

Crossrail project: logistics management strategy for the Elizabeth line, London

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The scale, complexity and geography of the Crossrail project to deliver the 118 km Elizabeth line across London, UK, presented a challenge to manage the hundreds of thousands of vehicle movements needed to support construction. It also presented an opportunity to implement a project-wide logistics strategy that would set a standard for activities outside the gate, leave a new benchmark in construction road safety management and demonstrate to external stakeholders that the many elements of the project could act collectively. This paper describes the scope of the logistics strategy, the challenges faced in its implementation and the measures employed to make it a success.

1. Introduction

Logistics in construction often focuses on the challenges within the site boundary, leaving those outside the gate to be addressed when dictated by the programme. However, early in the development of the £14.8 billion Crossrail project to deliver the 118 km new Elizabeth line east–west railway across London, undertaker Crossrail Limited identified this as an area to be proactively managed so that impacts outside the hoarding were treated with the same significance as those inside.

It required individual contractors to incorporate logistics practices into their normal working day and form part of their daily planning. With over 800 hauliers delivering to approximately 30 main contractors across more than 50 central London sites (Figure 1), the largest construction project in Europe had to take the initiative and set a standard for all contracts to follow, thus bringing consistency and oversight to the programme.



Figure 1. Concrete lorries in the lorry holding area at the Moorgate shaft site – the logistics team had to manage 800 hauliers delivering to approximately 30 main contractors across more than 50 central London sites

2. Delivery strategy

Crossrail was always going to be held directly accountable by sponsors and stakeholders for any impacts outside the gate. Consequently a degree of control was required over these activities, without overly restricting the contractors. This control was exercised by rolling out a common set of processes and tools designed to encourage collaboration, promote transparency and enable contractors individually, and collectively, to achieve the common goal of delivering a world class railway.

Initially, there was reluctance within Crossrail to implement a centralised strategy, a concern being that it placed the client within the contractor's traditional sphere of activity, creating an interface on which the contractor's operations would be reliant. However, the reality was a strategy that did not hinder the programme, rather it enabled Crossrail to demonstrate to its contractors and the local communities the importance it placed on activities outside the gate, and the standards it expected its supply chain to achieve. It ensured the contractors were prepared to control these activities by mandating the management of logistics both within and outside the site boundary by a dedicated, experienced logistics manager.

The strategy was underpinned by the use of a common logistics standard included in the main works contracts, and flowed down to subcontractors and hauliers. The main elements were as follows

- mobilisation – appoint a competent logistics manager and produce an approved logistics plan before works starts
- planning – communicate standards and processes to hauliers; ensure companies, vehicles and drivers meet safety requirements; and plan vehicle movements in advance, sharing them with other contractors and stakeholders
- implementation – deliveries to follow approved routes and use lorry holding areas, vehicles to be inspected and recorded at entry to site and non-compliant vehicles to be turned away
- review – compare actual against planned, review issues and implement improvements, and share best practice across contracts.

Including the above in all contracts at the procurement stage ensured that the project specified its requirements in

advance of award, and allowed the contractors to price this requirement, confirming every party understood their roles and responsibilities.

However, writing the standard was not enough to ensure its implementation. Therefore, Crossrail sought actively to support and engage with the contractors by way of the following three initiatives (see Figure 2).

- Vehicle management – Crossrail operated a traffic coordination centre and built an in-house vehicle management planning system, providing a standard platform for all to use.
- Engagement and collaboration – Crossrail actively engaged with its contractors through a team of area logistics managers and site logistics managers, who helped the contractors understand and implement the requirements, encouraging collaboration and transparency across all interested parties.
- Road safety programme – Crossrail developed an innovative road safety programme covering operators, drivers and vehicles, providing targeted training and support to suit the project’s needs.

The team responsible for implementing this strategy was small in comparison to the scale and complexity of the works, see Figure 3. This team was organised to mirror the project’s delivery structure, utilising expertise from Crossrail’s delivery partners such as logistics professionals from Unipart and road safety expertise from Aecom. In addition, in-house information technology skills were harnessed to develop technology solutions that formed the bond between Crossrail and the contractors.

The delivery strategy drove the development of planning systems and mobile recording technology (the vehicle management planning system). The vehicle management planning system was

a programme-wide shared platform with prescribed but simple processes for data capture which all contracts followed.

