our team exposed the scars of a city ravaged by bombing campaigns during both world wars. For Project Manager Rita Tayfield, it was a fascinating, albeit sobering, experience:

"Before undertaking our review of the site's history, chiefly to assess the risk of disturbing unexploded ordnance, I had not really appreciated the extent of bombing that London had been exposed to.

"It was interesting to piece together the past through historical mapping, aerial photography and military intelligence, but it was also a sad reminder of London's violent and not-too-distant past. It certainly gives me pause for thought when I pass this otherwise innocuous depot on my daily commute, but ultimately I feel proud to look at the additional section and think 'we designed this.'"

Bridge: Thomas Graham

ELECTRICAL TRACK EQUIPMENT

Working around the clock to get it right first time

Electrical track equipment (ETE) delivers the electrical supply for the conductor rails that power Thameslink trains. Renewing this equipment to enable trains to run, and to ensure a high-performing and reliable railway, demanded detailed designs that were right first time.

Our solution ensured that the next generation of track circuit technology could be successfully implemented. Our team advised on the implementation of a brand new substation to supply power to the trains at London Bridge Station, and on upgrades to existing substations.

Kit Ma, who led the WSP ETE team, recalls the sense of responsibility: *"Without an ETE system there would be no train service, so ensuring that it was completed on time and without delay was key to successful delivery. We couldn't relax until the services were up and running. But the sense of achievement at returning every service on time certainly outweighed the personal sacrifice."*

"I never thought that within a year of graduating my designs would be being used on a real project, let alone the largest and most complex railway project in the country."

The contribution of graduates, like Nick Haynes, enabled the programme to be delivered on time. Now a Senior Chartered Engineer, Nick recalls his first project fondly.

MEETING EVERY MILESTONE

To de-risk this highly complex project, construction was delivered across more than 70 stages. These were undertaken in 'possessions' where train services were suspended so work could take place safely and efficiently. With some possessions taking place in multi-day blockades, the ETE team had to work around the clock with the contractor and Network Rail to get everything in place and ready for passenger services to resume.

Together with Network Rail, our team supported the upgrade work on-site while the railway was shut down – usually during weekends and public holidays. The largest possession – 9 consecutive days – was delivered without one adverse media comment.

Our cable routing had to be threaded through a congested station throat and around existing trackside equipment. The scale of the task was unprecedented, Dennis Tregay, principal ETE engineer on the project, recalls...

"We designed four chambers within the listed arches to conceal the 70 cables that were coming from the substation and bring them to track level. Competition for space with signalling and power cables meant we had to be careful to avoid cable crossover. Once the route was established it was then a case of physically hauling them up through the chambers one by one and threading them through convoluted routes."

SAFETY AND RELIABILITY BUILT IN

Good ETE design should enable tracks to be maintained and faults to be cleared with minimal disruption to the service. Our design ensured small sections of track could be isolated separately, giving train operators and maintenance personnel flexibility to work safely.

DIGITAL RAILWAY
Delivering a world first

The Digital Railway can enable increased capacity, improve reliability and introduce a step change in passenger services and safety on the mainline railway. Using ATO and ETCS Level 2, trains can run closer together. And traffic management systems (TMS) can reduce and even avoid delays caused by disruption.

These benefits were purely theoretical until the Thameslink Programme took the Digital Railway from drawing board to reality.

From 2010 to 2012, WSP worked with Network Rail as system integrator to plan the implementation of this state-of-the-art technology. The result? A future ready Thameslink service that will feature greater throughput of trains through central London at peak times, and give passengers and staff detailed, real-time journey information that puts them in control.

Mike Stubbs, WSP's Digital Railway Director: *"The successful implementation of ATO and ETCS Level 2 on the Thameslink Programme shows the rest of the industry that a Digital Railway is possible and, more importantly, highly desirable."*

PROVING THE TECHNOLOGY CASE

Incorporating all-new digital signalling technology required extensive long-term planning. In 2011, our System Migration Plan clearly signposted precisely when every element of the ATO, ETCS and TMS technology needed to be tested to enable full confidence ahead of every major service change up until 2018 and to correspond with our construction plan.

