

SKANSKA



Connect Plus and M25

**Widening and operating London's
orbital motorway**

Overview

Connect Plus is a Skanska-led availability payment-based design, build, finance and operate (DBFO) Public Private Partnership (PPP) designed to add capacity to the M25, London's orbital motorway, which carries 15% of the UK's motorway traffic, or 200,000 vehicles a day. The construction project included four components:

- Widening 38 miles of highway to four lanes, in four sections
- Refurbishing a three-quarter-mile, two-bore tunnel
- Widening and converting a further 28 miles into the UK's first smart motorway
- Removal of the toll plazas and cash collection at the Dartford Crossing

The partnership also includes operation and maintenance of the whole 117 miles of the M25's existing and new road, as well as a further 117 miles of 'stubs and tails' into London and

to two of the world's busiest airports (Heathrow and Gatwick), plus the road's 1,800 structures, including 750 bridges and 150 gantries, five tunnels and one long span bridge. The 30-year concession with the UK Highways Agency is one of the UK's largest ever PPPs.

Construction was completed in two phases: the first in 2012 in time for the London Olympics, and the second in 2014. Operation and maintenance are ongoing, and the concession runs from May 2009 to September 2039, with services having started in September 2009 on financial close. The entire contract was worth US\$9.78bn* at Financial Close. Construction accounts for \$2.17bn of this and lifecycle/operations and maintenance (O&M) the remainder.

* Exchange rate based on prevailing rates, from British Pound to US Dollar, at Financial Close.



