

# Crossrail Project

Infrastructure design and  
construction

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## Door Forces in Underground Infrastructure

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### Abstract

During the course of commissioning the Crossrail stations, it was observed that a wide range of forces was required to open these doors, some of which appeared to be excessive.

Within the stations, certain door opening forces were significantly influenced by the pressures induced by the tunnel ventilation and shaft pressurisation systems, which operate independently. This paper reviews the opening forces measured at evacuation and intervention doors within the Crossrail stations and shafts, presents the requirements currently adopted by the Crossrail project, and outlines the standards and guidelines relevant for such doors. The legal requirements pertaining to the safety functions of evacuation doors are briefly presented, and analysis is presented of the physiological data pertaining to individuals' pushing strength.

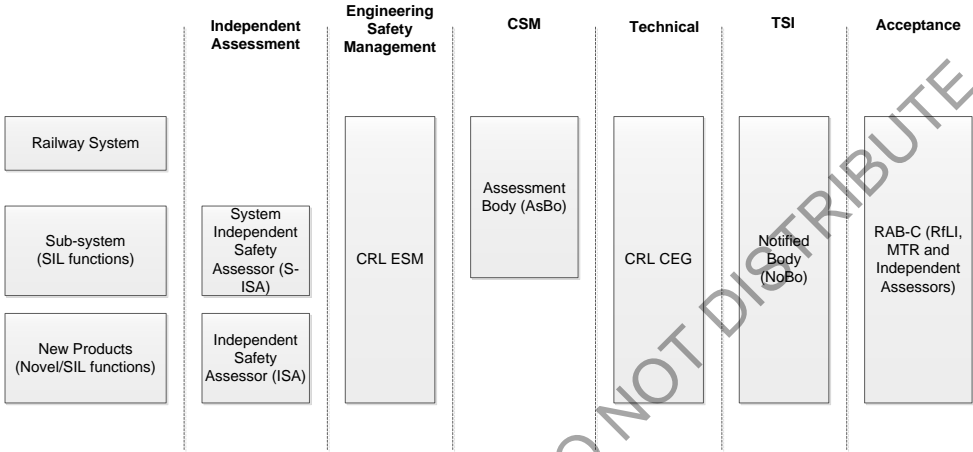
The paper sets recommendations for the maximum allowable opening forces on doors within evacuation and intervention routes impacted by the tunnel ventilation system, which were agreed through peer review.

### Definitions

Abbreviation	Meaning
CSM	Common Safety Method
DTI	Department of Trade and Industry
EED	Emergency escape door
HSE	Health and Safety Executive
NFPA	National Fire Protection Association
OPE	Over-platform exhaust
ORR	Office of Rail and Road
PRM	Person with reduced mobility
PSD	Platform screen door
RAIB	Rail Accident Investigation Branch
ROGS	The Railways and Other Guided Transport Systems (Safety) Regulations 2006
RRO	The Regulatory Reform (Fire Safety) Order 2005
TED	Tunnel evacuation door
TfL	Transport for London
TVS	Tunnel ventilation system

- Hazards from Network Rail (NR) On-Network works have been controlled in accordance with the NR Assurance regime and assessed by NR AsBo.

Figure 3 shows the levels of safety review for COS Railway Systems. This demonstrates the (typically six) layers of independent review applied and evidenced within a SJ.



**Figure 3. Levels of Assurance Reviews for COS Railway Systems**

### Writing Safety Justifications

The majority of the SJs for the Elizabeth Line were written by the Engineering Safety Management (ESM) Team however, just two were not – those for Earthing and Bonding and Electromagnetic Compatibility were written and delivered by the CEG respective Heads of Discipline (HoDs) assisted by their teams.

Focusing on the E&B HoD and team, the initial steps involved in writing the first revision of the E&B COS SJ were as follows:

- Familiarisation with the SJ standard format and what content was needed
- Familiarisation with the E&B SEJ and with the six railway hazards plus consequent twelve E&B related sub-railway level hazards
- Obtaining the alignment matrix of the SEJ Railway level hazards to the Project Wide Hazard Record and other evidence (produced by the ESM team)

The E&B system is the foundation of all other systems, hence the E&B COS SJ is one of a few key SJs which the rest of the SJs rely on and reference to, hence, it was critical to produce a clear well developed document from the start.

