



National Audit Office

---

## **Report**

by the Comptroller  
and Auditor General

---

**Department for Transport**

# A memorandum on the Crossrail programme

---

Our vision is to help the nation spend wisely.

Our public audit perspective helps Parliament hold government to account and improve public services.

The National Audit Office scrutinises public spending for Parliament and is independent of government. The Comptroller and Auditor General (C&AG), Sir Amyas Morse KCB, is an Officer of the House of Commons and leads the NAO. The C&AG certifies the accounts of all government departments and many other public sector bodies. He has statutory authority to examine and report to Parliament on whether departments and the bodies they fund, nationally and locally, have used their resources efficiently, effectively, and with economy. The C&AG does this through a range of outputs including value-for-money reports on matters of public interest; investigations to establish the underlying facts in circumstances where concerns have been raised by others or observed through our wider work; landscape reviews to aid transparency; and good-practice guides. Our work ensures that those responsible for the use of public money are held to account and helps government to improve public services, leading to audited savings of £741 million in 2017.

---



National Audit Office

---

Department for Transport

# A memorandum on the Crossrail programme

Report by the Comptroller and Auditor General

Ordered by the House of Commons  
to be printed on 25 February 2019

This report has been prepared under Section 6 of the  
National Audit Act 1983 for presentation to the House of  
Commons in accordance with Section 9 of the Act

Sir Amyas Morse KCB  
Comptroller and Auditor General  
National Audit Office

22 February 2019

This memorandum sets out background information about the Crossrail programme and the current position.

---

© National Audit Office 2019

The material featured in this document is subject to National Audit Office (NAO) copyright. The material may be copied or reproduced for non-commercial purposes only, namely reproduction for research, private study or for limited internal circulation within an organisation for the purpose of review.

Copying for non-commercial purposes is subject to the material being accompanied by a sufficient acknowledgement, reproduced accurately, and not being used in a misleading context. To reproduce NAO copyright material for any other use, you must contact [copyright@nao.org.uk](mailto:copyright@nao.org.uk). Please tell us who you are, the organisation you represent (if any) and how and why you wish to use our material. Please include your full contact details: name, address, telephone number and email.

Please note that the material featured in this document may not be reproduced for commercial gain without the NAO's express and direct permission and that the NAO reserves its right to pursue copyright infringement proceedings against individuals or companies who reproduce material for commercial gain without our permission.

Links to external websites were valid at the time of publication of this report. The National Audit Office is not responsible for the future validity of the links.

007232 02/19 NAO

---

# Contents

Introduction to this guide 4	Key facts 5	Summary 6	What is Crossrail? 7	Why are the government and TfL building Crossrail? 10	Who is paying for Crossrail? 13	Who is delivering Crossrail? 15	How is Crossrail being delivered? 21	When will Crossrail be complete and open? 24	Previous examinations of Crossrail by PAC and the NAO 27
			<ul style="list-style-type: none"> <li>Introduction</li> <li>History of the Crossrail project</li> <li>Elizabeth line services</li> </ul>	<ul style="list-style-type: none"> <li>Increasing capacity and reducing congestion</li> <li>Improving connectivity</li> <li>Government and TfL projections of the benefits of Crossrail</li> </ul>	<ul style="list-style-type: none"> <li>Crossrail funding and financing model</li> <li>How the funding position has changed</li> </ul>	<ul style="list-style-type: none"> <li>The governance and delivery structure</li> <li>How governance and delivery works</li> <li>Crossrail Ltd</li> <li>Crossrail Ltd, previous Board</li> <li>Issues identified with governance and information on the programme</li> </ul>	<ul style="list-style-type: none"> <li>The main component parts of the programme</li> <li>Integration of a complex programme</li> </ul>	<ul style="list-style-type: none"> <li>Events leading to the announcement of delays</li> <li>Progress against the timetable for opening the railway</li> <li>Remaining work</li> </ul>	

The National Audit Office study team consisted of: Hedley Ayres, Lee Nicholson, Kristian Barrett and Riaz Rahman, under the direction of Lee-Anne Murray.

This report can be found on the National Audit Office website at [www.nao.org.uk](http://www.nao.org.uk)

For further information about the National Audit Office please contact:

National Audit Office – Press Office  
 157–197 Buckingham Palace Road  
 Victoria, London, SW1W 9SP

Tel: 020 7798 7400

Enquiries: [www.nao.org.uk/contact-us](http://www.nao.org.uk/contact-us)

Website: [www.nao.org.uk](http://www.nao.org.uk)

Twitter: @NAOorguk



## Introduction to this guide

We have produced this memorandum on the Crossrail programme to support Parliamentary scrutiny of Crossrail in light of events that transpired during the second half of 2018. From July 2018, it became clear that programme costs were increasing significantly. In August 2018 Crossrail Ltd announced that it would not meet planned opening dates for the railway. In November 2018, the Chair of the Committee of Public Accounts wrote to the Comptroller and Auditor General and asked him to examine the reasons for cost and schedule increases.

The final cost remains uncertain. There is currently no date for when the railway will be fully operational.

This Memorandum sets out the background to the Crossrail programme, including why and how it is being built, and who is building and paying for it. It also includes public statements about when the Department for Transport (the Department), Transport for London (TfL) and Crossrail Ltd expect services to operate, how much they currently estimate the programme will cost, and what funding has been committed to the programme. It is based mainly on publicly available information.

The National Audit Office (NAO) will be publishing a value-for-money study on the programme in Spring 2019. The NAO's report will examine:

- the underlying causes of the delays and cost increases;
- the reasons why the programme unravelled in 2018, and why issues emerged so quickly and with such a significant cost increase; and
- the actions sponsors and Crossrail Ltd have taken to get the programme on track, and our assessment of whether these actions are likely to be sufficient.

Depending on the progress of the programme by the time we report, it will also set out the expected forecast cost and delivery schedule, and assess the programme's remaining future risks.

## Key facts

### December 2018

Original date when the Crossrail sponsors and Crossrail Ltd expected to start running services on the central section of the railway.

### Unknown

Revised opening date for Crossrail.

### £14.8 billion

Funding package, including contingency, agreed in the 2010 Spending Review to cover the delivery of the Crossrail programme, excluding trains and main depot.

### 19%

Percentage increase in the funding available for the Crossrail programme.

### £17.6 billion

Current total funding package for Crossrail, including contingency, but excluding trains and depots following government announcements in July and December 2018.

### £2.05 billion

Value of loans from HM Government, including £1.3 billion to the Greater London Authority and £750 million as contingency to TfL to cover the increased cost of Crossrail, as announced in December 2018. The Greater London Authority has also committed a cash contribution of £100 million.

### £600 million

Current assumption of revenue losses to TfL between 2019-20 and 2023-24, as a result of delays to the opening of Crossrail services.

### 118 kilometres

Approximate length of the line between Heathrow and Reading in the west and Shenfield and Abbey Wood in the east, on which Elizabeth line services will operate once the Crossrail programme is complete.

### 26 miles/42 kilometres

Approximate length of new tunnels in the central section of the railway.

### 10

New stations being built as part of the Crossrail programme.

## Summary

Crossrail is a complex programme to provide new rail services between Reading and Heathrow west of London and Shenfield and Abbey Wood. It includes a new underground railway beneath central London.

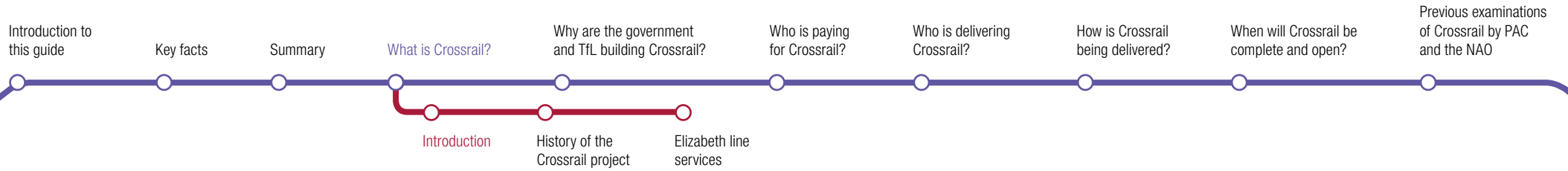
The Department and TfL are sponsoring and funding Crossrail jointly. The sponsors expect the railway to reduce congestion, increase capacity, reduce journey times and enable economic growth.

Crossrail Ltd is responsible for delivering the programme, from building the line and stations, through to integrating systems and providing an operational railway. Crossrail Ltd is a company wholly owned by TfL with an independent board.

During 2018 sponsors and Crossrail Ltd made a series of announcements about significant cost increases and delays to the programme.

It remains unclear when the central section of the railway will open, with Crossrail Ltd having missed its target to open this section in December 2018. Crossrail Ltd does not yet have a firm estimate of the revised cost to complete the programme.





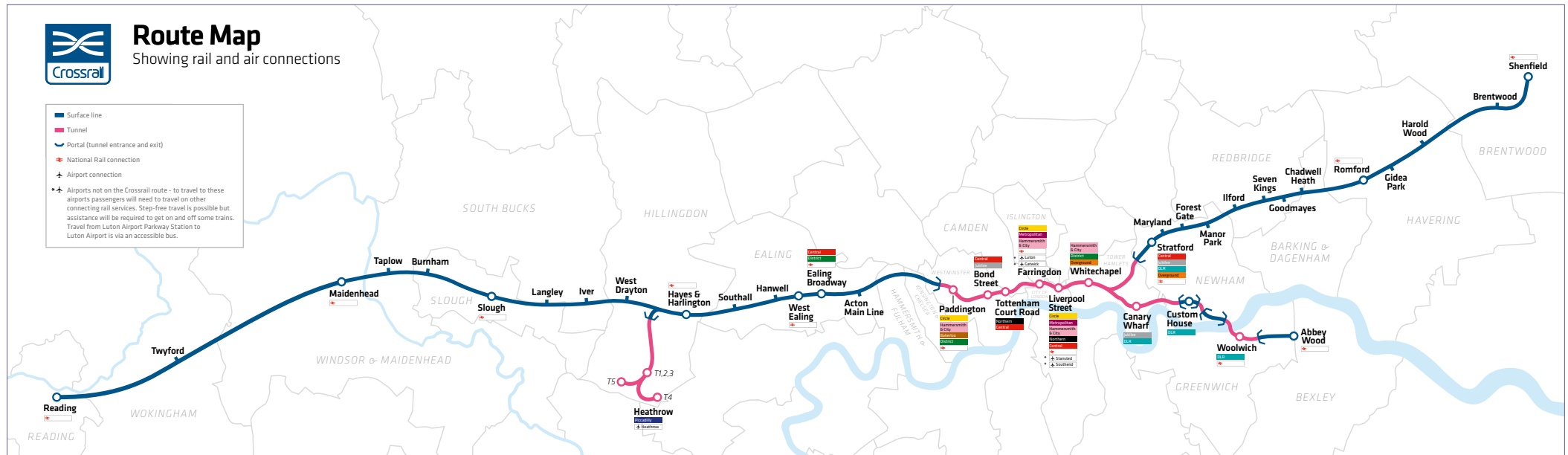
## Introduction

Crossrail is a major programme to run new, direct rail services between Reading and all passenger terminals of Heathrow Airport at the western ends of the railway, through a new underground section beneath central London to Shenfield in Essex and Abbey Wood in south-east London at the eastern ends.