The engagement and collaboration strategy utilised the vehicle management planning system as an accurate source of contractor-supplied data that helped identify best practice and areas for improvement, and was a fundamental ingredient to building trust between contractors, client and stakeholders. Getting the right behaviours from all involved was seen as key to the strategy’s successful delivery, which Crossrail approached on three levels, as follows.

- Site level – the site logistics managers would engage with the site teams, principally by way of the contractors’ logistics managers, but also with the Crossrail project and construction managers. Each site logistics manager would be responsible for a number of contracts, their focus being to ensure those contracts met the requirements and collaborated with each other.

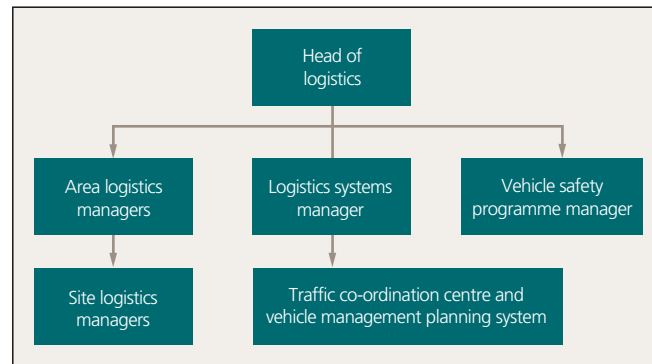


Figure 3. Logistics team structure

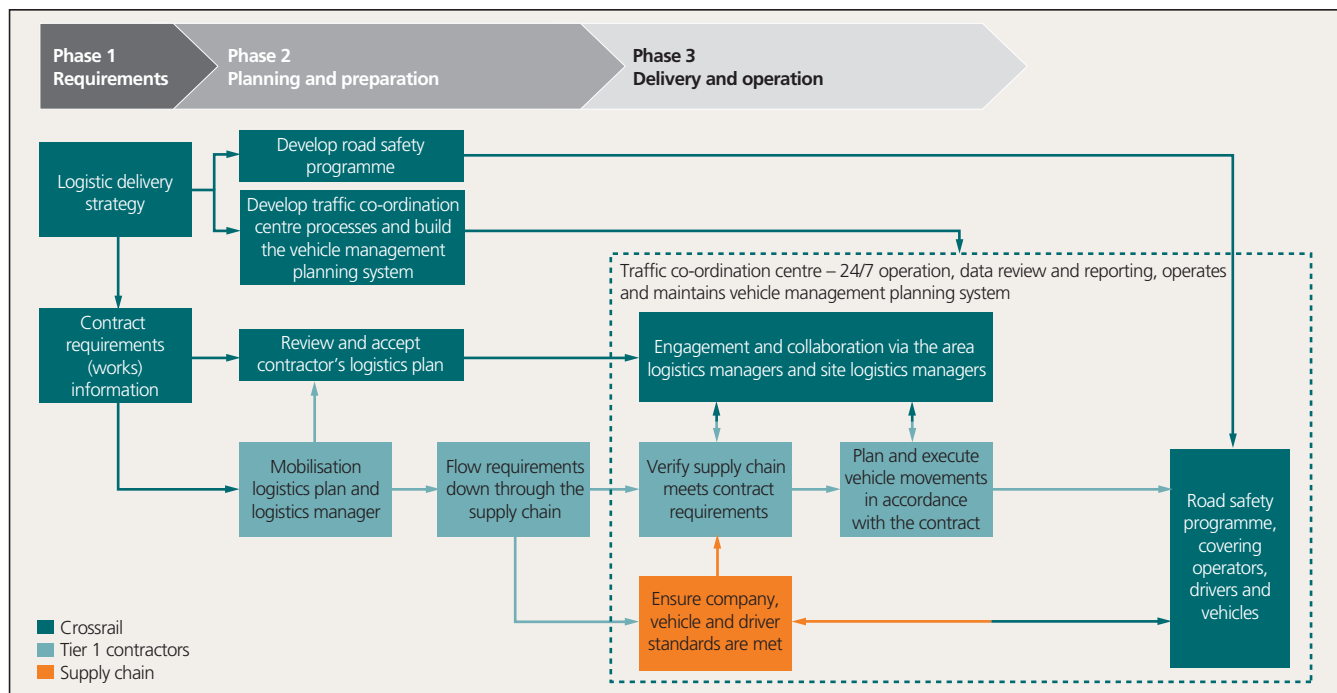


Figure 2. Logistics strategy delivery model

- Area level – the area logistics managers would engage with Crossrail’s area directors and project managers. With each area logistics manager responsible for at least one delivery area, their focus was to encourage best practice and solve problems across contracts and directorates, keeping the relevant managers abreast of performance.
- Programme level – the head of logistics would engage with the senior management team, heads of departments and sponsors, demonstrating that an integrated strategy was being delivered effectively and efficiently.