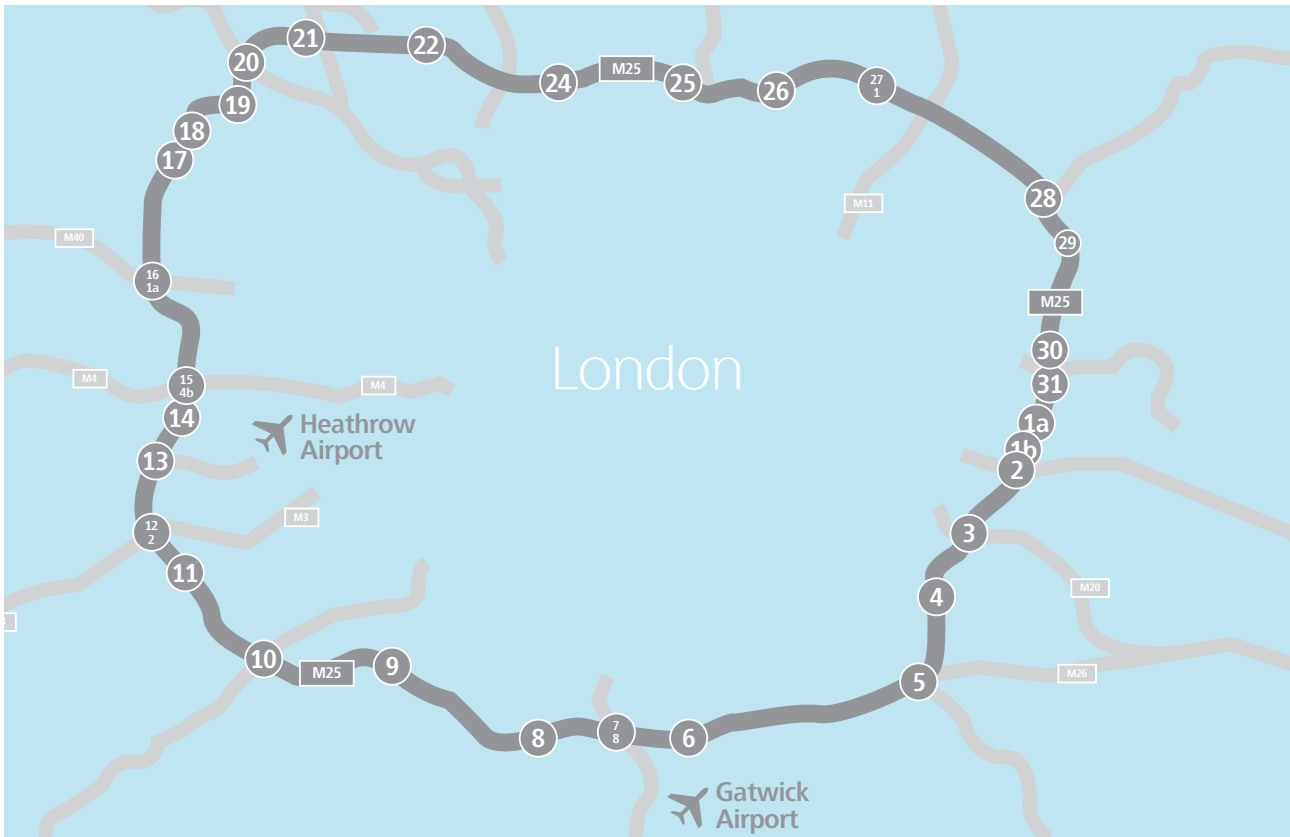


Skanska has 40% ownership in Connect Plus (an investment of \$124m), alongside Balfour Beatty (40%), Egis (10%) and Atkins (10%). Construction was delivered by a 50/50 construction joint venture between Skanska UK and Balfour Beatty, where Skanska's share of the contract was \$1.08bn. Connect Plus has responsibility for lifecycle management, with operations and maintenance (O&M) being delivered by Connect Plus Services, a joint venture between Balfour Beatty (52.5%), Atkins (32.5%) and Egis (15%).

Financing this immense project was challenging, as negotiations took place in the teeth of the global financial crisis and immediately after the collapse of Lehmann Brothers. With the cost of debt soaring and the appetite for risk low, Skanska took the lead in negotiations, bringing together a wide group of lenders and developing a risk profile that satisfied the Highways Agency client.

The \$2.01bn project funding was made up of \$1.43bn of floating rate senior debt provided by 16 commercial banks, a separate \$285m facility from the European Investment Bank and \$309m provided by the shareholders of Connect Plus. A complex series of interest rate swaps saved \$465m on the cost of borrowing.

The construction project was delivered early and to budget, despite additional availability pressure created by the 2012 Olympics, which used the M25 as the key route from Heathrow to the Olympic Park. The lifecycle/O&M associated with such a vast, complex and aging asset have been more challenging. But a unitary charge linked to inflation has allowed Connect Plus to invest beyond its contract in renewal, safety and capacity, and to maintain its key target of 50mph across the whole motorway.



Transportation Sector

Highway and interchanges

Project Similarities

Complex Design-Build contract
 DBFO PPP in the UK
 Large financing size
 Large participation by developer/contractor

Reference

Highways Agency UK (re-branded to Highways England in April 2015)

The project in figures

Concession: 2009-2039
 Construction: 2009-2014
 Construction: Skanska 50%
 Construction value to Skanska: \$1.08bn
 Skanska investment: \$124m
 Shareholding: Connect Plus Consortium – Skanska (40%), Balfour Beatty (40%), Atkins (10%), Egis (10%)
 Skanska Balfour Beatty construction JV – Skanska (50%), Balfour Beatty (50%)

Design, construction and finance of Phase one - the Initial Upgraded Sections (IUS), including:

Section 1x
 M25 Junction 16 to 18 (12 km) widening
Section 1y

M25 Junction 18 to 21 (12 km) widening
Section 1z
 M25 Junction 21 to 23 (13 km) widening
Section 4
 M25 Junction 27 to 30 (25 km) widening
Section 6
 Hatfield Tunnel refurbishment
 All completed Sept 2012

Design, construction and finance of Phase two - the Later Upgraded Sections (LUS), including:

Section 2
 M25 Junction 5 to 7 (17 km) widening
Section 5
 M25 Junction 23 to 27 (27 km) widening
 All completed December 2014
 Payment Mechanism: Availability
 Date of Financial Close: May 20, 2009
 Construction Start Date: Early works started before FC (Jan 2009 Early works agreement)
 Concession Period Length: 30 years
 Concession Period Year End: 2039
 Project Value at time of Financial Close \$9.78bn
 Equity Investment/Financing Size at time of FC: \$309m/\$1.71bn senior debt
 ID's Equity Investment at time of FC (and percentage): \$124m (40%)
 O&M Value at time of FC: \$7.6bn
 Debt/Gearing 85:15



The challenge

London's 117-mile M25 is one of the world's largest orbital motorways. Originally intended as an orbital bypass of the city for long distance traffic, the road's design included numerous junctions that have attracted local and commuter traffic.

Since its completion since 1986, the M25 has become increasingly congested, carrying 200,000 vehicles a day, of which 50% use the M25 to travel to and from work. For many years, the M25 was often called 'the world's biggest parking lot'.

In May 2009, the Highways Agency awarded the Skanska-led consortium Connect Plus a 30-year DBFO contract to add capacity to the M25 and manage it and key arterial link roads.

- An initial project to widen two sections of the road to four lanes by adding 38 miles of new road, plus refurbishing the Hatfield Tunnel on the A1(M), was completed in 2012 in time for the London Olympics.
- A second phase of widening was completed in 2014, adding 28 more miles of road to two sections, which have also been converted to smart highway, and converting the tolled Dartford Crossing to a freeflow system.

- The contract also includes the operation and maintenance of the new and existing sections of the M25 and a further 117 miles of associated stretches of motorway and trunk roads and the Dartford Crossing for 30 years.

The widening work was completed on behalf of Connect Plus by the Skanska Balfour Beatty Joint Venture (SBBJV) in two phases, supported by designer Atkins, alongside the Hyder Halcrow Joint Venture acting as the client's representative.

The benefits of the scheme include:

- Improved and more reliable journey times
- Reduced congestion
- Enhanced motorway safety
- Better driver information
- Faster-flowing traffic at the Dartford.

At the peak of construction, the team delivered a mile of road a month at a cost of \$1.55m per day, employing between 3,500 and 4,000 people.

During the life of the concession, we are spending around \$3m per week on lifecycle and maintenance, with 700 permanent jobs.



A major construction programme

Phase one

- 38 miles of road widened
- 35 months
- 125 gantries, including 44 super-span gantries
- 2,168,092m³ of material excavated and recycled
- 58 miles of sheet piling to retain the embankment
- 350 miles of cable
- 124 miles of drainage
- 360,000 m³ of concrete
- 500,000 tonnes of recycled road planings
- 11,872,000 man-hours worked
- Two .75 mile bores at Hatfield Tunnel refurbished to EU standards
- 170 miles of cabling and 56 jet fans installed in the tunnel

Phase two

- Two new sections converted to 'all-lane running'
- 28 miles of new road
- Delivered 22 weeks early, saving 25% of program duration
- \$37m cost saving shared with client
- 9 gantries that span both carriageways
- 23 refuge areas

- 39 emergency telephones
- 167 overhead signals
- 91 verge mounted signs
- 95 CCTV cameras.

Phase two was completed as part of the Connect Plus Smart Motorway All Lanes Running (SM-ALR) initiative, the UK's first highway of this type, which also developed and deployed cutting edge technology. Under SM-ALR, the hard shoulder is permanently converted into a traffic lane on these sections of the motorway and replaced by regularly spaced emergency refuge areas, each one with an emergency telephone. CCTV cameras help the operations room to spot incidents and deal with them as fast as possible. Other innovative technologies used include LED signs, radar vehicle detection and remote diagnostics

For vehicles which can't make it to an emergency refuge, smart motorway technology allows the closure of any lane by the display of a red "X" on the gantries, moving traffic away from the incident and keeping it clear for emergency vehicles.