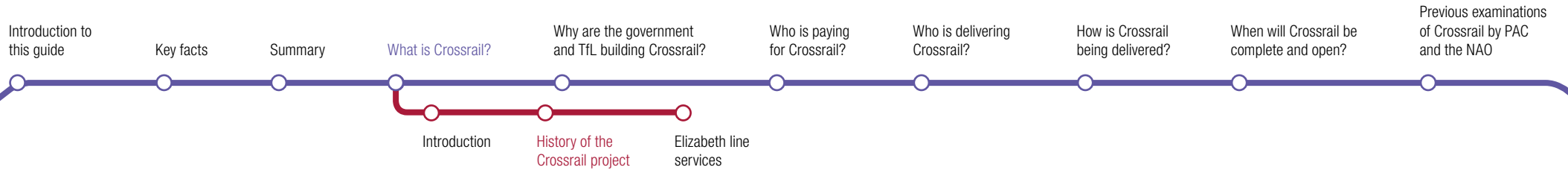
When complete, the railway will be around 118km long, with around 26 miles (42 kilometres) of new tunnels in the central section between Paddington and Canary Wharf, and at Woolwich. There are 10 new stations being built as part of the Crossrail programme, and a further 31 are being improved.

Once Crossrail is open, it will become part of TfL's rail and underground network, and will be known as the Elizabeth line.

**Figure 1** Crossrail regional map



Source: Crossrail Limited, Regional Map. Available at: [www.crossrail.co.uk/route/maps/](http://www.crossrail.co.uk/route/maps/)

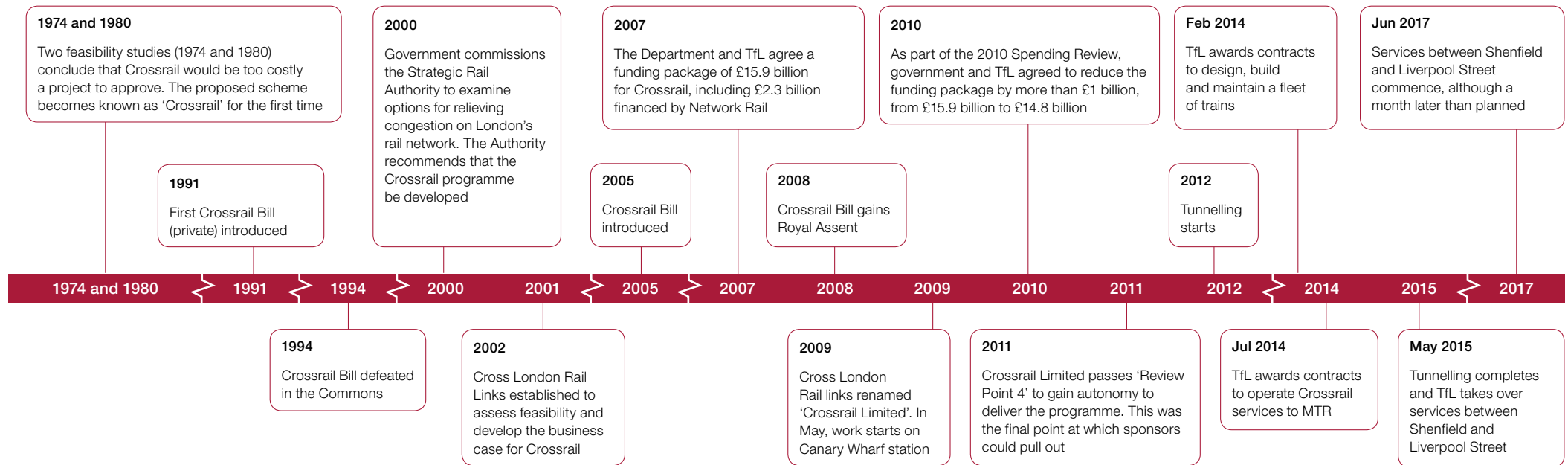


## History of the Crossrail project

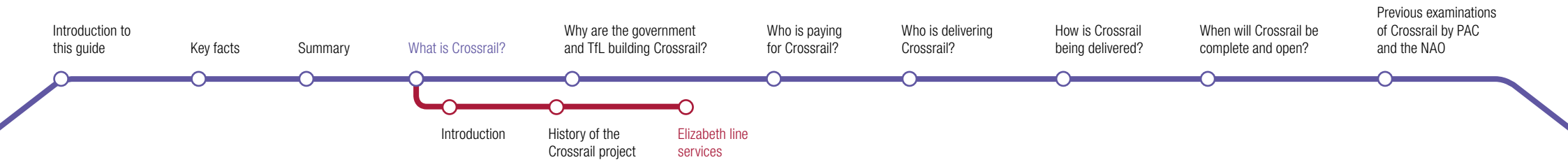
Crossrail has a long history. In 1974 and 1980, feasibility studies concluded that it would be too costly a scheme to build and in 1994 a private members bill to build Crossrail was defeated. The current incarnation of Crossrail goes back to 2002, when the newly formed Cross London Rail Links (which became Crossrail Ltd in 2009) assessed the feasibility of the scheme again, after the Strategic Rail Authority

recommended that new rail links should be built across London to relieve existing and forecast overcrowding and to reduce congestion on the rail network between east and west. Legislation required to build the railway gained Royal Assent in 2008 in the form of the Crossrail Act. Construction started in 2009 on the first Crossrail site, Canary Wharf station.

**Figure 2** Crossrail development timeline



Source: National Audit Office analysis of departmental information



## Elizabeth line services

When Crossrail is complete and fully open, passengers will have access to a large number of new services for travelling between east and west. **Figure 3** summarises the promised peak-time service frequency.

**Figure 3**  
Planned Elizabeth line services at peak times

Section of the railway	Examples of service frequency at peak times
Central section	24 trains an hour between Paddington and Whitechapel stations
Eastern section	12 trains an hour between Shenfield and central London; an additional four trains an hour will run between Gidea Park and Liverpool Street main-line station
South-eastern section	12 trains an hour between Abbey Wood and Canary Wharf, and central London
Western section	6 trains an hour between Maidenhead and central London 4 trains an hour between Reading and central London 4 trains an hour between Heathrow Terminals 2, 3 and 4 and central London 2 trains an hour between Heathrow Terminals 2, 3 and 5 and central London

Source: Crossrail Ltd

Increasing capacity and reducing congestion

Improving connectivity

Government and TfL projections of the benefits of Crossrail

## Increasing capacity and reducing congestion

One of the main objectives of Crossrail – and central to the business case for the programme – is the need to increase capacity on the underground and main-line rail network in London to meet future demand, thereby reducing congestion on some of the most overcrowded lines on the London Underground network. According to Crossrail Ltd's website, Crossrail will increase capacity on the rail network in central London by around 10%.

In 2010, the Crossrail business case forecast that London's population would continue to grow, with nearly 1.3 million additional people living in London and 750,000 new jobs being created between 2010 and 2031, and that annual growth in demand for peak-time public transport would increase to around 1.5% a year. At that time, Crossrail Ltd estimated that Crossrail would carry around 200,000 people each day during the morning peak.

**Figures 4a and 4b** shown on the right, which are taken from the 2010 business case, show that Crossrail Ltd was forecasting that the introduction of Crossrail services to the network could result in peak-time reductions in overcrowding of between 20% and 60% on the Bakerloo, Central, District and Jubilee lines of the London Underground as well as reductions in overcrowding on the national rail network.

**Figure 4a**

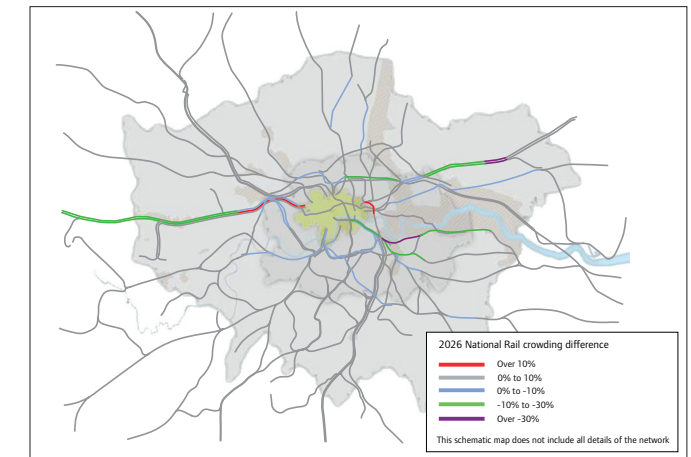
London Underground crowding changes with Crossrail 2026



Source: Crossrail business case, July 2010. Available at: <https://webarchive.nationalarchives.gov.uk/20120215100250/http://assets.dft.gov.uk/publications/crossrail-business-case-update/crossrail-business-case-update-summary-report-july-2011.pdf>

**Figure 4b**

Rail crowding changes with Crossrail 2026



Source: Crossrail business case, July 2010. Available at: <https://webarchive.nationalarchives.gov.uk/20120215100250/http://assets.dft.gov.uk/publications/crossrail-business-case-update/crossrail-business-case-update-summary-report-july-2011.pdf>