The final strategic element was the road safety programme. This was both innovative in the standards it was setting, and the scale on which it was being implemented. Fundamental to its success were the processes and data afforded to it by the traffic coordination centre and vehicle management planning system, and the open relationships built by the engagement/collaboration strategy.

To be a success, the safety programme had to be incorporated into the contractor’s daily practices to become the accepted operational norm. However, its originality meant that Crossrail had to engage directly with hauliers and drivers to achieve this.

The following sections of this paper describe the detail behind the delivery strategy, sharing the challenges and successes that have resulted in a united approach across all contracts. This united approach allows Crossrail to present a single logistics voice to sponsors and stakeholders, leaving a legacy that can be built on for future projects.

3. Vehicle management

The oversight and coordination of vehicle movements on a project the size of Crossrail required a structure capable of managing a large amount of data in real time and reacting to those data in the timeframes dictated by the construction programme. The approach taken by Crossrail needed to benefit the contractors, and assist the delivery of their contracts; otherwise they will be reluctant to use it.

Accordingly, Crossrail operated a traffic coordination centre that acted as a central hub for the projects logistics activities, supporting the main contractors and their supply chain 24 hours a day, 365 days per year. The centre’s main function was to provide support and consultation to the whole programme, which it did by way of the following key activities

- provide the vehicle management planning system through which the contractors can plan their vehicle movements, log arrivals and record vehicle safety compliance checks
- review contractors’ logistics plans, considering the cumulative impact across contracts
- manage the lorry driver training course and vehicle compliance workshops
- communicate real-time traffic information to the sites
- provide a wide range of bespoke reports from planning through to implementation, for use by senior management and contractors.

Figure 4 shows the operation of the vehicle management planning system and Figure 5 provides a summary of all central area vehicle arrivals by 4 week period.

Administered by the traffic coordination centre and linked to a network of 80 personal data assistants, the vehicle management planning system was utilised by all contracts, with over 400 users

The vehicle management planning system was the key system supporting the strategy. It was a web-based information technology platform for planning, recording and reporting Crossrail vehicle movements. Administered by the traffic coordination centre and linked to a network of 80 personal data assistants, it was utilised by all contracts, with over 400 users. They could plan vehicle deliveries and record real-time vehicle safety and arrival rates, giving the traffic coordination centre a centralised view of vehicle planning and safety compliance rates across all contracts. Consequently, contractors were able to demonstrate that they are complying with the contract, run

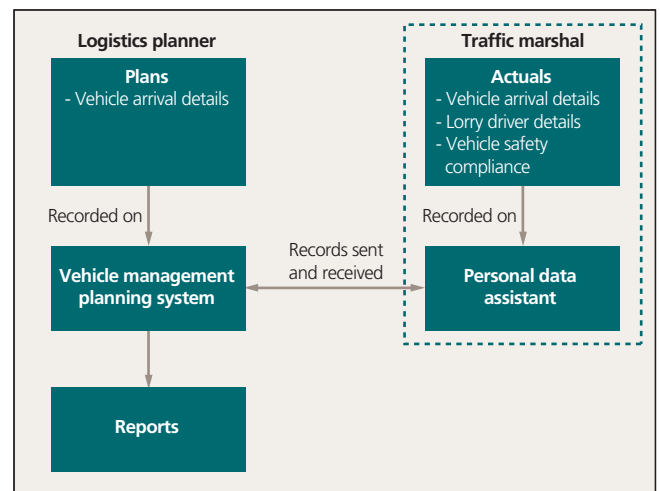


Figure 4. Vehicle management planning system operational schematic diagram

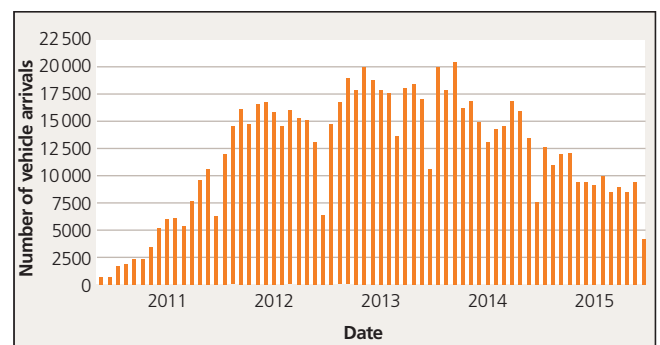


Figure 5. Summary of central area vehicle arrivals by 4 week period

reports to manage each day's plan and coordinate deliveries with site activities and neighbouring sites.