All lane running increases the capacity of the motorway to reduce congestion and makes journeys more reliable at a considerably lower cost and with less disruption than a traditional road widening scheme.

Collaborative planning with our supply chain and Highways Agency client allowed us to reschedule the program for concurrent working on two phases, which helped us deliver the project 22 weeks early at a saving of \$37m, which we shared 50/50 with the client.

Sustainability and environmental management

The M25 DBFO partners were committed to working in the most environmentally responsible manner. Before starting work, the project team carried out a full environmental impact assessment including ecological and archaeological surveys. The comprehensive environmental management plan they produced took into account:

- Ecological works to protect plants and wildlife

- Consultation with regulatory and advisory bodies
- Moving species and habitats that might be affected
- Assessment of ecological information to inform the detailed design of the work

The following measures helped to minimize disruption caused by construction work:

- Use of the quietest possible plant and construction methods
- Controlling dust by covering vehicles carrying dry, dusty materials and mechanically sweeping hard surfaces and exits onto public roads
- Use of low noise surfacing materials
- Noise and visual protection

A bespoke materials and waste strategy was designed to maximize the use of recycled, secondary and manufactured aggregates in preference to primary aggregates. This approach diverted significant quantities of material from landfill, reducing traffic impact on the local network as well as enhancing the overall sustainability of the project.

Phase one used a total of 2.3 million tonnes, including 1.2 million tonnes of material





processed on site from inert construction and demolition waste, imported from other projects in the south east of England.. This represents 92% recycled content for bulk materials and a saving of 35,000 tonnes of embodied carbon. Where use of primary aggregate was unavoidable, responsible procurement was undertaken in line with BES 6001.

A supplementary earthworks strategy retained 100% of inert material on site. Over 1.8m tonnes of surplus inert soil was diverted from landfill and reused to create eight environmental bund structures at appropriate locations.

These environmental bunds provide visual and noise screening to nearby residential areas with up to 5dB reduction in traffic noise. The bunds were designed to enable the slope facing away from the motorway to be returned to agriculture.

Key statistics

- 2.2m tonnes of high-quality aggregates produced on site – 98% recycled materials
- 250,000 tonnes of glass sand used for drainage and backfill, saving virgin aggregates
- 320,000 tonnes of asphalt – 15k tonnes

of embodied carbon – saved by value engineering during pavement design

- 125,670 trees, 28,000 shrubs planted
- major grassland planting
- 400 bird boxes
- 2,800+ animals moved

Phase two of the project continued this environmental performance, reducing our carbon footprint by 80 percent against traditional road widening programs and saving approaching \$17m per mile completed.

Saving the client money through value engineering and alternative technical solutions

Throughout construction, our team was alert to the potential to save our client money through a variety of technical and value engineering measures. Some of the most effective of these were:

- *King Sheet Piling* – our innovative, patent pending King Sheet Pile (KSP)

system reduces the quantity of steel by 33% and eliminates 45,000 tonnes of embodied carbon, as well as allowing faster construction. The system replaces alternative pairs of the traditional, heavy piles used in the construction of hard retaining walls with lighter, thinner and shorter piling sections spanning horizontally between the remaining full-length sheet piles. The 15 miles of wall installed on the M25 has saved up to 33% of steel and delivered a four-fold increase in productivity in the chalky earth between junctions 16 to 23 of the road, as well as doubling overall installation speed. The sheet piles were sourced from 100% scrap steel using a highly efficient electric arc furnace, reducing the embodied carbon by 75%.

- *Slipforming* – Innovative slipform concrete processes incorporated ducting into the central safety barrier during installation. This carries the miles of cable required to connect the motorway's lighting columns. A much higher slipformed concrete

retaining wall was adopted as a preferred widening solution in the verges, with communications installed behind the wall. Walls up to 2.3m were constructed by this process, which is believed to be the highest slipformed wall in Europe. The slipforming process was faster than other widening options and the resulting narrower verge reduced excavation volumes and overall CO emissions. This technique has also been used for slot drains, surface water channels and pavement widening.