Increasing capacity and reducing congestion

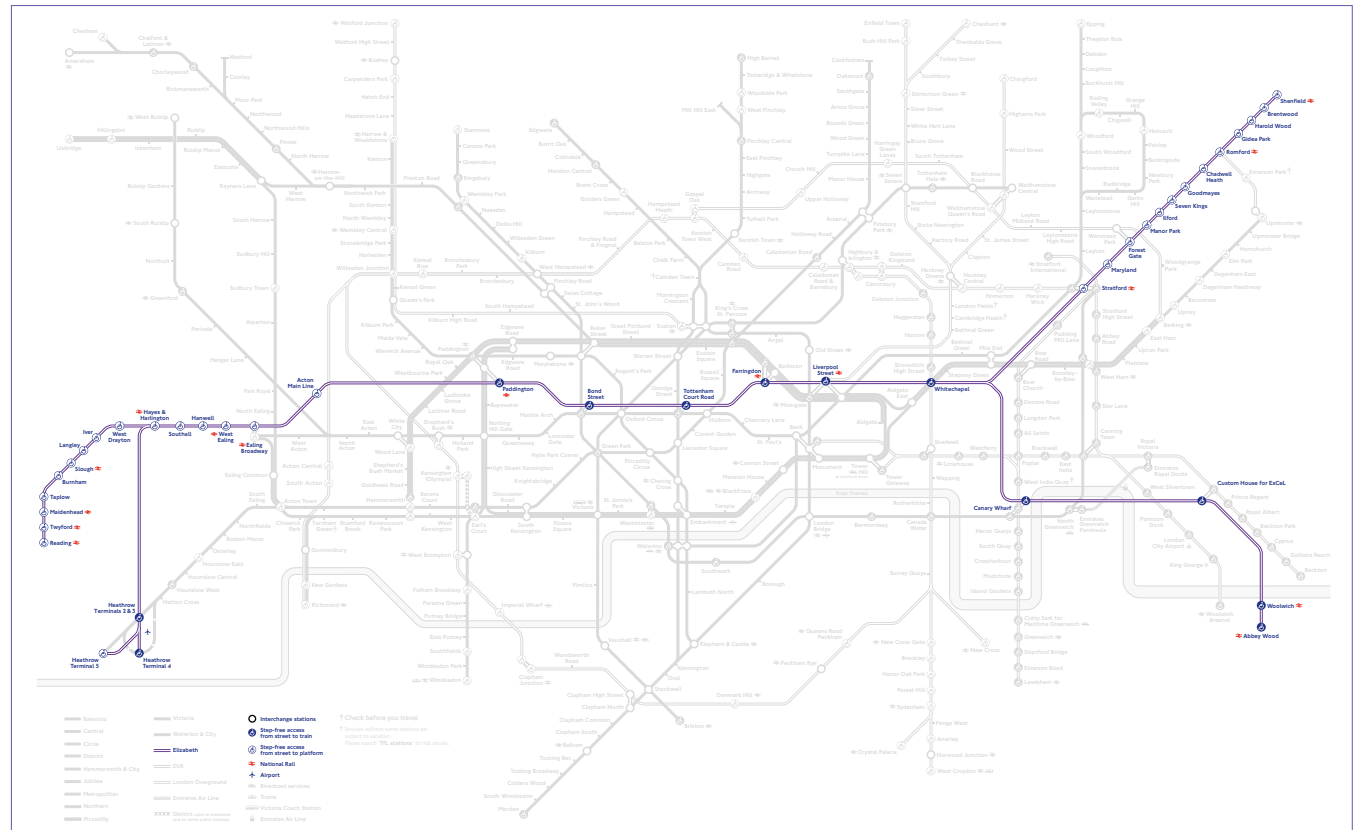
Improving connectivity

Government and TfL projections of the benefits of Crossrail

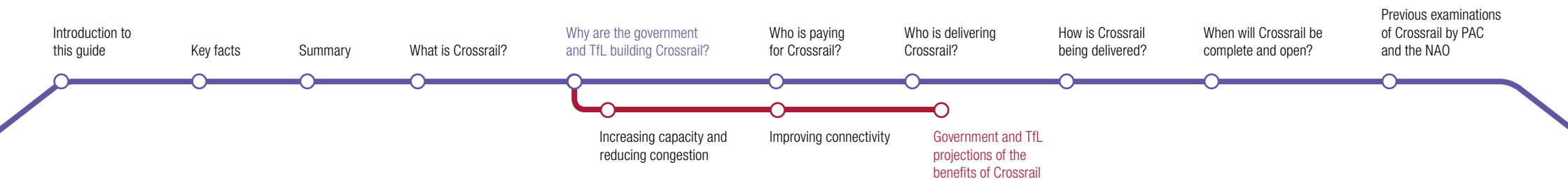
## Improving connectivity

Improving connectivity was one of Crossrail's main objectives. When the railway is fully open and all services are running – the timing for which is not yet clear – Crossrail will provide a direct link between London's existing major employment centres, including Heathrow, the City of Westminster and the West End (Paddington and Bond Street), the City of London (Farringdon and Liverpool Street) and Canary Wharf. Crossrail has interchanges with most London Underground lines, the Docklands Light Railway, and the London Overground, as well as main-line stations including Stratford, Woolwich, Paddington and a number of stations on the Great Western and Great Eastern main lines.

**Figure 5**  
Crossrail (the Elizabeth line) as it will appear on the London Underground map



Source: Crossrail route map. Available at: [www.crossrail.co.uk/route/maps/](http://www.crossrail.co.uk/route/maps/)



## Government and TfL projections of the benefits of Crossrail

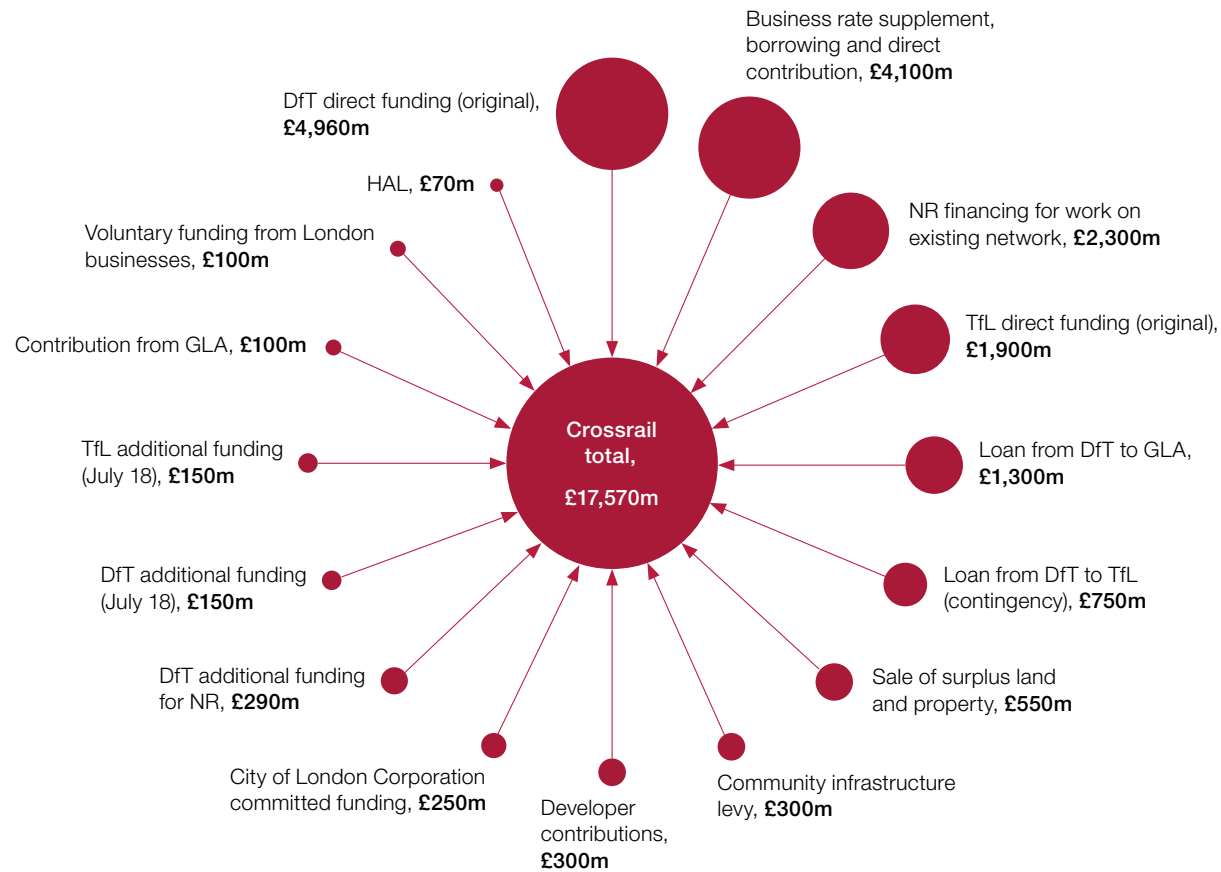
The benefit–cost ratio in the latest 2011 update of the business case was 1.97. This means every £1 invested in Crossrail would achieve £1.97 of benefits to the economy. The assessed benefits of Crossrail in the economic appraisal of the programme are shorter journey times and less congestion. This is within the Department’s definition of ‘medium’ value for money, a range of 1.5 to 2. The benefit–cost ratio increases to £3.10 of benefits for every £1 of investment in Crossrail if estimated wider economic benefits are included. Crossrail Ltd has not updated the business case since 2011.

The business case states that Crossrail will bring about a wide range of additional economic and social benefits. For example:

- The Elizabeth line will bring 1.5 million more people within a 45-minute commute of the existing major employment centres of the West End, the City and Canary Wharf (up from 5 million currently), and make major international gateways like London Heathrow more accessible.
- Crossrail will support up to 14,000 construction jobs and 1,000 jobs operating and maintaining the railway once complete.

## The Crossrail funding and financing model

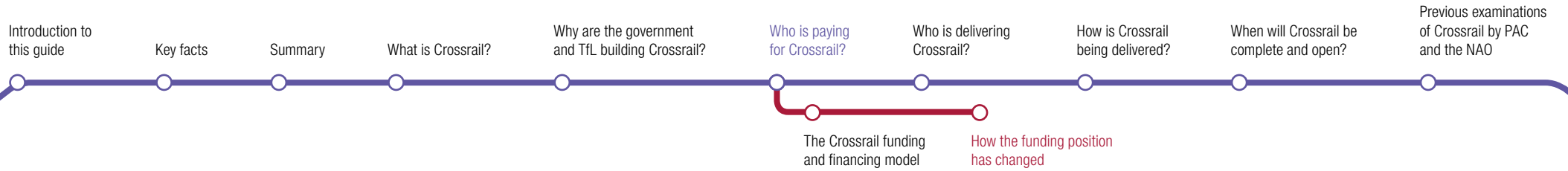
**Figure 6** Breakdown of contributions to the Crossrail funding package of £17.6 billion



**Notes**

- Cost in £ millions, includes £750 million contingency loan announced in December 2018. Excludes the cost of the rolling stock and depot.
- GLA = Greater London Authority; DfT = Department for Transport, TfL = Transport for London; NR = Network Rail; HAL = Heathrow Airport Limited.
- Precise levels of funding from some sources, such as sale of surplus land and property may be subject to change.

Source: National Audit Office analysis of departmental information



## How the funding position has changed

Funding for the project has increased by £2.8 billion to £17.6 billion

In 2007 the government announced a **funding package from project sponsors of £15.9 billion** for the infrastructure elements of the project, including improvements to the existing network to be delivered by Network Rail.