The original delivery strategy was to outsource the vehicle management planning system to a third party provider but as the system's functionality was certain to change over time, an in-house system was developed. This gave the project greater control over its cost and development, while permitting flexibility to

- issue as many user licences as necessary at no extra cost
- respond efficiently to feedback from contractors and other users, making improvements and bug fixes (these were particularly important as high user satisfaction would help ensure the contractors wanted to use the system, as they could see and influence the benefits)
- add functionality to the system, such as vehicle compliance checks
- update reporting templates as requirements changed.

This flexibility allowed the traffic coordination centre to meet the challenges presented to it, some of which are summarised in Table 1.

The traffic coordination centre proved to be a successful function within the logistics team and wider Crossrail programme because it provided an important technical service for Crossrail and contractor

staff, enabling them to comply consistently with their contract obligations in real time. By retaining the traffic coordination centre's expertise and systems in-house, Crossrail enabled itself to meet changing requirements and deliver continual improvement to the logistics function. It is these processes and tools that formed the framework for effective engagement and collaboration between Crossrail and the contractors.

4. Engagement and collaboration

Engagement with the contractors was principally by way of the site logistics managers and area logistics managers. The site logistics managers were typically experienced with construction logistics at site level. This small team provided oversight of all principal contractors working across the programme, and was not dedicated to an individual contract. The site logistics manager role involved frequent contact with the contractor's operational team to observe the logistics processes at site level, check the compliance with the contract and represent the Crossrail project team in operational discussions. In addition, the site logistics manager provided operational support to these project teams in the form of advice and liaising directly with the site marshals and their supervisors.

Table 1. Traffic coordination centre challenges and solutions

Ref	Challenge	Solution
1	Standardise and introduce efficiencies of repetition in the execution of contract requirements including standardising documentation, guidance and metrics across 32 contracts	Established a 24/7 project office to provide an administrative service to contractors and Crossrail staff Produce reports and metrics on planned and actual vehicle movements in support of regular contractor period review meetings
2	Allow different contractors to share information and collaborate and provide programme-wide metrics for performance reporting	Established an automated reporting suite to produce information quickly Attend period review meetings with contractors
3	Provide a robust user-friendly information technology platform for diverse users such as logistics managers, site administrators, traffic marshals and security staff	Adopted an on-going in-house iterative approach to developing the vehicle management planning system and related systems with input from contractors and Crossrail staff
4	Ensure contractor vehicle delivery plans do not create traffic and worksite issues	Prepare and distribute information on events impacting roads and traffic Continual review of vehicle deliveries
5	Ensure all logistics staff (contractor and Crossrail) are competent in logistics requirements of the contract	Provide lorry driver training Provide vehicle compliance assurance training Provide vehicle management planning system training Provide personal data assistant equipment and capture data training
6	Reduce the manual effort and inaccuracy of paper-based record keeping	Provided a business system (vehicle management planning system) to create delivery plans and send to staff on site at vehicle gates Provide personal data assistants to traffic marshals in the field for recording vehicle and driver details and vehicle safety item compliance rates
7	Capture records of every vehicle and driver and vehicle safety compliance checks arriving at a Crossrail worksite	Real-time record capture with electronic personal data assistants iPhone mobile vehicle safety checking application issued to Crossrail staff
8	Ensure adequate phone network coverage to operate personal data assistants on distributed and isolated worksites	Data-roaming subscriber identity module (Sim) cards installed in personal data assistants
9	Provide robust and resilient technology in the field (including waterproof) and keep up-to-date with changing technology and software	On-going equipment upgrade programme established

The area logistics manager role was to be a lead representative for the Crossrail project team, and manage the site logistics managers. They were responsible for monitoring contractor performance against the measures required in the contract.

A key facet of the logistics strategy was to engage frequently with each of the Crossrail principal contractors to oversee their logistics activities, and encourage appropriate management behaviours. To ensure this was the case, all contractors were required to appoint a suitably competent logistics manager, with the area logistics managers approving their curriculum vitae.