- *Smart motorway* – Phase two of the road widening program used the converted the sections of highway concerned to 'smart motorway', which uses the hard shoulder as a permanent lane, and replaces it with regularly spaced refuges. This saves a substantial proportion of cost as seen by the comparison between phases one and two:
 - o Phase one – road widened and 38 miles added – \$1.55bn
 - o Phase two – converted to all lane running and 28 miles added – \$621m.





Our approach to collaborative planning also saved a further \$37m on the bid price by delivering the highway 22 weeks early, which reduced the program duration by 25% and saved \$37m.

- *Building Information Modeling (BIM) and Laser scanning* – we have used laser scanning techniques to improve worker safety and deliver cost, program and CO² emissions savings. Survey data from laser scans were used to redesign the carriageway over Ockendon Railway Bridge, located between junctions 29 and 30, which kept trains running while the work was carried out. The engineering team initially produced laser scan data to investigate the design and sequencing of widening works across the bridge, which saved repeat journeys to the site. As the scan was completed from a place of safety away from the live carriageway and railway boundary, the program gained 18 weeks by eliminating the need for a three-night railway possession.

The same laser scanning data were used to identify a temporary works clash with the existing structure. A constructed model of the existing structure was compared to the second drawings, which allowed early identification of discrepancies and allowed the design to be adapted before construction, avoiding delay, duplication of work and reordering materials.

Keeping traffic running on this hugely busy highway

While some disruption during construction was unavoidable, our team minimized the impact of our work on local communities, keeping delays to a minimum and protecting the environment while prioritizing the safety of our workforce and the public.

The fast paced program required both day and night working; at peak the team was working



24 hours a day/7 days a week. Advance notice was routinely given for all lane and slip road closures, in agreement with local motorway police. Several principles were strictly followed:

- The need to maintain three lanes in contraflow
- Overnight and slip road closures as necessary
- Temporary 50mph running with average speed enforcement
- Regular liaison with local police and highways maintenance stakeholders
- 24/7 free recovery available from the carriageway
- Customer Care Unit where motorists could wait in safety for their own recovery service. The Unit included a kitchen area, vending machines, playhouse and toys for children, payphone, TV and toilets with baby changing facilities

The widening works required a stringent safety strategy due to the close proximity of road workers, plant and site vehicles to the live network and within the limited space of

the hard shoulder. These risks were carefully managed through risk assessments and effective controls, combined with an ethos that united the project delivery partners behind the aspiration of achieving a completely injury free environment and a shared vision of what constitutes good safety practice. These principles supported the Highways Agency's 'Aiming for Zero' health and safety strategy.

The 24-month refurbishment of the Hatfield Tunnel was completed with no accidents reported under the UK regulatory framework RIDDOR, lost time injuries or dangerous occurrence, totaling almost 1m man hours. The project team's vigilance and devotion to safe working was commended with a Gold RoSPA* Award in 2011 and shortlisting in the NCE International Tunneling Award for industry leading achievements in safety. Phase two of the program completed 1.2m man-hours without a reportable incident.

*The Royal Society for the Prevention of Accidents



However, although our safety record was exceptional, the inherent danger of the project was demonstrated by a fatality in 2010, which led to prosecutions of a subcontractor and an individual last year, and another incident that resulted in a double amputation. To reinforce the role of safety at the heart of the project, the construction joint venture (CJV) partners share information about safety alerts from their whole organizations, not just the M25.

Operation and Maintenance – a journey of discovery

In addition to undertaking major improvement and lifecycle works, Connect Plus is responsible for the operation and routine maintenance of the M25 and key spur roads. From two control centers and a network of seven depots, 700 employees interface closely with the Highways Agency, managing a

network of 234 miles, including five tunnels and the Queen Elizabeth II (QE2) Bridge. Our contract specifies that at the end of our 30 year concession we must hand back the whole network in a condition no worse than when we took it over.