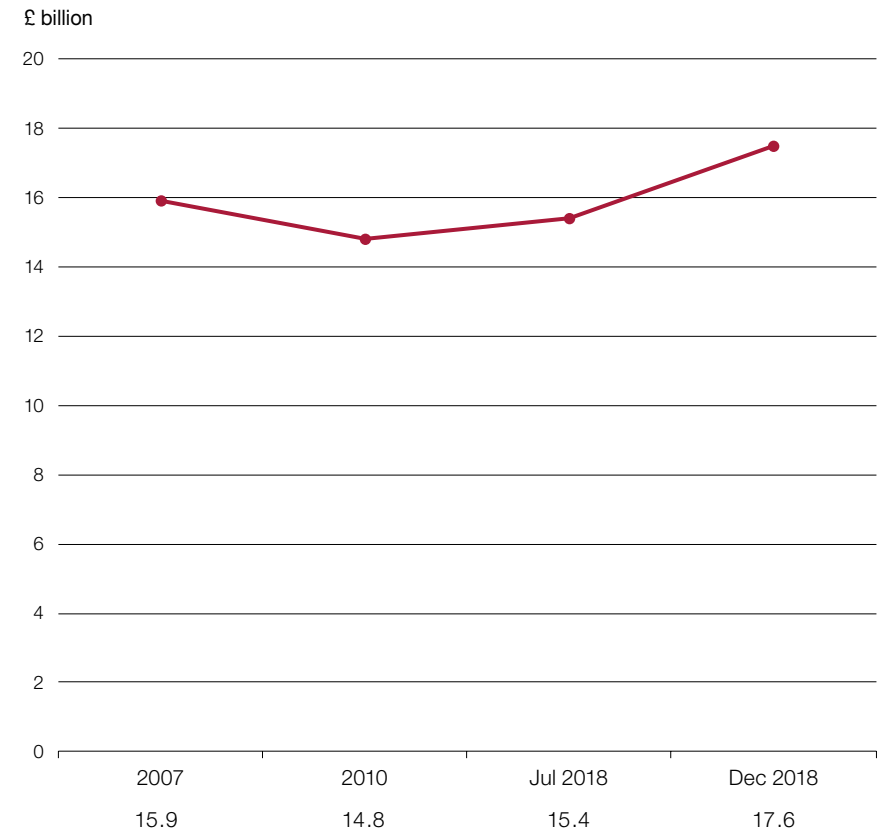
In 2010 project sponsors **reduced available funding to £14.8 billion** to reflect savings identified and revised cost estimates.

Reflecting cost pressures, in July 2018 the Department announced that project sponsors had agreed an additional £590 million of funding, bringing the overall funding to **£15.4 billion**.

Reflecting delays and further cost increases, in December 2018 the Department announced that it would loan £1.3 billion to the Greater London Authority (GLA). The GLA intend to repay this loan via London's Business Rate Supplement and from the Community Infrastructure Levy. In addition the Department announced a £750 million loan could be made available to Transport for London (TfL) as additional contingency. The GLA has also agreed to make an additional cash contribution of £100 million. **The total funding package for the infrastructure project is now £17.6 billion.** The final cost of the programme is not yet known.

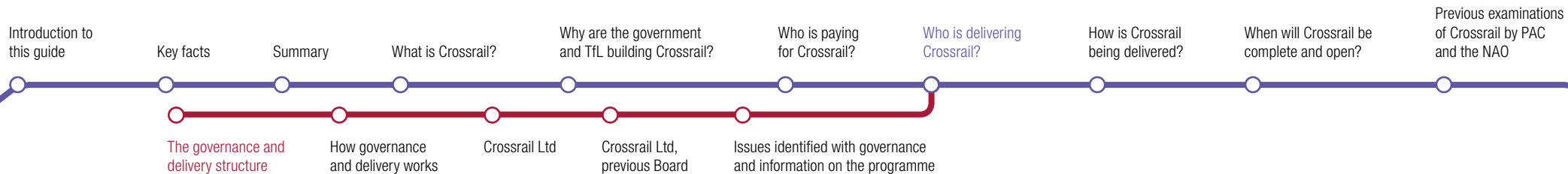
The upfront capital cost of rolling stock and depot is around £1 billion. The capital cost of the trains was funded directly by TfL and is outside the main funding package shown in **Figure 7**. In January 2018, TfL announced its intention to sell the rolling stock and to lease it back from the buyer, in order to release capital to invest in the enhancement of other tube lines. This transaction has not yet been concluded.

**Figure 7**  
Funding package

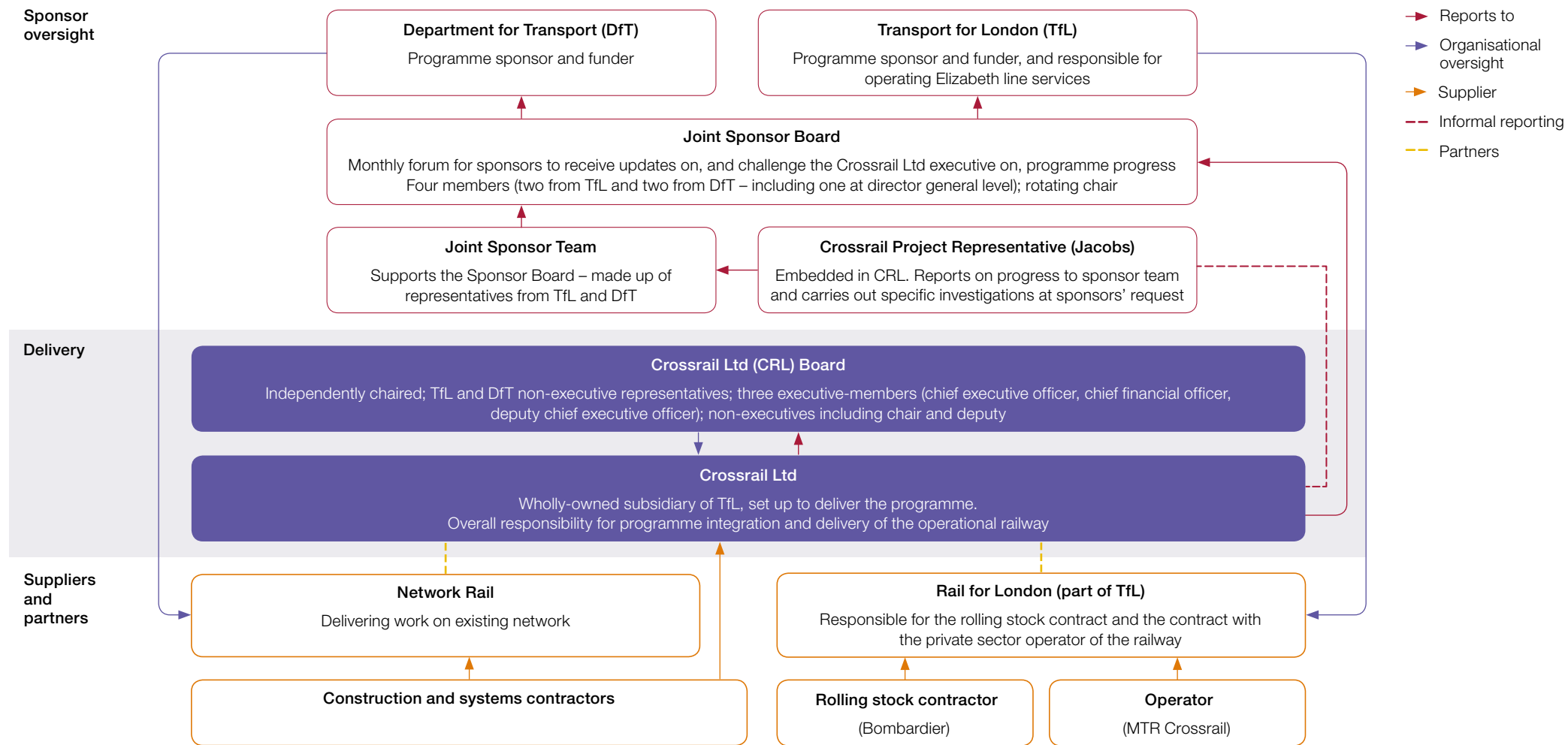


Source: National Audit Office analysis of departmental information

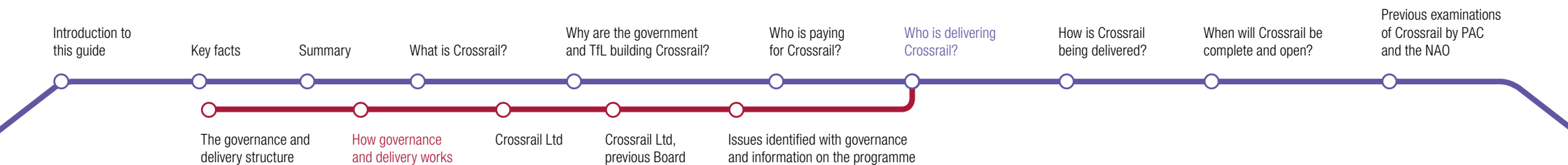




**Figure 8** The governance and delivery structure



Source: National Audit Office analysis of departmental information



## How governance and delivery works

### Sponsor oversight

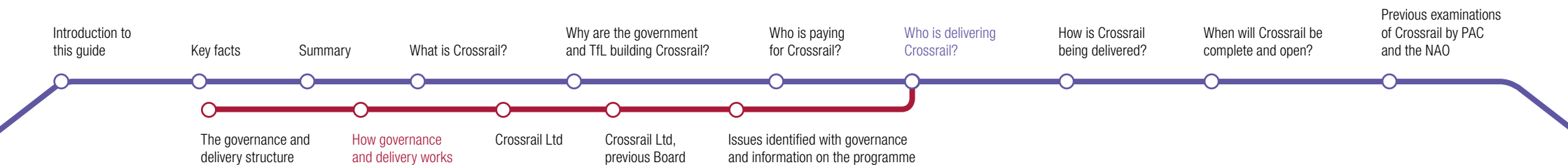
The Department and TfL are jointly sponsoring the Crossrail project. A number of agreements formalise delivery and governance arrangements:

- An agreement between the Department and TfL, which sets out the respective responsibilities of the two sponsors and how the programme will be governed.
- A Project Development Agreement between the Department, TfL and Crossrail Ltd, which defines Crossrail Ltd's overall responsibility for successful delivery of Crossrail, including construction, integrating the programme and making preparations for operating the railway. The project development agreement did not state how sponsors would gain assurance about Crossrail Ltd's readiness to move to the operational phase of the programme.
- A protocol between Network Rail and Crossrail Ltd sets out Network Rail's responsibilities for delivering the surface elements of the route.

A joint sponsor board oversees the programme and meets monthly to discuss progress on the programme. A joint sponsor team supports the sponsor Board, and is made up of staff from TfL and the Department. The Project Representative (P-Rep) is a team of engineers and project management specialists from engineering firm Jacobs that is contracted by the sponsors to provide support and advice to the sponsor team and sponsor board. It reviews and provides commentary on Crossrail Ltd's regular progress reports, as well as carrying out focused reviews of particular aspects of the programme.

In the project development agreement, the sponsors and Crossrail Ltd agreed a set of 'intervention points' to encourage Crossrail Ltd to keep its own direct costs within available funding, and set out actions sponsors could take in the event that forecast costs increased above specified thresholds. Crossrail Ltd's forecast costs breached the first two intervention points in November 2015 and June 2017 respectively, which resulted in sponsors seeking assurance that Crossrail Ltd could bring costs under control.