Development of the E&B SJ was time consuming and involved several iterations to arrive at a reasonably good first draft, it took three people – the E&B HoD (providing a lot of the technical input as the only person with continuity on Crossrail over many years), a Principal Engineer (acting as editor, progress monitor, researcher and problem resolver) plus a Graduate Engineer (researcher and reference finder). As the team built the first draft, two (lauded) innovations came about:

- The creation of a spreadsheet, divided by site/system to record every E&B reference document – over 2000 documents are listed



# System Integration EMI Issues in Large Complex Installations – A Case Study

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## Abstract

Achieving Electromagnetic Compatibility (EMC) between systems on a large complex project such as Crossrail can be challenging especially where different contractors are involved. Individual contractor tend to focus only on their scope of works and Electromagnetic Interference (EMI) between different systems can only become apparent towards the end of the project when all systems are available and can be operated together.

Issues can also arise when it is assumed that if equipment meets applicable EMC standards then there will be no issues. It's important to understand the limitations of the EMC standards used and how they can impact the overall system.

EMC Control Plans, produced at the start of a project, will give the good engineering practices needed to achieve EMC in the final installation. However, it is not enough to just produce the EMC Control Plans their guidelines also have to be followed. Failure to follow the guidelines can result in an installation with EMC issues.

This paper looks at EMI between two systems on Crossrail where aspects of the above all played a part in creating EMC issues in the final installation and the mitigations used to overcome them.

## Introduction and Industry Context

Large infrastructure projects such as Crossrail present significant challenges in managing Electromagnetic Compatibility (EMC) through the design, installation and commissioning stages of the project.

## Main Story

During the commissioning of the lighting control system at a ventilation shaft the lighting control contractor found they could not communicate with many of the lighting devices on the system. After going through their usual trouble shooting routine they could find nothing wrong with their system. It was noted that the Tunnel Ventilation System (TVS) was operational due to the proximity to the variable speed drive (VSD) room and they could be heard operating. Further investigation confirmed that it was the TVS system that was causing Electromagnetic Interference (EMI) with the lighting control system.

The lighting control used was a Digital Addressable Lighting Interface (DALI) system. The DALI bus used to control the lighting devices is a two wire system with a nominal 16 V dc



# Transitioning of the engineering management in the handover phase of programme delivery

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## Abstract

Engineering Management Office (EMO) function provides an important link between the client's specifier of requirements and its contracting arm delivering the works. The longevity, scale and geographical fragmentation often necessitate a phased completion approach in delivery of major infrastructure programmes. Nearing the completion point brings pressures of schedule and cost and demands changes in the organisation and approach of EMO. It is an acquired leadership skill to recognise the need early, to reap the long-term benefits of engineering knowledge retention and ultimately its transfer to the end user.

In this paper we present a model set-up and timeline for deployment of a transitional engineering team. We introduce the workings of an engineering integration task force, whose success became a blueprint for that transformation. We set out guiding principles of workings, moving away from a vertical to more horizontal representation across the programme. We also draft a pathway for embedding the residual engineering team in the Infrastructure Manager's organisation.

The findings will inform long term strategies for transition of engineering knowledge and resource planning for handover phases of major projects and programmes.

## Introduction and Industry Context

For large infrastructure projects the handover date is a phase, not an event. The value received by the client organisation can be greatly enhanced by, amongst other, transfer of knowledge and a meaningful aftercare.

Association for Project Management's recent research paper on improving handing over of projects<sup>[1]</sup> briefly focuses on knowledge transfer, in a form of documentation and training. This case study enhances that learning and proposes a model change, implemented within Crossrail's (CRL) Technical Department, enabling retention of people and skills needed post-handover. The nature of Crossrail project makes this paper particularly relevant to large-scale programmes, new or upgrade metro construction and mainline railways, as well as linear infrastructure projects in energy, water and transportation sectors.