The logistics manager was responsible for delivering a logistics plan for their works, which described the approach they intend to take to satisfy the key requirements

- planning and recording of vehicle movements to sites (using the vehicle management planning system)
- safety compliance of vehicles, drivers and companies arriving at site
- movement management requirements such as dwelling vehicles in lorry holding area
- use of authorised routes and coordination with other Crossrail contractors and third parties
- coordinating vehicle movements with the construction works teams to avoid clashes and agree priorities.

The contractor's daily delivery operation followed a standard process, the first part being for the contractor to ensure that the supplier knew Crossrail's standards. This operation is shown in Figure 6 and involved all vehicles using authorised routes to travel to site, and using a lorry holding area to dwell vehicles before being released to travel to the site gate. The lorry holding area is an essential part of the logistics system, often located on the highway with appropriate traffic management.

On receipt of the vehicle at a lorry holding area, the contractor would carry out a set of standard checks on the delivery plan, the driver, and the vehicle, and record this information on the vehicle management planning system. If a vehicle did not meet Crossrail's safety requirements, then the contract required it to be turned away. This process operated continuously throughout the working day, which was often 24 hours, such that every arrival was checked and recorded. An average hourly breakdown of these arrivals is shown in Figure 7.

To reinforce appropriate behaviours, the performance of daily operations was reviewed every period by way of a meeting with the contractor's logistics managers. The aim of the review was to determine corrective measures, highlight and share best practice and to identify continuous improvement actions. This collaborative approach to routinely discussing details of the contractor's planning and operational performance encouraged openness where complicated site access arrangements existed, such as shared access on congested sites. The fact that all Crossrail contractors followed a common planning and operational standard helped facilitate this approach.

For example, three contractors needed to complete works at the Moorgate shaft site in the middle of the City of London (Douglas *et al.*, 2015). This congested site has little space to receive vehicles, with access limited to a single gate, supported by a common lorry holding area on London Wall, where vehicles could dwell and be safety checked before being released to site (Figure 8).

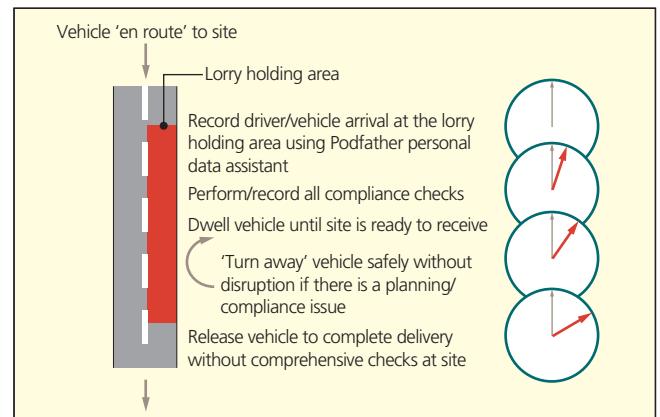


Figure 6. Operation for vehicle delivering to site by way of a lorry holding area

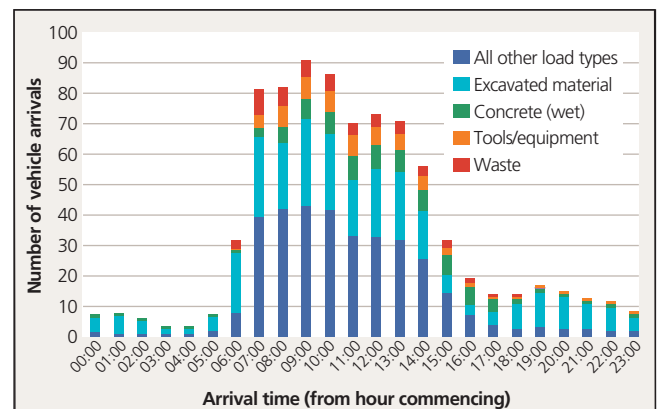


Figure 7. Average weekday arrival profile from the vehicle management planning system (all central area sites)

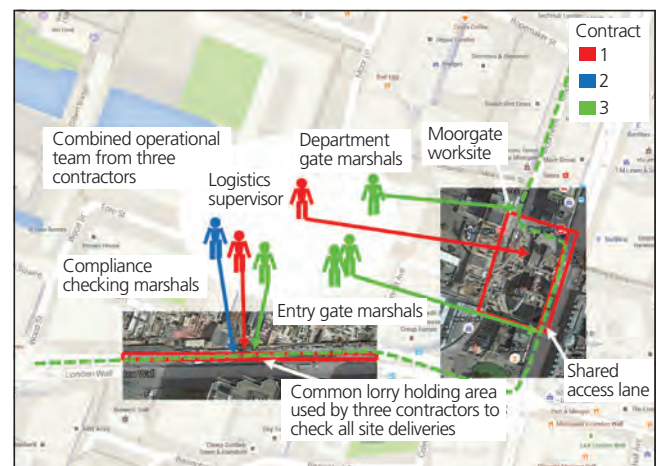


Figure 8. Three contractors used shared lorry holding area and shared site access