The project formally breached the final intervention point in May 2018. At this stage, TfL could have required the Department to take ownership of Crossrail Ltd and either wind-up or continue with the project. In the event, sponsors decided not to take this option, but sought further assurances from Crossrail Ltd that it could bring costs under control.



## How governance and delivery works

2/2

### Delivery

Crossrail Ltd is a company wholly owned by TfL that is responsible for delivering the programme, from building the line and stations, through to integrating systems and providing an operational railway. The main governance body overseeing delivery of the programme is the Crossrail Ltd Board. Sponsors' oversight of the programme has been through appointed non-executive members of the Board and through discussions with the Crossrail Executive at the Sponsor Board. The Crossrail Board does not report to the sponsor Board.

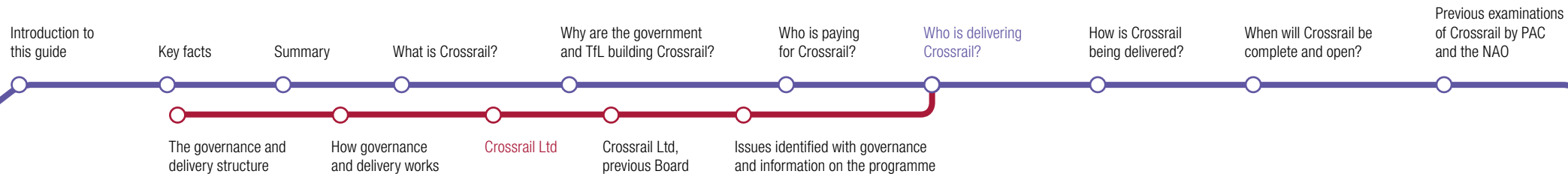
The Crossrail delivery model, which involves the establishment of a separate delivery body, was previously used on the programme to develop the Olympic Park (now the Queen Elizabeth Olympic Park) in Newham, east London, and to construct the venues required for the 2012 London Olympic and Paralympic Games. This model is now being used on, for example, High Speed 2. The Crossrail model differs from the Olympics and High Speed 2 in that the Olympic Delivery Authority was, and High Speed 2 Ltd is, a non-departmental public body sponsored by government departments, and chief executive officers who are/were also accounting officers.

Crossrail Ltd earned autonomy from the sponsors to deliver the programme – meaning that it had, for example, authority to award major contracts – by passing four review points between July 2008 and April 2011. In our January 2014 report on Crossrail we recommended that the Department should finalise its plans for the development of governance arrangements as appropriate for the transition from construction to operation.

### Suppliers

Crossrail is being delivered through contracts between Crossrail Ltd and a range of private sector suppliers, including programme delivery partners, Bechtel and Transcend (a consortium of AECOM, CH2M Hill and Nichols Group), Siemens, and other joint ventures from firms including Alstom, Costain, Skanska and Balfour-Beatty. These main contractors have contracts with other suppliers for the supply of services, materials and components of the railway. The contract to design, build and maintain the trains is between TfL and Bombardier Transportation.

Although Network Rail is a public sector body sponsored by the Department, on the Crossrail programme it functions as a partner to Crossrail Ltd, funded directly by the Department, with its responsibilities set out in the protocol agreement between Network Rail and Crossrail Ltd.



## Crossrail Ltd

There were significant changes to the executive team and board during 2018 to strengthen Crossrail Ltd's capabilities:

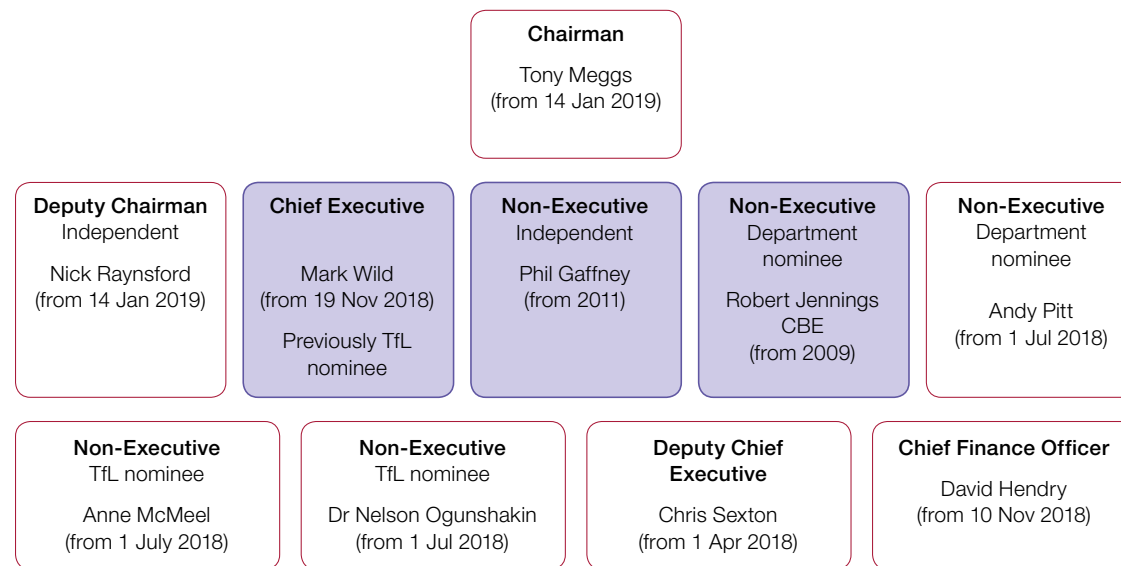
- The Crossrail Board approved the appointment of a new executive management team during late 2018. The sponsors also approved the appointment of the chair and chief executive.
- Crossrail Ltd's current Board of Directors is chaired by Tony Meggs, previously the Chief Executive of the Infrastructure and Projects Authority, following the resignation of Sir Terry Morgan in December 2018.
- The new Chief Executive, Mark Wild, was previously a non-executive member of the Crossrail Board and has been appointed on secondment from his role as Managing Director of London Underground.
- Three members of Crossrail's Board have been with the project for more than one year (**Figure 9**).

The sponsors have increased their representation on Crossrail Ltd's Board to increase scrutiny and support transition to operations:

- The Board now includes two non-executive directors nominated by the Department.
- TfL now has two appointed non-executive nominees on the Board.
- Up to mid-2018, each sponsor only had one nominated non-executive member on the Board.

**Figure 9**

Crossrail Ltd Board of Directors at February 2019

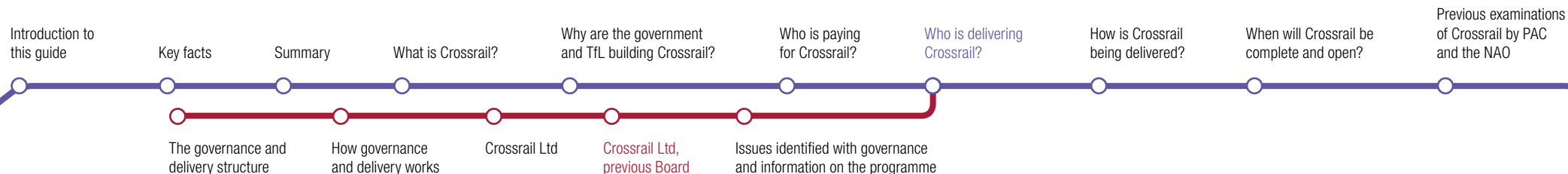


- Board member for less than one year
- Board member for more than one year

**Note**

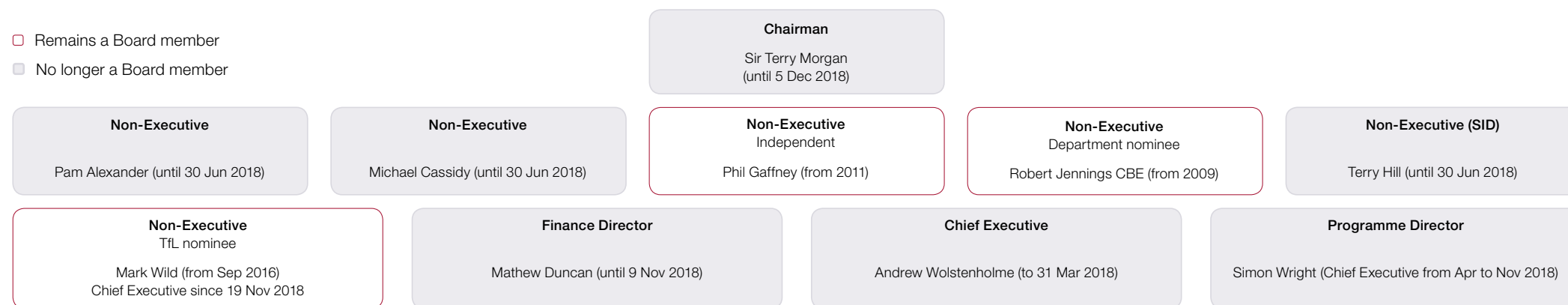
1 The Chief Executive, Deputy Chief Executive and Chief Finance Officer are executive members of the board.

Source: Crossrail Ltd



## Crossrail Ltd, previous Board

**Figure 10** Crossrail Ltd Board of Directors at 31 March 2018



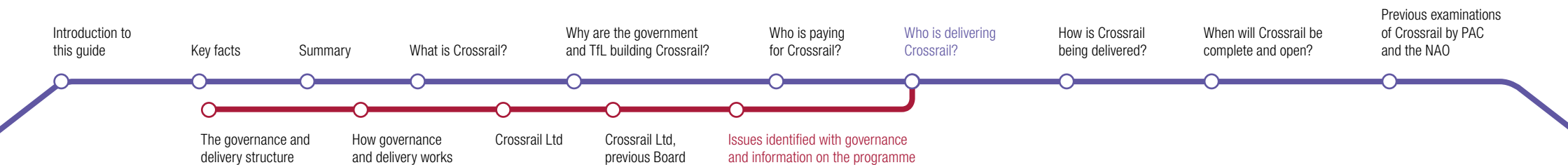
### Crossrail Ltd senior remuneration

Remuneration in 2017-18	Salary	Performance related pay for 2016-17	Compensation for loss of employment	Benefits in kind	Total remuneration (excluding pension contributions)	Total remuneration (excluding pension contributions)
	2017-18 (£000)	2017-18 (£000)	2017-18 (£000)	2017-18 (£000)	2017-18 (£000)	2016-17 (£000)
Andrew Wolstenholme, Chief Executive	477	160	98	2	736	946
Simon Wright, Programme Director	329	106	–	2	436	494
Sir Terry Morgan, Non-Executive Chairman	250	–	–	2	252	252
Mathew Duncan, Finance Director	247	112	–	2	361	270

#### Note

1 The sponsor agreement, to which the Department and TfL are parties, sets out the Remuneration Principles governing the remuneration and benefits package which applies to all members of the Crossrail Ltd Board. The Crossrail Ltd Remuneration Committee develops the Remuneration Framework, consistent with the Remuneration Principles. TfL approves the Remuneration Framework and ensures that the Secretary of State is provided with the approved Framework promptly. The Secretary of State may object to any part of the Remuneration Framework or a specific remuneration and benefits package which is not consistent with the Remuneration Principles and TfL shall take appropriate action to ensure that the inconsistency is addressed. The remuneration and benefits package of the executive directors of Crossrail Ltd and the chair and chief executive officer of Crossrail Ltd is determined by the Crossrail Ltd Remuneration Committee in accordance with the Remuneration Framework and in consultation with TfL.