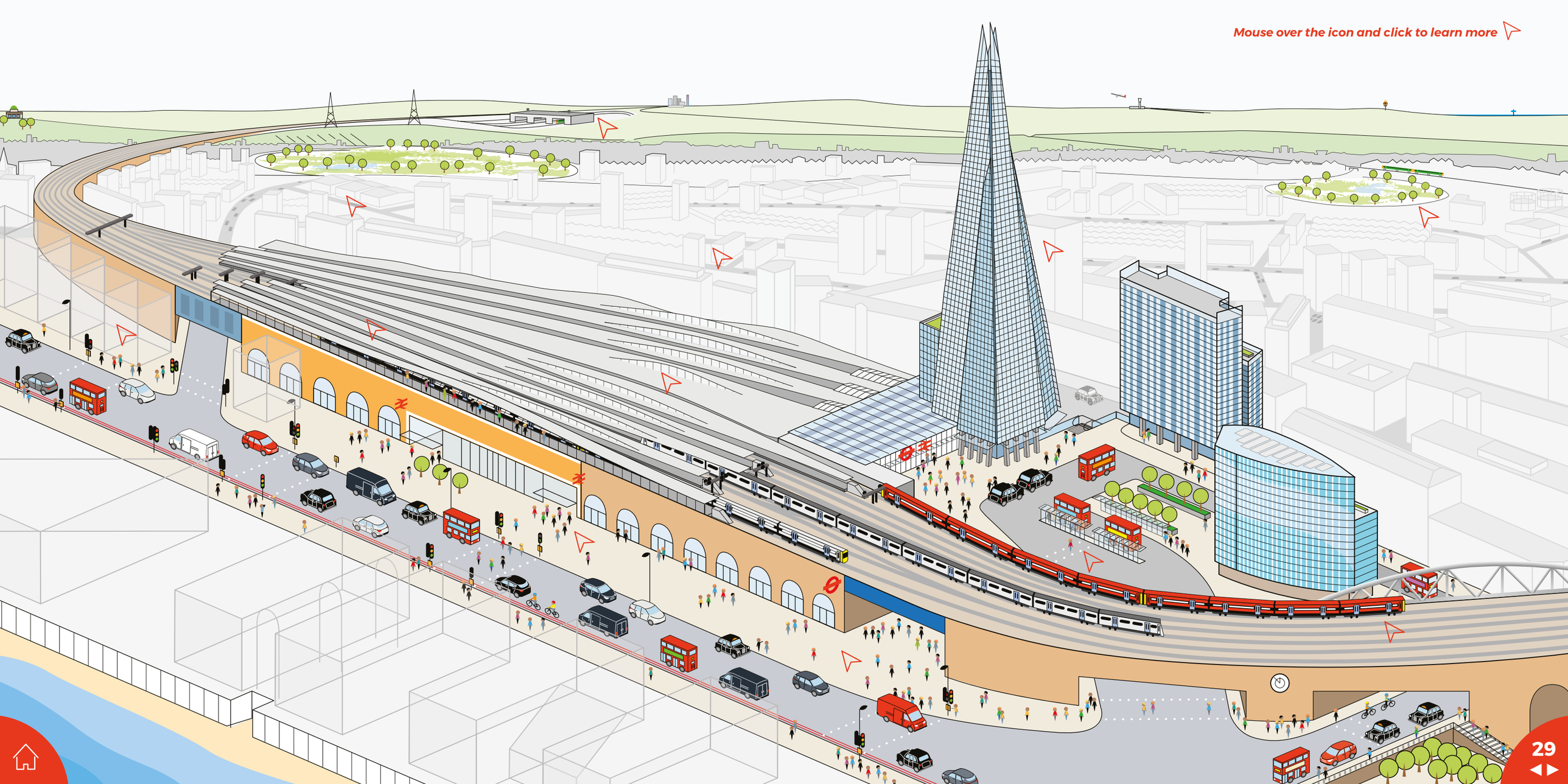
European Train Control System (ETCS) – a supervisory system that tells a driver the speed and the movement authority by which to drive. If the driver falls outside these parameters, ETCS will intervene.

Automatic Train Operation (ATO) – the train's movements and speed are controlled automatically, the driver retaining control of functions such as the doors. ATO is used on the Jubilee, Northern, Victoria and Central lines on the London Underground.

COMBINING TECHNOLOGY FOR THE FIRST TIME

The Thameslink Programme Partners realised early on that a human driver would be unable to deliver the desired performance in and out of the platforms. Combining ATO and ETCS technology for the first time, we overcame this challenge and early testing de-risked our novel strategy well in advance of the timetable change.

