



National Audit Office

Report

by the Comptroller
and Auditor General

Department for Transport

Completing Crossrail

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Department for Transport

Completing Crossrail

Report by the Comptroller and Auditor General

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Sir Amyas Morse KCB
Comptroller and Auditor General
National Audit Office

30 April 2019

This report examines the causes of the cost increases and delays to the Crossrail programme.

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The National Audit Office study team consisted of:
Hedley Ayres, Kristian Barrett, Stephen Hathorn, Matthew Hemsley, Matt Paramor, Josh Perks, Rachel Robinson, under the direction of Lee-Anne Murray.

This report can be found on the National Audit Office website at 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

Website: www.nao.org.uk

Twitter: @NAOorguk

Key facts

£14.8bn

funding agreed for Crossrail in 2010, including contingency

£17.6bn

current total funding package for Crossrail, including contingency, an increase of 19%. As at March 2019 Crossrail Ltd expects the overall programme to cost around £17 billion

£2.8bn

increase in available funding for the Crossrail programme to cover cost increases and remaining risks

October 2020 to March 2021

revised target period for opening services on the central section of the Elizabeth line

Yet to be announced

opening date of full Elizabeth line services

December 2018

date, announced in 2010, when the Crossrail sponsors and Crossrail Ltd expected to start running services on the central section of the railway

£600 million

assumption in 2018 Transport for London's (TfL's) business plan of revenue losses between 2019-20 and 2023-24, as a result of delays to the opening of Crossrail services. To be reviewed in line with opening dates announced on 25 April 2019.

£2.5 billion

increase in the cost of contracts between 2013 and 2018 due to design and contract changes

£2.05 billion

value of loans from HM Government to London, including £1.3 billion to the Greater London Authority and £750 million as contingency to TfL to cover the increased cost of Crossrail

Summary

The Crossrail programme

1 Crossrail is a large, complex programme to run new, direct rail services between Reading and Heathrow Airport at the western ends of the railway, to Shenfield in Essex and Abbey Wood in south-east London at the eastern ends. When complete, the railway will be around 73 miles (118 kilometres long), stopping at more than 40 stations, including 10 new stations and 26 miles (42 kilometres) of new tunnels. Once Crossrail is open, it will become part of Transport for London's (TfL's) rail and underground network and will be known as the Elizabeth line.

2 The Department for Transport (the Department) and TfL are jointly sponsoring the Crossrail programme. Crossrail Ltd, a wholly owned subsidiary of TfL, is responsible for delivering an operational railway. Network Rail is undertaking work to improve existing surface infrastructure to meet the needs of the new service. In July 2014, TfL awarded the contract to operate Elizabeth line services to MTR Crossrail.

3 In August 2018, Crossrail Ltd announced that the programme could not be delivered on time and that they would not be in a position to open the central section through London in December 2018 as planned. In December 2018, the Department announced that cost increases on the programme had resulted in an increase in funding to £17.6 billion (some £2.8 billion more than the level of funding announced in 2010), including more than £2 billion of loans from the government to TfL and the Greater London Authority. The guiding principle of this funding package was that London should pay for the cost increases, as it will be the primary beneficiary of the Elizabeth line.

4 Since the end of 2018, Crossrail Ltd has been developing plans that set out when it will complete the programme and introduce Elizabeth line services. In April 2019, Crossrail Ltd announced that it plans to introduce services, excluding Bond Street station, which is still significantly delayed, on the central section of the railway at some point between October 2020 and March 2021.

Scope of the report

5 This report is not intended to apportion blame for what has happened to the Crossrail programme. Our aim is to set out why and how the programme ran into difficulty, and what Crossrail Ltd needs to do to manage the remaining risks to the programme and deliver the promised benefits to passengers and the economy.

6 We have focused primarily on the period from 2015 to March 2019, as problems started to emerge on the programme from 2015. We have also looked at some of the decisions Crossrail Ltd made before this point. This report is based on review and analysis of documents produced by Crossrail Ltd and sponsors, including reports on the programme's progress, and interviews with key senior figures involved in the delivery and oversight of the programme. Crossrail Ltd now has a new management team, Chair and board members. We have not audited the work of the new management team.