Source: Transport for London Annual Report and Statement of Accounts, 2017-18

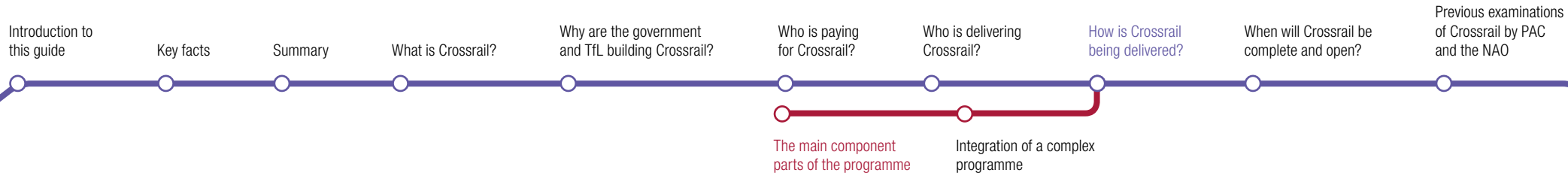


## Issues identified with governance and information on the programme

**Figure 11**  
The Department and TfL commissioned KPMG to perform three reviews of the programme

Review	Purpose
<p>Financial and commercial (published January 2019)</p> <p>Available at: <a href="http://content.tfl.gov.uk/financial-and-commercial-redacted.pdf">http://content.tfl.gov.uk/financial-and-commercial-redacted.pdf</a></p>	<p>To establish the extent to which Crossrail Ltd's financial modelling reflects the true state of the finances of the programme. It was a high-level assessment and did not include detailed analysis of the programme schedule or remaining works. It found that based on this information, it expected the programme to need between £1.6 billion and £2 billion more to complete the programme, including the additional £300 million announced in July 2018.</p> <p>The sponsors used this work to determine the revised funding package, and the amount the Department would loan the Greater London Assembly and TfL.</p>
<p>Governance (published January 2019)</p> <p>Available at: <a href="http://content.tfl.gov.uk/governance-redacted.pdf">http://content.tfl.gov.uk/governance-redacted.pdf</a></p>	<p>To assess how governance and oversight of the programme had been working, and to make recommendations for improvement. It examined the relationship between the sponsors and Crossrail Ltd, and information coming to the Crossrail Board and on to the sponsors. It found that:</p> <ul style="list-style-type: none"> <li>● Reporting within, and by, Crossrail Ltd was neither timely, nor sufficiently clear, as to the impacts and magnitude of the range of probable consequences of issues within the programme.</li> <li>● Crossrail has taken action to update governance arrangements to reflect the changing nature of the programme. For example, Crossrail Ltd has created the Elizabeth line Strategic Steering Group. However, the revised governance arrangements have not sufficiently reflected the changing balance between construction, systems, integration and operational readiness activities.</li> <li>● The Project Representative reported many of the key issues and risks to achieving the December 2018 opening date for the central section, but did not provide an assessment of the potential or likely impact on the opening date. KPMG found that the Project Representative did not adequately challenge Crossrail Ltd in its assumptions that it could recover delays, but this is not necessarily the view of sponsors.</li> <li>● There was a much-reduced level of internal scrutiny during 2017-18 and 2018-19, as the Crossrail Board continued with its plans to reduce central resources. This included reduced internal audit coverage and disbanding the Crossrail Limited Audit Committee in July 2018 and the reallocation of its responsibilities.</li> </ul> <p>The sponsors are considering what actions to take as a result of the review.</p>
<p>Timeline of events</p>	<p>To validate the Department's timeline of events between November 2017 when the explosion at Pudding Mill Lane occurred, and October 2018. The first phase of this work confirmed that the Department's timeline was largely consistent with source documents. A second phase is now underway to produce a more detailed timeline of events. Sponsors plan to publish this work once the second phase is complete.</p>

Source: KPMG reviews



## The main component parts of the programme



The Crossrail programme has the following main components:

### Tunnels

The 26 miles of Crossrail tunnels were created by eight tunnel-boring machines, each lowered into a series of shafts along the route. The machines cut their way beneath London with precision, removing spoil and creating the main structure of tunnels as they went.

### Systemwide track and electrification

Once the tunnels had been built, concrete slab track and the steel railway itself could be laid, as well as the overhead lines required to provide power to the trains, and the systems needed to operate the railway.

### Stations

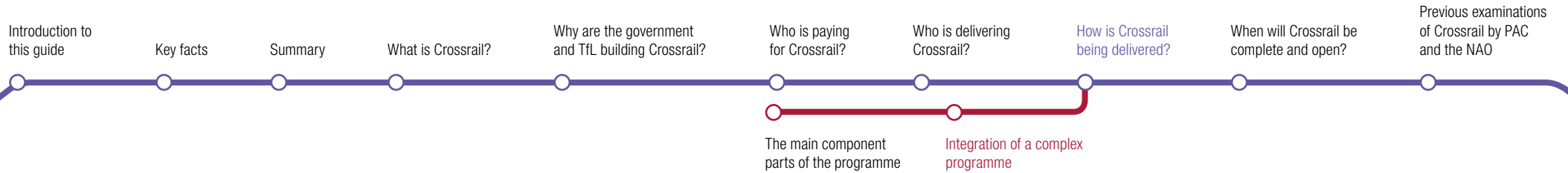
The Crossrail programme required the construction of 10 new stations; seven of them below ground in the central section and three on the existing network. The programme also included the enhancement of 31 existing stations. Each station platform is around 240 metres long to accommodate the 200-metre-long, nine-carriage trains. A range of complex IT systems support management of the stations, including keeping passengers safe, and ensuring that they can move efficiently through the stations.

### Trains and depots

In February 2014, TfL awarded the contract to design, build and maintain the trains that will run on the Elizabeth line (including a maintenance depot). The new Class 345 trains have new systems to provide passengers with information. Passengers are able to walk through the train from carriage to carriage and each train is designed to carry 1,500 passengers.

### Railway operations

In July 2014, TfL awarded a concession contract to Mass Transit Railway (MTR), a transport operating company based in Hong Kong, to operate Elizabeth line services. MTR Crossrail began running services on the eastern section of the railway in May 2015 and has a contract to operate services for eight years, with an option to extend to 10 years.



## Integration of a complex programme

1/2

The design of the programme involves a number of complex elements.

### The trains

Crossrail's new Class 345 trains are the first of a new class of train involving new systems and software. They will be run with nine carriages and will be nearly twice the length of a tube train, and are designed to carry 1,500 passengers.

### Signalling

The Crossrail trains will use an on-board Train Control and Management System (TCMS) to integrate information from a range of signalling systems to maintain safe and effective operations. The nature of the Crossrail route, which runs on both the existing national network and a new section of underground railway will use three separate signalling systems: Train Protection Warning System (TPWS), which is used on the mainline sections of the railway and is focused on ensuring safe operation of the railway; and two separate systems – Communication Based Train Control (CBTC) and European Train Control System (ETCS) – which use technology on the trackside and train to identify the position of trains and issue instructions to both maintain safety and enable the railway to operate with shorter distances between trains to increase overall capacity. The safe and efficient operation of Crossrail services depends on the TCMS software being able to switch between these three systems as the trains move from one part of the route to another. This transition between signalling systems has not been used in this way before on the UK's railways. **Figure 12** shows which signalling systems are being used on which sections of the railway.

### Operational systems

To maintain safe and efficient management of stations, Crossrail will use Supervisory Control and Data Acquisition (SCADA) software. These systems require data collection sensors to be installed in stations to enable key systems such as on-platform sliding doors, lifts and escalators to be monitored effectively.

### Stations

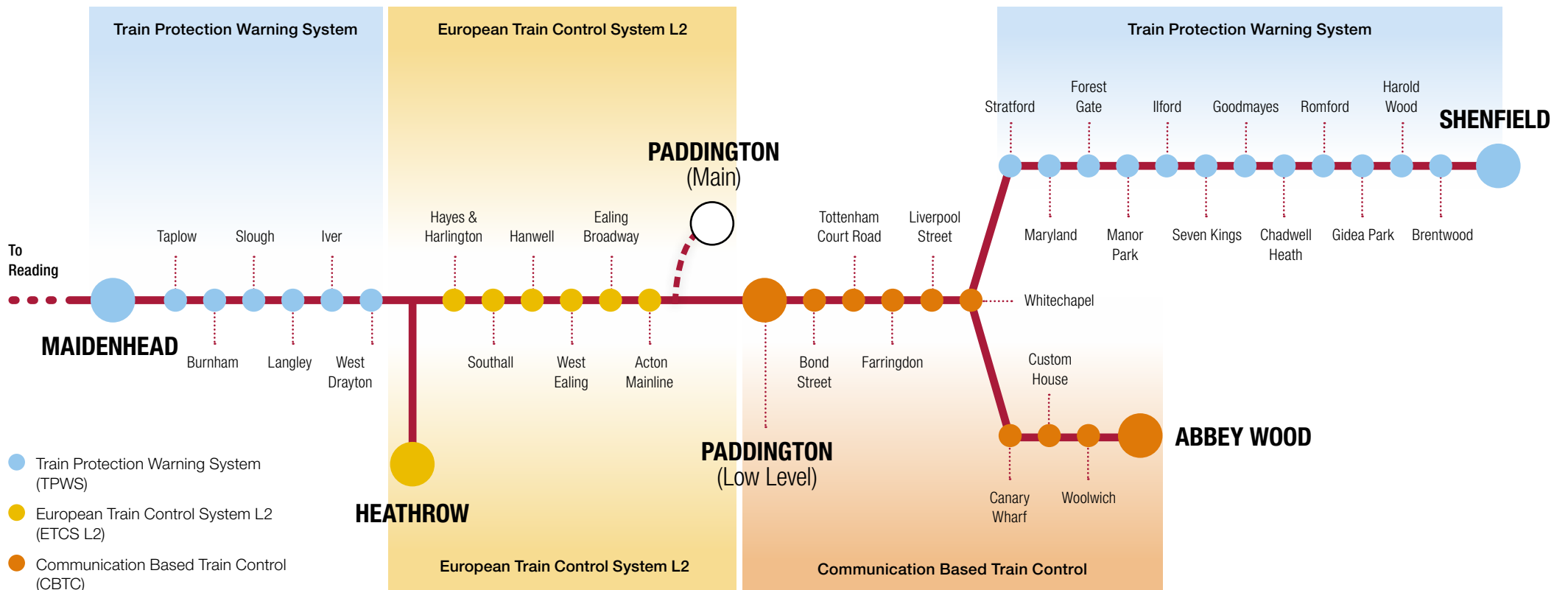
A number of the stations on the Crossrail route have been designed to a high architectural specification. Examples of complex design features include the roof and ceiling of the ticket hall at Farringdon station and the extensive use of a large steel and glass canopy at Paddington station to bring in natural light.