Image: Siemens



STATION DESIGN
Creating a destination station

London Bridge is an important link between the capital and south-east England and various railways have been vying to use the station since it was constructed in 1836. It has been rebuilt and extended many times, with sporadic redevelopment driven by the political machinations of the Victorian and Edwardian railways, damage from two world wars and London's growing population.

The need for the latest comprehensive redevelopment was identified after passenger demand outgrew the breathing space granted by the last upgrade in 1978. Four decades later, we have led the development of a bigger, more accessible station that provides more train services with better connections. To achieve this we had to unpick a cluttered station design, including reconfiguring the platforms, while ensuring it was business as usual for millions of passengers. It's no surprise that this £900 million station regeneration project was Network Rail's biggest-ever station works.

A NEW BEGINNING

Working with architects Grimshaw and joint venture partner Arcadis, the design for the new station sought to provide an improved customer experience without losing the character and charm that has made the station so iconic. As WSP Project Director Adrian Tooth explains: *"While the different eras of development had created something of a labyrinth underneath the platforms, the new design pays homage to its Victorian roots, with its splendid arches lining the increased retail and leisure space".*

The vision was to create a more connected space, with an open design that links the station more closely with the public realm. The giant new concourse, framed by attractive new entrances on Tooley Street and St Thomas Street, links passengers to the underground station via a sensitive extension of the Victorian arches that run underneath the tracks. It is here that visitors can also enjoy 7,300m² of retail space.

Above the platforms, distinctive 'eyebrow' canopies protect passengers from the weather. Taking a modular approach to the canopies, as prescribed in the construction planning phase, meant using prefabricated sections already containing elements such as wiring for station systems, to enable a quick construction sequence.

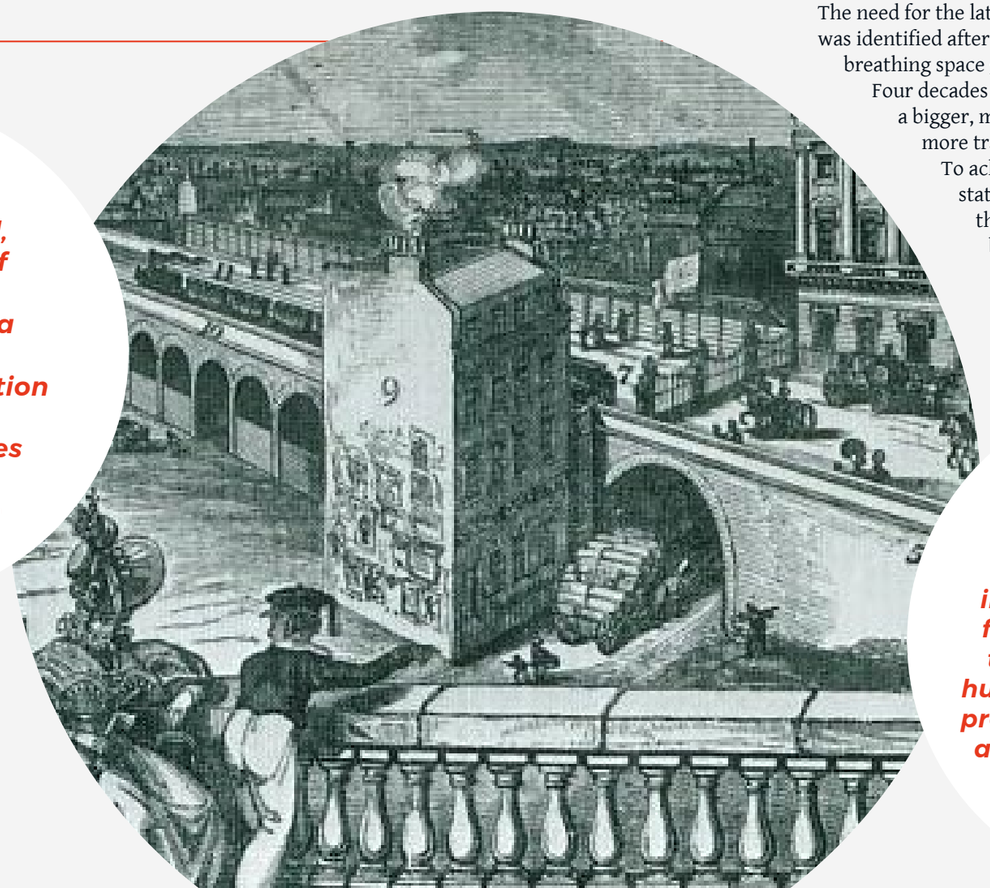
Our integrated design avoided costly utilities diversions and challenged unnecessary requirements, saving £40 million. And our sustainability strategy has helped Network Rail achieve its target of reducing the station's carbon emissions by 20%.