A key element of the logistics strategy was the road safety programme. This turned into an innovative strategy that redrew the traditional boundaries of health and safety for construction and civil engineering projects

Close coordination of deliveries was important to ensure all three contractors, and therefore Crossrail, met the programme, and the deliveries did not adversely impact on the surrounding area and other highway users. To achieve this, operational teams from both the contractors and Crossrail met weekly at a crane and logistics coordination meeting, the purpose being to share information and identify and solve conflicts.

Making logistics an integral part of the discussions improved the efficiency of lifting activities, while the vehicle management planning system proved invaluable as it could import and overlay all three contractor programmes, highlighting pinch points and focus the discussion on resolving access conflicts, see Figure 9. Consequently the meetings could consider the detail of vehicle movement plans including crane-lifted deliveries, lorry holding area, site and access capacities, and the impact of combined deliveries on stakeholders.

Having agreed a combined vehicle movement plan for the deliveries of the three contractors, their logistics managers brought efficiencies and planning to the operations by sharing the lorry holding area marshals, site gate marshals and vehicle banksmen. As all were already using common Crossrail standards and processes, the different teams could easily come together and collaborate.

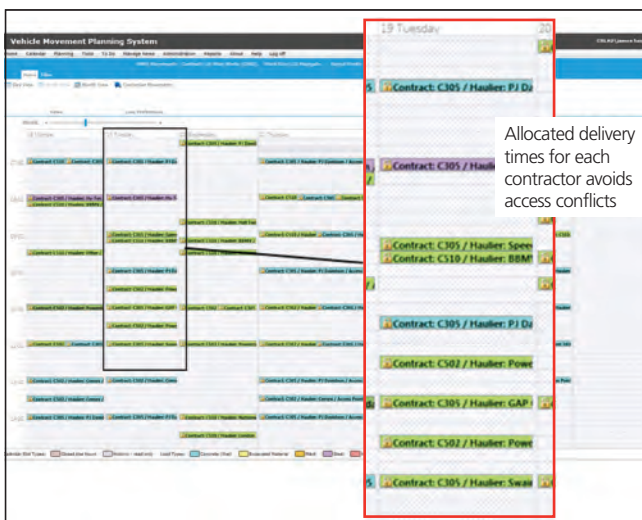


Figure 9. Vehicle management planning system planning screen for three contractors planning deliveries to Moorgate

The benefit of instructing all contractors to use common standards and tools was the collaborative base this provided for agreeing and managing complex logistics operations without the need for contractual agreements each time logistics interfaces arose. This shared approach has reduced the cost of resourcing the operation and enabled Crossrail to present a joined-up approach to local stakeholders.

5. Road safety programme

A key element of the logistics strategy was the road safety programme. This started as a single initiative to address an undertaking to provide vulnerable road user training for large goods vehicle drivers working on the project, and turned into an innovative strategy that redrew the traditional boundaries of health and safety for construction and civil engineering projects.

Crossrail had an undertaking to minimise the impact its construction would have on vulnerable road users in London. This was seen as a significant undertaking that warranted the employment of a subject matter expert to lead the programme. Initially, consultation with key stakeholders (the London Cycling Campaign and Road Peace) led to the launch of Crossrail's lorry driving training course in 2009. This was followed by other initiatives and work streams, some elements of which were included as contractual requirements while others were directly implemented by Crossrail, but all with the aim of improving construction road safety outside the site.

The three main contract requirements were directed at haulage companies, the drivers and the vehicles as follows.

- Company – hauliers to become bronze members of the fleet operators recognition scheme (FORS).
- Driver – frequent drivers to attend Crossrail's bespoke lorry driving training course.
- Vehicle – vehicles to be fitted with 17 specific items of safety equipment, the five key items that make a direct contribution to the safety of vulnerable road users being: blind spot mirrors; fresnel lenses; warning signs for cyclists and pedestrians; side under-run guards (including vehicles exempt by the construction regulations); and blind spot detection systems, including external spoken warning alerts.