Mark Wild, Crossrail Ltd Chief Executive, has stated that integrating the stations into the new railway and into the wider London underground and national rail network is a significant undertaking. There are around 60,000 different elements that must be integrated for the stations to operate effectively. TfL would usually undertake this activity once a year. Crossrail Ltd is developing its schedule and approach to do this for 10 stations in a compressed timeframe.



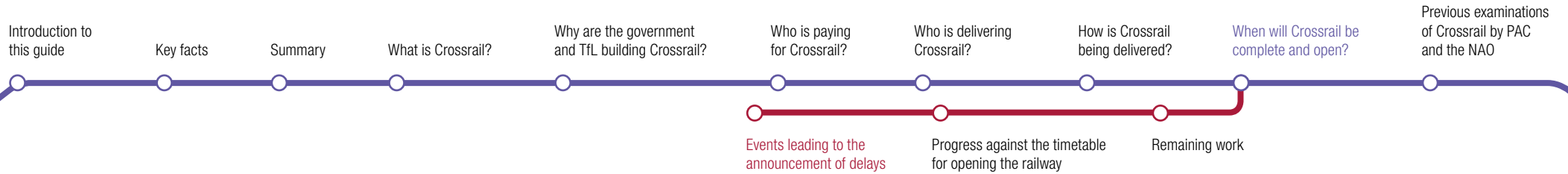
## Integration of a complex programme

**Figure 12** Signalling systems on the Crossrail route



**Note**  
1 TPWS will be used from Reading to Paddington until ETCS is fitted on the Great Western main line.

Source: Crossrail Ltd

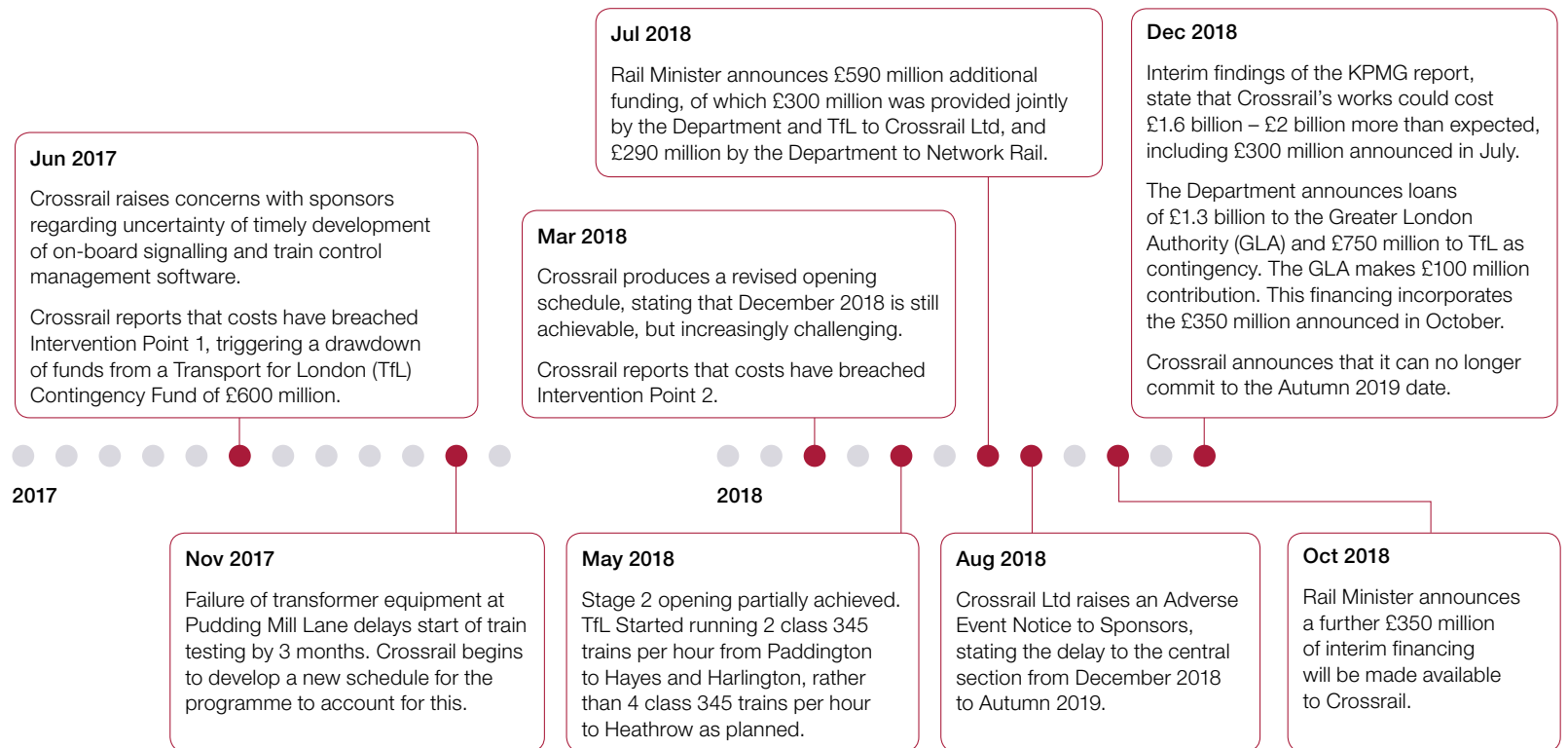


## Events leading to the announcement of delays

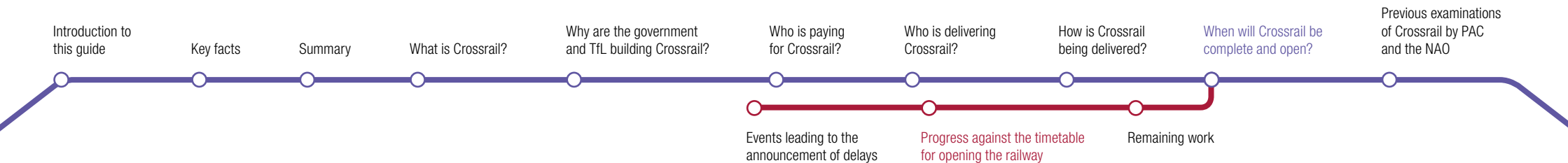
From late 2017, cost pressures escalated, eventually causing costs to exceed the revised £14.8 billion funding agreed by sponsors in 2010.

Risks to the schedule began to materialise. First there were delays to the train software, and then delays to the testing of the trains in the tunnels. Crossrail produced a revised schedule to allow testing while construction and fit out continued, but in August 2018 it was decided that the December 2018 deadline for opening the central section could not be met.

**Figure 13**  
Recent events on the Crossrail programme



Source: National Audit Office analysis of departmental information



## Progress against the timetable for opening the railway

The Department and TfL originally planned for the central section of the railway to start running from December 2018. In 2010, sponsors decided to stagger the opening of the railway by opening the railway in sections and introducing services in a phased way. This was in order to reduce risks – and therefore reduce the costs allocated to risks – associated with opening the railway ‘all at once’.

As **Figure 14** on the right shows, Crossrail Ltd did not open the full, planned services for stages 1 and 2 on time, and it remains unclear when stages 3, 4 and 5 will open. New class 345 Bombardier trains are in use between Shenfield and Liverpool Street as part of the opening of stage 1 services, but are not yet in use between Heathrow and Paddington as had been planned. This is because the software required to use the ETCS signalling system that is on the line into Heathrow has not yet been successfully implemented and tested.

Project sponsors have agreed a concession arrangement with Mass Transit Railway (MTR) to operate the new railway. MTR are paid a performance-related fee for operating the railway, with TfL retaining revenues. Because of the delays to opening the railway, TfL’s revenues will not start to increase significantly until stage 5 is complete and full end-to-end journeys through central London are possible. TfL’s December 2018 business plan states that its revenues could be around £600 million lower than expected as a result of delays to the opening of Crossrail services. Because Crossrail Ltd and sponsors have not yet confirmed the opening dates for stages 3, 4 and 5, these estimates remain uncertain.

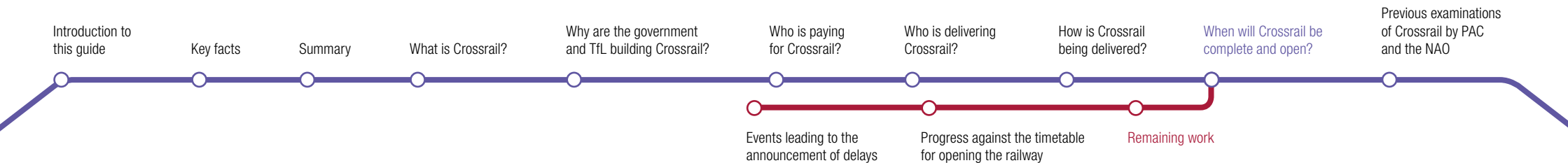
Crossrail Ltd is currently developing a new schedule for the programme.

**Figure 14**

Current plans for introducing new Elizabeth line services

Stage	Description	Target date	Actual/forecast delivery
1	Liverpool Street (main line) to Shenfield	May 2017	June 2017
2	Heathrow to Paddington (main line)	May 2018	Stage 2 opening partially achieved in May 2018. Two Class 345 trains per hour are running from Paddington to Hayes and Harlington, rather than four trains per hour to Heathrow as planned. The Department currently expects four trains per hour to be running by December 2019
3	Paddington (Crossrail) to Abbey Wood – using new Class 345 trains with 15 trains per hour	December 2018	Unknown
4	Paddington (Crossrail) to Shenfield – using new Class 345 trains with 12 trains per hour	May 2019	Unknown – dependent on stage 3
5	Full east–west service with 24 trains per hour in each direction	December 2019	Unknown – dependent on stage 3. There are currently plans to introduce some Crossrail services between the existing Paddington station and Reading from December 2019

Source: National Audit Office analysis of departmental information



## Remaining work

There remains significant work to complete in key areas: the construction and fit-out of the tunnels and stations; and the testing of the signalling and other systems.

Construction and fit-out of the tunnels and stations:

- Work to fit-out tunnels with, for example, cabling and equipment needed to support signalling systems is not yet complete.
- Stations are in different states of completion and there is still significant work to be completed. Bond Street and Whitechapel stations have caused particular problems. Stations are not required to be fully completed in order for some services to start running but opening the railway without stopping at some unfinished stations will delay passengers receiving the full benefits of the railway, and significant further construction work could continue to delay testing.

Testing of the signalling and other systems:

- This includes the lineside signalling systems, the signalling equipment on the trains, as well as the station systems that remotely monitor and control systems, for example, ventilation.