In every way, the transformative design marks a new beginning for London Bridge Station, its passengers and the surrounding area.

"Inside the station, everything's so old, So inconvenient, of such manifold Perplexity, and, as a mole might see, So strictly what a station shouldn't be, That no idea minifies its crude And yet elaborate ineptitude."

John Davidson on London Bridge Station

Fleet Street and Other Poems, 1909



"We are in awe of the engineering achievements and architectural ingenuity involved in the project. The finished station finally ties the area together with its huge concourse at the centre, providing a space that can be a cultural as well as a retail destination in its own right."

Nadia Broccardo, Chief Executive of Team London Bridge

Image: Team London Bridge

London Bridge won 'MAJOR STATION OF THE YEAR' at the 2018 National Rail Awards

Judges said that "the redevelopment had given the UK a new 'Cathedral' station in place of a mundane congested legacy."

PLANNING CONSENTS
Achieving project approval

We obtain planning consent for clients on large, complex and nationally significant projects. London Bridge Station was all of these things: the planning application boundary of the site extended to just over six hectares; the site was surrounded by a heavily used road network; there were sensitive land uses nearby, including Guy's Hospital and Southwark Cathedral; and the station redevelopment was key to the wider Thameslink Programme.

NAVIGATING THE PLANNING PROCESS

WSP successfully led the London Bridge Station redevelopment project through the environmental impact assessment (EIA) process. To support the planning process and achieve consent on behalf of the client, we worked closely with project planning consultants and station architects Grimshaw, while engaging with the local community and other key stakeholders to understand their concerns.

Our first step was a gap analysis of EIAs prepared for surrounding areas over the last decade – to ensure that the cumulative effects of development were properly understood. From the beginning we engaged and negotiated with environment stakeholders including the Environmental Health Officer, London Borough of Southwark, Natural England, English Heritage, Transport for London (TfL) and the Environment Agency. This close collaboration enabled us to draw a tight and robust scope for the assessment, which meant we could deliver the EIA within budget, in just six months.

The highly complex risk assessment required specialist studies. As well as examining the air and noise impact of construction works, we had to consider the effect of demolishing listed structures and buildings in a conservation area, as well as the impact of the project on local flora and fauna, including rare birds.

MINIMISING THE IMPACT OF CONSTRUCTION

We effectively managed stakeholder objections to construction by minimising disruptions and proving to local area users that we had accommodated their needs. Using TfL's traffic model, we determined the impact of the temporary closure of two strategic roads. We also modelled local noise and air quality to provide a more detailed picture of the potential effect of construction traffic. This study enabled us to smooth the peaks in HGV movements, reducing traffic disruption and environmental impacts by minimising emissions.

PAYING HOMAGE TO HERITAGE

To meet the conservation requirement for listed buildings, much of the station's Victorian heritage has been preserved, including the characteristic quadripartite arches in the Western Arcade that link the new concourse to the underground station. The project required the demolition of the Victorian South Eastern Railway office building in Tooley Street to create the new station concourse. This proposal attracted public scrutiny, making careful management of local stakeholders essential in gaining planning approval.

SAFEGUARDING RARE BLACK REDSTARTS

The black redstart is a robin-sized bird that has adapted to live at the heart of industrial and urban centres. It's also very rare, with fewer than 100 breeding pairs in the UK, and it's protected under the Wildlife and Countryside Act 1981. Surveys before the start of work at London Bridge identified two black redstart territories, so we incorporated measures into our planning to avoid disturbing the birds. Ongoing monitoring protects this precious population.

SUSTAINABILITY
Setting a new benchmark

Sustainability was at the heart of our future ready design for London Bridge Station, our client setting demanding targets from significant CO2 savings to achieving a net gain in biodiversity.