Around-the-clock monitoring captures all aspects of the network's performance, and a Travel Time Monitoring System helps us deploy our resources to tackle congestion, ease traffic flow and identify potential improvement initiatives. We use GPS technology to track the position of our 16 incident support vehicles (ISUs) and winter maintenance fleet, which enables a more dynamic approach to incident and winter service management.

With traffic flow at 50mph our target, and substantial financial penalties for not achieving it or closing lanes, we have clear priorities and over 8,000 contractual obligations. However, the road is immense, with literally tens of thousands of different components, from 6,000



signs and 18,000 lamp standards (complete with light bulbs) to the Dartford Crossing, made up of two, two-lane tunnels and the four-lane, 812m cable stayed QE2 bridge.

Such a vast and complex network, much of it dating back to 1986, had many secrets that were not uncovered until Connect Plus began work in earnest on the O&M contract. The ongoing ‘journey of discovery’ by the lifecycle and maintenance teams has unearthed major challenges ranging from a lack of standardization that means maintenance crews can’t carry enough equipment to have the right tools for every job, to construction through chalky terrain and major structural faults that threaten lives. A brief selection of the challenges we have faced and the way we have responded with investment from our own finances and an attitude that seeks innovation in adversity include:

- *Potential ramp collapse in the run up to the 2012 London Olympics* – the M25 was

primary transport corridor for 2012 London Olympics, but only 12 weeks before the games were due to start, we discovered cracks on a major steel ramp and were forced to close the road in the face of considerable opposition from senior members of the government. By bringing together an emergency team and using advanced laser scanning techniques that had never been tried in construction before, we were able to map the existing structure, with all its complex load-bearing distortions, and mill steel plates that would reinforce it. Under intense political pressure, which demanded photographs of daily progress for the Prime Minister, we resolved the situation and opened the road the day before the first visitors arrived. We invested the cost of the repairs (\$10m+) as part of our commitment to safety.

- *QE2 bridge joints replacement* – every bridge has joints that enable it to ‘breathe’, expanding or contracting in response to temperature changes. When the O&M team started work



on the M25 they discovered that the joints on QE2 were old and fatigued and needed replacing. There were two issues:

- o The cost of replacing these 19mx1m grids was not included in the original contract, but they could be crucial to the safe operation of the bridge – Connect Plus would have to invest.
- o The potential disruption to traffic caused by closing lanes to replace the joints threatened to expose us to massive financial penalties.

Our solution was to research the market carefully and select high quality joints that were expensive at more than \$10m but that would only need to be replaced this one time in the 30-year concession. Beyond that, we developed a way of working on the bridge at night and under it during the day, we replaced the grids over the course of two summers without slowing down the traffic.

- *Asset management system* – with over 60,000 separate components and a contract to hand them back in as good a condition as we found

them, it's still not clear approaching six years after financial close, exactly what makes up the network. To address this, Connect Plus is investing \$4m in an asset management system, which will be used to store details about all the individual elements on the M25, support maintenance and manage risk. Connect Plus is working with the US supplier of the system, AMSIT, to create one of the world's most advanced highway management systems, with two main capabilities:

- o Routine management data based on the condition scoring required by our client, the Highways Agency.
- o Decision support – where we input scenarios and the system identifies various ways of optimizing them.

Again, the cost of this system was not included in our contract, but we believe it will deliver major savings across a program that is currently costing \$3.1m per week.



Awards

- Institute of Civil Engineers Health & Safety Project of the Year, 2014
- Construction News Sustainable Project of the Year award 2014
- RoSPA Gold Award for Occupational Health & Safety 2011
- Institute of Civil Engineers Merit Award 2010
- Brownfield Briefing
- Construction News Environmental Project of the Year (shortlisted)
- National Recycling Award
- International Green Apple: Environmental Best Practice and Bronze award 2011
- Considerate constructors Scheme: 5 Silver and 1 Bronze awards to date; 'Performance Beyond Compliance'
- Recycling Stars Gold award
- CEEQUAL, 87% Excellent



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