CRL Handover Strategy<sup>[2]</sup> sets out the path to transfer the Central Operating Section – the railway and stations in twin-tunnels under Central London – to the relevant Infrastructure Managers (IMs). It pivots around 30 Elements – integrated but distinct, location or system specific building blocks of assurance. Due to sheer scale and effort needed on the receiving

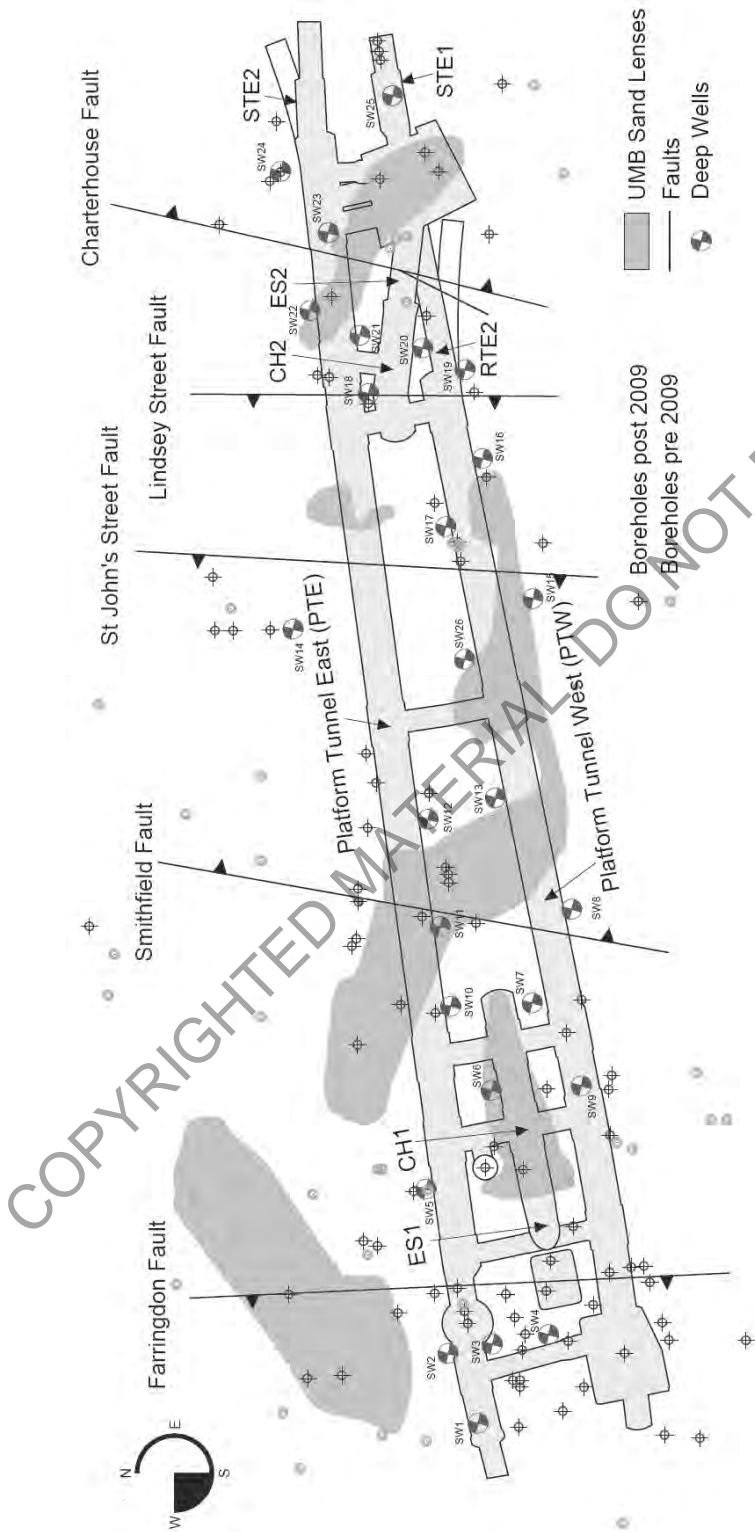


Figure 1. Plan view of Farringdon Station showing the UMB sand lenses, the faults, the boreholes as well as the Reference Design proposed deep wells