As a result of this push for excellence, our work on the redevelopment of London Bridge Station set a new benchmark for sustainability. It achieved a score of 97.3% in CEEQUAL, the evidence-based sustainability assessment, rating and awards scheme for civil engineering, infrastructure, landscaping and public realm projects. This is one of the highest ever scores for a transport project.

BOOSTING BIODIVERSITY

Major construction projects can affect plants and animals living nearby. To understand how the work at London Bridge Station could make a positive impact overall, we began by measuring the levels of biodiversity at the start of the project. We then used this to create a baseline for the whole route, with the biodiversity metric issued by the Department for Environment, Food and Rural Affairs (Defra).

How could we improve biodiversity from this baseline by the end of the project? Biodiversity offsetting involves conservation activities that are designed to compensate for losses – ensuring that when a development damages nature, new, bigger or better nature sites will be created. We helped achieve a net gain for biodiversity by developing robust protocols for biodiversity offsetting and partnering with the London Wildlife Trust on initiatives including a programme of planting at Streatham Common in Lambeth.

The Thameslink Programme is the first Network Rail infrastructure project to achieve a net positive gain for biodiversity, and Defra named it as a demonstration project as part of its national pilot test on biodiversity offsetting.

CUTTING CARBON EMISSIONS

Heating and cooling the newly designed station would be highly carbon-intensive if regular temperature control methods were used. The carbon reduction and energy-efficiency measures we incorporated into the station design enabled Network Rail to meet its target of reducing CO2e emissions by 20%.

10 SUSTAINABLE MEASURES FOR A FUTURE READY STATION

1. The station concourse is designed to be naturally ventilated, so no cooling is needed in this area.
2. Innovative geothermal loops in 145 structural piles generate natural heat and cooling, acting as a heat source in winter and a heat sink in summer to save 79 tonnes of CO2e annually.
3. Condensing loops supply retail units at the west and east ends of the station with highly efficient cooling.
4. ‘Eyebrows’ create a vertical rise in the canopy profile, letting natural light in and reducing the need for artificial lighting.
5. Where artificial lighting is required, the LED fittings will save over 235 tonnes of CO2e annually.
6. We introduced energy-saving variable speed escalators that operate on demand, saving over 36 tonnes of CO2 every year.
7. Despite the contaminated nature of the site we were able to re-use 5,000m² of aggregates and divert 98% of waste from landfill.
8. The utilities design optimises voltage and reduces the requirements for uninterruptable power supply – with battery backup reduced from three hours to just one hour.
9. The station design incorporates around 700 cycle spaces, promoting active travel.
10. By specifying 98% recycled steel, we achieved a 58% reduction in embodied carbon compared to industry standards.

Image: Thomas Graham

SMART BUILD
Reducing construction time

Breaking down construction work at London Bridge Station into more than 70 sub-stages to keep the station open reduced the impact on passengers and train services, but it posed a major challenge for the project team. To squeeze the build into the limited time available, we identified opportunities to use modular construction for elements of the station including the façade, platforms and canopies – and harnessed the power of 3D and 4D building information modelling (BIM) to help us do it.

MODULAR CANOPIES

The distinctive form of the canopies that flow along the station's platforms was born out of necessity. A full station roof was the planning authority's preferred option, but this was unaffordable for the client. So, working with contractor Costain and architect Grimshaw, we took the unusual step of covering the platforms with a series of flowing steel and aluminium canopies.

During early construction planning, we understood that canopies built as modules off-site and then craned into place, instead of fabricating sections on site, would speed up the construction sequence.

Each module is approximately 9m deep by 3m wide, and is pre-loaded with everything it needs – including speakers, lighting and cameras. Due to the striking, undulating geometry of the rooftop, each of the 1,200 steel cassettes was a bespoke unit. As well as speeding up the assembly process, manufacturing these elements off site helped deliver the high-quality finish required of the design – something that's easier and safer to achieve in a factory environment than on a building site.

"The modular design led to canopy construction proceeding at a rate of 50m a week, faster than typically seen."

Claire Gott, Senior Engineer

Prototypes enabled the planning authority to review the design and gave the construction teams the chance to practise erecting the units. Together with the attention to detail it allowed during the design stage, this meant that when construction began everything went smoothly. Three-metre sections were delivered and installed quickly and safely on a plug-and-play basis during the short night time construction windows.