The obligation for contractors was to turn away all vehicles that did not satisfy these requirements, classifying them as non-compliant. However, these requirements were new to much of the industry, which, coupled with pressures to meet the programme, led to inconsistencies in the compliance checking process and a reluctance to report non-compliance in case it was perceived as poor performance. As a result some non-compliant vehicles were allowed on site, which Crossrail took the following steps to address.

- Engagement – initially there was resistance within the industry to fit the additional safety equipment, with, for example, some saying it was not possible to fit side under-run guards to exempt vehicles. This was addressed by the Crossrail site logistics manager team engaging with the supply chain. They listened to their concerns and assisted by demonstrating how

the equipment could be installed, with examples of where it was already in use.

- Training – a compliance checking training course was rolled out by Crossrail to all contracts, giving confidence to the checker and bringing consistency to the process.
- Reporting – data from the vehicle management planning system was used to commend contracts that reported non-compliance and identify this on dashboards. Contracts with very low or no compliance were subject to additional audits to ensure this was the case.
- Leadership – Crossrail and contractor senior leadership teams jointly reinforced the need for all sites to comply with these requirements and turn away non-compliant vehicles by introducing a ‘consequence process’, which required drivers of non-compliant vehicles to be temporarily suspended from the project until both themselves and their fleet manager had re-attended the lorry driver training course.

These measures improved compliance rates as shown in Figure 10. Their consistent application across all contracts, particularly of leadership, created a level playing field for all hauliers to operate in.

As the programme progressed, Crossrail introduced many other road safety initiatives to complement the contractual requirements. Together these became the overall strategy, which can be summarised under the following five themes (see Figure 11).

- Initiatives designed to change driver behaviour – having initially developed a lorry driver training course at the outset this initiative focused on raising driver standards, particularly the perception of risk and ability to identify potential hazards. This is delivered through Crossrail’s certificate of professional competence from the accredited lorry driving training course, an online refresher course and the translation of road safety material into 17 languages. The 1 day course has trained over 10000 drivers and is probably the largest upskilling programme of professional drivers by a single UK civil engineering project.
- Initiatives designed to raise road user awareness – while part of driver behaviour, the primary intervention took the form of running ‘exchanging places’ events in conjunction with the Metropolitan and City of London police forces, by working with thousands of cyclists to sharpen their perception of risk and blind spots when cycling close to large goods vehicles. Legal seminars aimed at transport managers were held, and a working group established, to increase awareness of the duty of care owed under health and safety law and The Corporate Manslaughter and Corporate Homicide Act 2007.
- Initiatives designed to support the supply chain – these were focused through a working group that gave transport managers a voice, delivering consistent information using a web-based forum and providing free compliance assurance workshops to train contractors’ staff to safety check and record the compliance of vehicles systematically against Crossrail standards.
- Initiatives designed to improve vehicles and junctions – encouraging contractors to change their daily walk-round checks and include Crossrail safety items as part of the routine increased the likelihood of their vehicles being compliant and

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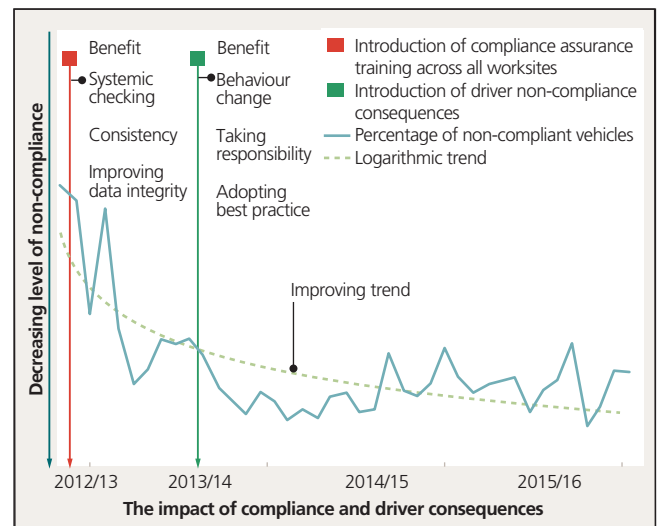