- The software and infrastructure required to operate the complex signalling systems on trains and at the trackside has been significantly delayed. These systems are critical for the safe and efficient operations of services.
- Crossrail Ltd is adopting an incremental approach to the testing of trains running through tunnels, gradually increasing the number of trains tested on the central section, before beginning testing across the entire line. Crossrail Ltd does not yet know how long this testing will take.

Trial running and preparing for operations:

- Once the signalling and safety systems are complete and full testing has been carried out, the railway will be ready to be commissioned and handed over to the operator to begin trial running. This process allows operators to test how the service will work in practice, and refine areas such as passenger management, and how to address delays and faults when they occur.

## Previous examinations of Crossrail by PAC and the NAO

### Relevant reports and transcripts of the Committee of Public Accounts (PAC)

Crossrail, Eighth Report of Session 2014-15, Session 2014-15, HC 574, July 2014.

Available at: [www.parliament.uk/business/committees/committees-a-z/commons-select/public-accounts-committee/news/report-crossrail/](http://www.parliament.uk/business/committees/committees-a-z/commons-select/public-accounts-committee/news/report-crossrail/)

Oral evidence, Rail Franchising in the UK, HC 689, February 2018.

Available at: <http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/public-accounts-committee/rail-franchising-in-the-uk/oral/79138.pdf>

Oral evidence, Department for Transport: Implementation of Brexit, HC 1657, October 2018.

Available at: <http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/public-accounts-committee/department-for-transport-implementation-of-brexit/oral/92048.pdf>

Oral evidence, Rail management and disruption, HC 1793, December 2018.

Available at: <http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/public-accounts-committee/rail-franchising/oral/93794.pdf>

### Relevant report of the National Audit Office (NAO)

Crossrail, Session 2013-14, HC 965, January 2014.

Available at: [www.nao.org.uk/report/crossrail-3/](http://www.nao.org.uk/report/crossrail-3/)



Report by the Comptroller and Auditor General

## A memorandum on the Crossrail programme

HC 1924 Session 2017–2019

ISBN 9781786042439

Ordered by the House of Commons to be printed on 25 February 2019

### CORRECTION

**On page 15 of the memorandum:**

We propose changing the wording describing the role of the Joint Sponsor Board in the governance diagram on page 15 from:

Monthly forum sponsors to receive updates on, and challenge, programme progress

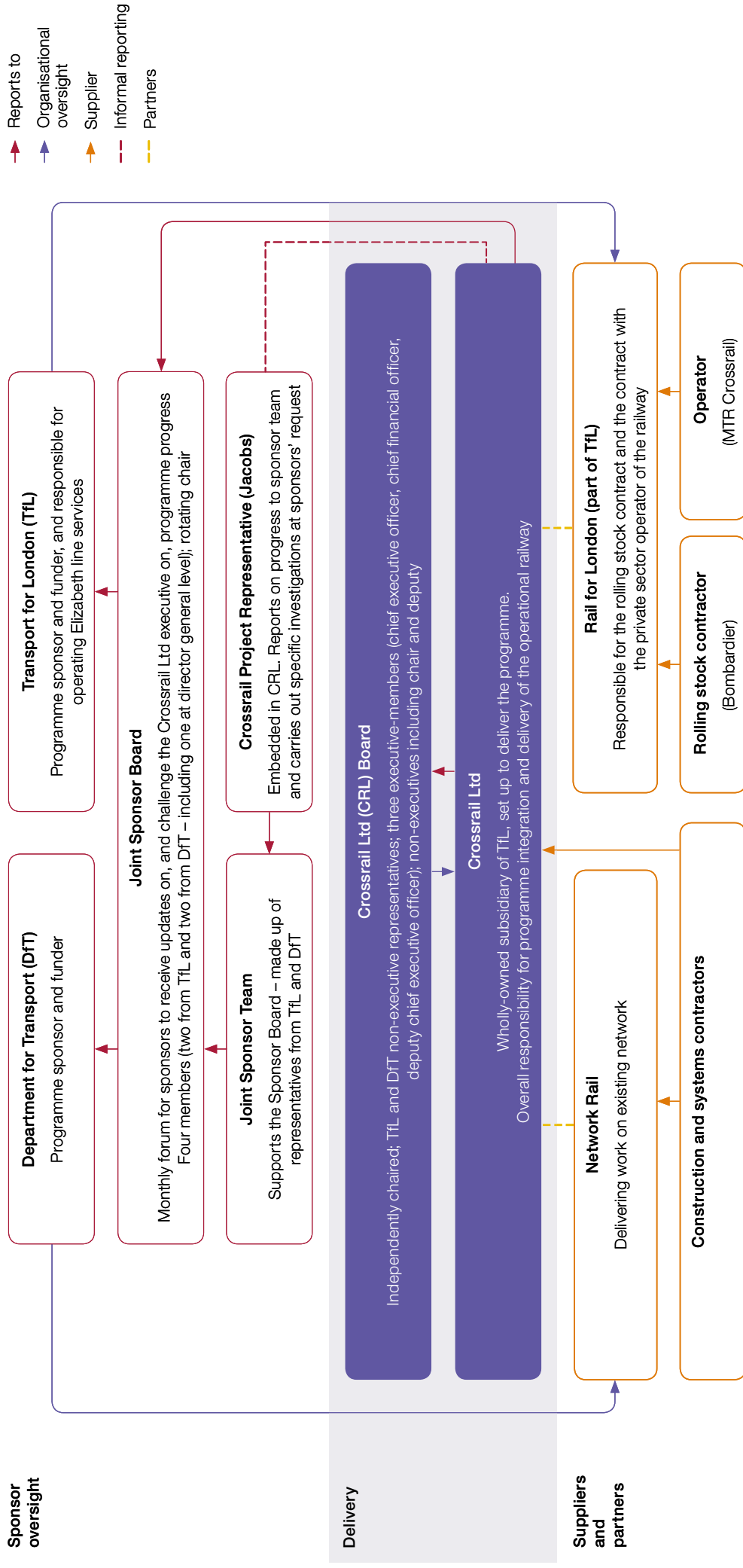
to:

Monthly forum for sponsors to receive updates on, and challenge the Crossrail Ltd executive on, programme progress

This then makes it clear that the Crossrail exec attends sponsor board and is challenged on progress. We also propose including a solid red arrow on the right hand side of the diagram from the box 'Crossrail Ltd' to the box 'Joint Sponsor Board'.

See the corrected **Figure 8** overleaf.

**Figure 8** The governance and delivery structure



Source: National Audit Office analysis of departmental information



**On page 21 of the memorandum:**

We also propose changing the date when MTR Crossrail started running services on the eastern section of the line on page 21 from:

MTR Crossrail began running services on the eastern section of the railway in June 2017

to:

MTR Crossrail began running services on the eastern section of the railway in May 2015

**The corrected paragraph should read**

[Railway operations](#)

In July 2014, TfL awarded a concession contract to Mass Transit Railway (MTR), a transport operating company based in Hong Kong, to operate Elizabeth line services. MTR Crossrail began running services on the eastern section of the railway in May 2015 and has a contract to operate services for eight years, with an option to extend to 10 years.

**On page 19 of the memorandum:**

We also propose changing the date the finance director was no longer a board member, from:

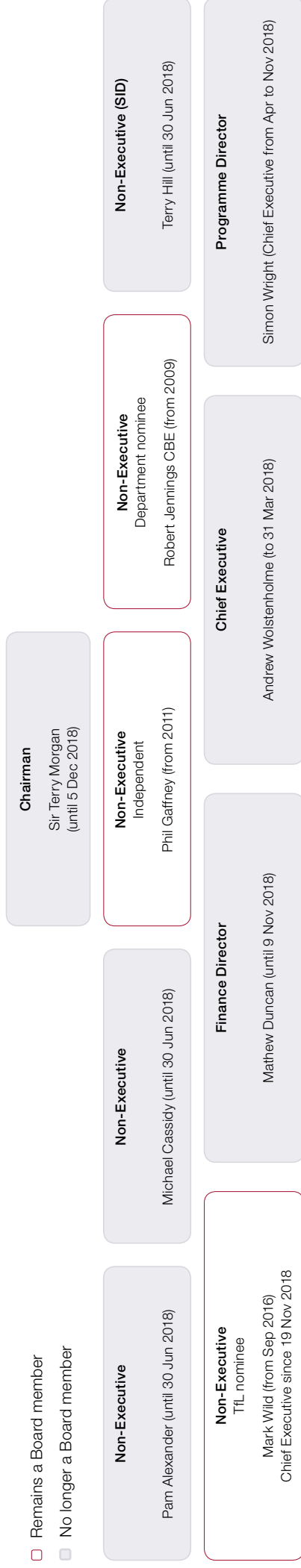
Finance Director Mathew Duncan (until 19 November 2018)

to:

Finance Director Mathew Duncan (until 9 November 2018)

See the corrected **Figure 10** overleaf.

**Figure 10** Crossrail Ltd Board of Directors at 31 March 2018



**Crossrail Ltd senior remuneration**

Remuneration in 2017-18	Salary 2017-18 (£000)	Performance related pay for 2016-17 2017-18 (£000)	Compensation for loss of employment 2017-18 (£000)	Benefits in kind 2017-18 (£000)	Total remuneration (excluding pension contributions)	
					2017-18 (£000)	2016-17 (£000)
Andrew Wolstenholme, Chief Executive	477	160	98	2	736	946
Simon Wright, Programme Director	329	106	-	2	436	494
Sir Terry Morgan, Non-Executive Chairman	250	-	-	2	252	252
Mathew Duncan, Finance Director	247	112	-	2	361	270

**Note**

1 The sponsor agreement, to which the Department and TfL are parties, sets out the Remuneration Principles governing the remuneration and benefits package which applies to all members of the Crossrail Ltd Board. The Crossrail Ltd Remuneration Committee develops the Remuneration Framework, consistent with the Remuneration Principles. TfL approves the Remuneration Framework and ensures that the Secretary of State is provided with the approved Framework promptly. The Secretary of State may object to any part of the Remuneration Framework or a specific remuneration and benefits package which is not consistent with the Remuneration Principles and TfL shall take appropriate action to ensure that the inconsistency is addressed. The remuneration and benefits package of the executive directors of Crossrail Ltd and the chair and chief executive officer of Crossrail Ltd is determined by the Crossrail Ltd Remuneration Committee in accordance with the Remuneration Framework and in consultation with TfL.

Source: Transport for London Annual Report and Statement of Accounts, 2017-18

This report has been printed on Evolution Digital Satin and contains material sourced from responsibly managed and sustainable forests certified in accordance with the FSC (Forest Stewardship Council).

The wood pulp is totally recyclable and acid-free. Our printers also have full ISO 14001 environmental accreditation, which ensures that they have effective procedures in place to manage waste and practices that may affect the environment.



National Audit Office

Design and Production by NAO External Relations  
DP Ref: 007232-001

£10.00

ISBN 978-1-78604-243-9



9 781786 042439

---