As well as improving speed, safety and quality, modular construction enabled us to future-proof the station. Our design took into account forecast demand for 2016 plus 35%, allowing for the next 60 years of passenger growth. But we recognised that, within this timescale, the station design should also allow adaption and alteration. Using standard materials, modular components, and panels in manageable unit sizes means elements can be removed, replaced or altered easily and cost-effectively in the future.

THE NEED FOR SPEED

Designing for modular construction was just one of the many uses of BIM at London Bridge, for which we created one of the most complex 3D models used on a Network Rail project to date.

A full, multidisciplinary 3D BIM model helped manage all the different stages, ensuring that conflicts were identified and designed out before construction of the stage began. We also used the model to create a visual fly-through showing Network Rail and stakeholders, such as train companies, what would happen at each stage in construction.

Even after the station re-opened to passengers, we continued using 3D BIM to complete preparations for the handover to Network Rail. Mandy Thomas, Station Design Team Lead, led the team preparing for the handover, a task which included preparing 10,000 as-built drawings to guide the ongoing operation and maintenance of the station.

Mandy notes that it's not just the model that has helped to maintain close collaboration:

"We were co-located with our client in their office, along with Grimshaw Architects and Arcadis. It was a very collaborative environment, and one in which many people have worked for the entire length of the project – helping to ensure that information has been retained."

PASSENGER EXPERIENCE
A people-friendly space

Our ultimate objective of improving the passenger experience was achieved by boosting capacity and enhancing the station environment.

With a carefully planned construction programme we did this while keeping the station open throughout. The result is a station fit for the 21st century – modern, spacious and fully accessible, and a destination in its own right.

MINIMUM DISRUPTION, MAXIMUM SAFETY

Understanding exactly how passengers use the station was vital. *"We worked with station designers, passenger demand and pedestrian modellers, and railway systems designers to propose a construction sequence that would minimise the impact on passengers, both through and at the station,"* says David Carter, WSP Construction Planning Manager.

Our progressive handback solution meant we could demolish old platforms and progressively reconfigure the tracks, reducing the number of closed platforms to three out of 15 at any one time to minimise passenger disruption.

Progressive handback also made the station environment safer during construction. In the planning stage we tested this by developing a comprehensive pedestrian model to check capacity for each construction stage, accounting for hoarding positions, access and overhead working.

Our robust programme meant only three timetable changes were required over the five-year period. It also contributed to a step-change in passenger communications, enabling operators to plan for and communicate service disruptions to passengers via social and mainstream media. Commuters appreciated this much needed continuity as it enabled them to re-plan their journeys ahead of time.

LONDON'S BIGGEST STATION CONCOURSE

"The huge, street-level concourse is the largest in the UK, and roughly twice the size of the pitch at Wembley Stadium," explains Adrian Tooth, Project Director at WSP. *"Overall, the project has created two-thirds more space, enabling almost twice as many passengers to use Britain's fourth-busiest station every day."*

The concourse, with its central load points to improve passenger flow, will ease peak-time passenger congestion and simplify interchanges. The attractive environment includes clear wayfinding and enables free movement through the station from street to platform.

London Bridge won the PUTTING PASSENGERS FIRST category at the 2018 Rail Partnership Awards.

Image: Team London Bridge

We undertook a sound study to ensure announcements would still be audible to passengers as reverberations from the trains passing over the bridge decks echoed in the cavernous new concourse. We played sound recordings of trains going over different types of structures, and applied dampening factors to understand the impact of different design scenarios.

LONDON QUARTER
Achieving a unified vision

Our role in redeveloping the area around London Bridge Station is extensive. In designing the four key projects that are now synonymous with the London Quarter we realised our unified vision for a positive, integrated space for residents, workers and visitors.

THE SHARD

Adjacent to London Bridge Station is the project that kick-started the regeneration: The Shard. Our structural engineering expertise helped deliver architect Renzo Piano's 1.37 million sq ft mixed-use 'vertical city' – the tallest building in Western Europe at 309.6m – quickly and safely.

Innovative construction methods enabled the building to be completed in just 44 months. These included the world's first use of top-down construction for the core of the building, which was built off plunge columns on piles before the excavation of the basement.

The Shard's tapered form was made possible by a hybrid structure comprising three distinct systems: a steel frame for the first 40 floors, a post-tensioned concrete frame up to level 72, and a steel spire to the equivalent of level 95.