Figure 10. The impact of compliance assurance and consequence initiatives

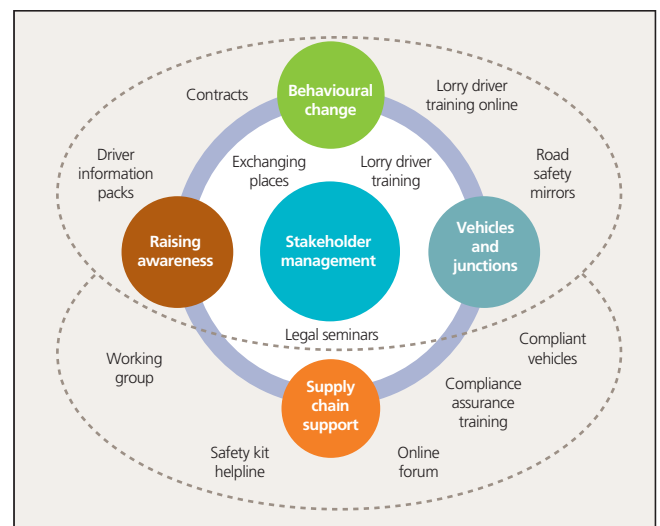


Figure 11. Crossrail’s road safety initiatives

safer when arriving at site. Convex road safety mirrors were also positioned at over 50 junctions near Crossrail worksites, allowing cyclists and large goods vehicle drivers to see each other before moving off.

- Initiatives designed to improve stakeholder relations – a strand of the road safety strategy was to engage directly with relevant stakeholders, whose feedback helped develop several initiatives. This was particularly the case with lorry driving training, with observers from the police, borough representatives, cycling lobby groups and road safety charities frequently attending lorry driving training and participating in the course.

The road safety initiatives, coupled with Crossrail's contract requirements, have taken construction health and safety beyond the site gate. With companies in Crossrail's supply chains joining FORS, their drivers attending lorry driving training and safety equipment being added to their vehicles, the project has helped redraw the traditional boundaries of health and safety. The success of this road safety programme has been recognised through industry awards such as the Institution of Occupational Safety and Health best achievement in transport and logistics 2012 and the Brake fleet safety award 2013.

Several large projects have been keen to learn from Crossrail's experience, such as major infrastructure projects in the UK (Thames Tideway and High Speed 2) and organisations further afield such as Transport for New South Wales, Australia. In addition, the Crossrail team responsible for developing the road safety programme has assisted the development of the construction logistics and cycle safety (Clocs) initiative facilitated by Transport for London, which has now become the standard for construction projects in London and beyond (Davies and White, 2015).

6. Lessons learnt

Ultimately the logistics strategy was delivered successfully, but not without overcoming a number of challenges, which required changes in behaviours and working practices from all parties. Addressing these challenges has resulted in some lessons learnt, which can be summarised under the following three themes.

- Consistency – this started with the contract which defined requirements, responsibilities and the parameters within which the contractors should operate. This was applied consistently across all contracts, and was designed to encourage the right behaviours and make the process simple to administer. Crossrail found that an insistence that the contractors' logistics manager role was undertaken by a competent person, and not added to another employee's role, was critical to its success.
- Collaboration – the proactive engagement/involvement in key aspects of managing the logistics operation, traditionally led by contractors, provided assurance that the contractual requirements were being met. As aspects of the strategy were new to the industry, it became apparent early on that Crossrail needed to focus its efforts on communicating the requirements

to the supply chain and provide additional training to ensure consistency.

- Leadership – Crossrail's stance on the vehicle safety initiative was vitally important to its success. Turning away a non-compliant concrete vehicle when a pour is on-going was not a behaviour easily adopted by contractors with commercial and schedule pressures, although it was a contractual requirement. It took consistent, unwavering, joint leadership from Crossrail and the contractors to embed this behaviour.

7. Conclusion

This paper has described the main facets of Crossrail's logistics strategy and how they were implemented into the programme. Its success started with a defined contractual requirement but was only realised because Crossrail actively engaged with the contractors and their supply chain to help them understand and meet the requirements, providing bespoke training, adaptable tools and flexible processes.

The approach by the Crossrail logistics team supported the project as it transitioned from a civils project through to a systems project, ensuring that Crossrail addressed the challenges outside the site boundary without overly restricting the contractors. And for the project stakeholders, Crossrail has been able to respond as a single entity while leaving a new benchmark in construction road safety management.

Acknowledgements

The authors would like to thank and acknowledge the important role played by past and present members of the Crossrail logistics team, whose hard work, diligence and commitment ensured the strategy was successfully delivered. They would also like to thank the contractors' logistics teams and wider site teams who embraced the strategy and worked proactively and collaboratively with Crossrail and its stakeholders in its implementation.

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