Using concrete rather than steel in the middle section absorbs wind energy and eliminates the need for a tuned mass damper, freeing up two entire residential floors. Thinner concrete floors also meant we could fit in an additional floor within the building's total height.

The building's 500-tonne, 66m steel spire sits 300m up. Ground level prefabrication and assembly, along with detailed training and lifting plans, eliminated the risks of assembly at such an unprecedented height.

The completed building has become a feature of the London skyline and hosts 8,000 workers, residents and hotel guests daily, as well as a million visitors every year.

SHARD PLACE

The final element of the Shard Quarter redevelopment around London Bridge Station, Shard Place is a multi-storey residential tower designed by WSP with architect Renzo Piano. It comprises a 27-storey north block and a 16-storey south block, roof gardens, public realm and retail space.

We devised an efficient solution for the superstructure – a concrete frame with 200mm post-tensioned flat slabs and blade columns. Placing the concrete core centrally between the two blocks provides lateral stability. Beyond this, the design is a direct response to the site and its constraints.

The building's shape was determined by the existing street elevations. The public realm and planting reflects the differing ground levels on the north and south sides. While the structural design accounts for constraints underground – including a Jubilee Line tunnel, a ventilation shaft and other foundations.

Ensuring Shard Place's foundations did not impede underground assets was vital. We used a series of transfer structures to achieve this, employing them on the south block to deliver Renzo Piano's goal of making the building appear to float by reducing the number of columns.

To avoid the London Underground assets below, ten steel mega-columns support the north block while the south block has eight steel mega-columns.

The result is a building that turns site constraints into a virtue.

THE NEWS BUILDING

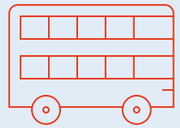
Located close to London Bridge Station, the News Building demonstrates how intelligent engineering solutions can triumph over a whole series of demanding site constraints.

As multidisciplinary engineers for the project, we ensured construction did not hinder the daily operations of the existing bus station – an important transport hub that lies under the building. We also had to design around the clearance zones and soil-bearing capacities of a host of assets in and around London Bridge underground station, including the main ticket hall. This meant that only 45% of the building's basement footprint was available for foundations.

Despite these constraints, we designed an 18-storey, twin-cored composite steel superstructure with a single-storey basement. Extensive transfer structures were needed, along with inclined columns that transfer loads diagonally into the cores and allow the building to extend by 14m over the area without foundations. This maximised the use of a very difficult site.

With no supports permitted in the area over the live bus station, we used another transfer structure to ensure it could remain open to passengers during the London 2012 Olympics and beyond.

To enable coordination on such a constrained site we placed all the project information in a 3D building information model (BIM). This was one of the first buildings in London to use BIM from start to finish and it enabled works to be closely monitored, particularly the cladding, and reduced the number of post drilled service penetrations in the structural core by more than tenfold.



BUS INTERCHANGE

The bus interchange was a total reconfiguration of the original bus station layout moving away from the front of the station to create a new concourse area in front of the Shard. Integrated, accessible transport was vital to the successful regeneration of London Bridge Station and the surrounding area. On a constrained site, the existing bus interchange had to be upgraded to handle not only buses but taxis and pedestrians as well. It also had to accommodate forecast growth in demand, enhance the public realm, meet all operational and safety requirements and be compatible with all the neighbouring schemes – including integrating with the train station.

The project was jointly funded by the quarter's developer, Sellar Properties, and Network Rail and was developed in close liaison with Transport for London. So another key challenge was obtaining accord on the different stakeholder requirements.

We were responsible both for the finished designs, and for phasing the delivery of the project – a complex logistical challenge. To deliver an interchange that met a multitude of challenges, we deployed our pedestrian modelling expertise and developed proposals for phased construction that coordinated with all neighbouring construction activities and kept the bus interchange open throughout. The finished interchange is a vital element in the transport-led regeneration of this area of London.

LONDON BRIDGE AWARDS

A MULTI-AWARD-WINNING PROJECT

National Award, London Award, London Building of the Year | RIBA Awards 2019

World Architecture Festival Winner – Transport category | 2019

CEEQUAL Excellent Whole Project Award 97.3% | 2019

Putting Passengers First | Rail Partnership Awards 2018

Transport Project of the Year and ICE 200 Award | British Construction Industry Awards 2018

Station of the Year prize | British Transport Awards 2018

Station of the Year Award | National Rail Awards 2018

Overall Winner, Sustainability Prize and Transport & Infrastructure Winner | New London Awards 2018

Winner | Structural Steel Design Awards 2018

Green Apple Award | Green Council 2018

Greatest Contribution to London Award | The Institution of Civil Engineers 2017

BIM Project Application Award | British Construction Industry Awards 2015

UK Project with a Geotechnical value of over £3M | Ground Engineering Awards 2014

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WSP is one of the world's leading engineering professional services consulting firms. We are dedicated to our local communities and propelled by international brainpower. We are technical experts and strategic advisors including engineers, technicians, scientists, architects, planners, surveyors and environmental specialists, as well as other design, program and construction management professionals. We design lasting solutions in the Property & Buildings, Transportation & Infrastructure, Environment, Industry, Resources (including Mining and Oil & Gas) and Power & Energy sectors as well as project delivery and strategic consulting services.

With 8,200 talented people in the UK and more than 49,000 globally, we engineer projects that will help societies grow for lifetimes to come. WSP has been involved in many high-profile UK projects including Crossrail, High Speed Two, Manchester Metrolink, M1 Smart Motorway and the London Olympic & Paralympic Route Network.

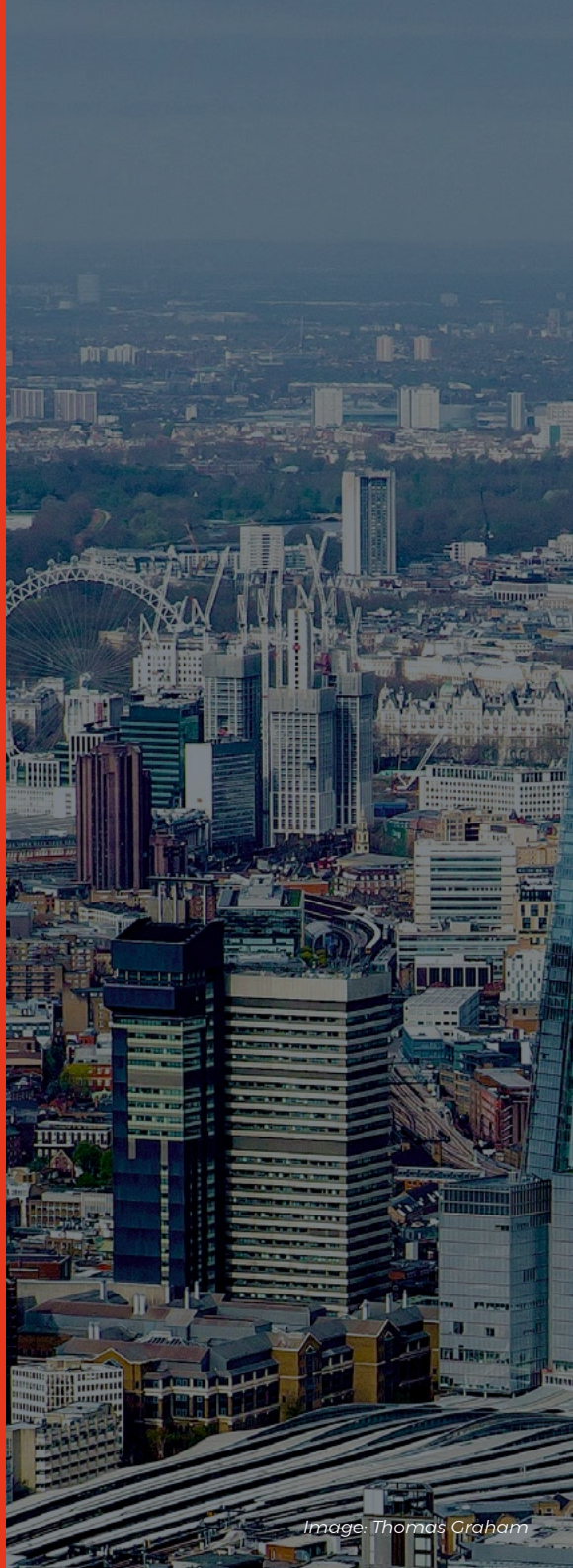

Image: Thomas Graham