Key findings

7 Crossrail is past the point of no return. Nearly £16 billion has already been spent. Tunnelling completed in 2015, trains have been ordered and some are already in service, and Network Rail has lengthened platforms, and enhanced stations and signalling on the existing network in readiness for Crossrail services. In our view, there is no going back. We are not TfL's auditors and have not looked in detail at TfL's finances. It is, however, the case that TfL's financial position depends, in part, on the timing and scale of future revenue that it raises from Elizabeth line services, which remains uncertain, and the final cost of the programme to build the railway (paragraphs 3.1 and 3.16 to 3.21).

8 Crossrail was always going to be complex and challenging. Crossrail involves constructing around 26 miles of tunnels beneath London and 10 new, bespoke stations, most of which connect to the existing underground network. Much of the construction work is taking place in small, enclosed, hard to reach places beneath London, which makes it more difficult to do. Taken together, the Crossrail works on the national rail network are among Network Rail's largest infrastructure projects. The programme also requires software to be developed for a new fleet of trains that can switch between the three different signalling systems along the route (paragraph 1.3).

9 Crossrail has been dominated by a fixed completion date of December 2018. On top of the inherent complexity of the project, in 2010 sponsors and Crossrail Ltd agreed a fixed opening date of December 2018 for the central section, which drove much of Crossrail Ltd's decision-making on the programme. The sponsors set the requirements for the programme, including the scope, budget and timetable. But by providing Crossrail Ltd with a high degree of autonomy, sponsors had few effective contractual levers to enable them to take action, particularly towards the later stages of the programme (paragraphs 1.3 to 1.8, 2.16, 2.20 and 3.12, and Figures 2 and 3).

10 Delivering by December 2018 meant multiple activities ran in parallel.

This approach meant that some work to install systems required to operate the railway, and complete stations, would take place at the same time during the latter stages of the programme. This created vulnerability on the critical path. The delivery approach, delays to some contracts and the decision to set and then stick to the December 2018 opening date, led to increased compression in the programme and increased risks. A number of stakeholders we spoke to expressed the view that the Crossrail Ltd executive team recognised the challenges but believed this was an exceptional team capable of delivering exceptional results and overcoming these challenges (paragraphs 2.12, 2.16 to 2.17, Figure 7, and case example 3 in Appendix Three).

11 Thirty-six main contracts increased delivery and cost risks. Costs on most of the 36 main contracts have increased substantially. Crossrail Ltd did not require individual contractors to manage interfaces with other contractors, and so protected contractors from changes that were outside their control. Therefore, Crossrail Ltd had to compensate individual contractors for delays that occurred on other contracts, on which their work depended, and had to engage in costly change control negotiations. Changes to the design of construction and systems installation work, and changes to contractors' delivery schedules cost around £2.5 billion between 2013 and 2018. This resulted in substantial drawdowns of contingency, which Crossrail Ltd had set aside to manage such risks. Settlement of accumulated compensation events with contractors accounted for nearly £1 billion of these cost increases. Crossrail Ltd decided to hold the delivery and cost risks itself. Crossrail Ltd originally hired Bechtel and Transcend as project management partners to support it in managing the overall programme, including integrating the work of multiple contractors. However, in 2011, Crossrail Ltd chose to fold the Bechtel and Transcend teams into its own project management effort, rather than hold them at arm's length and accountable for integration of the overall programme (paragraphs 2.3, 2.8 to 2.9, and 2.11 to 2.19, Figure 4, Figure 5 and Box 1).

12 Crossrail Ltd did not have a sufficiently detailed delivery plan against which to track progress. Crossrail Ltd started to produce a detailed, realistic, bottom-up plan in late 2018. Prior to this, from 2015, it had based its management of the programme on an aspirational plan designed to improve progress by suppliers, rather than to provide a reality check on overall progress. Crossrail Ltd presented the plan as the critical path for completing the overall programme. However, the plan did not adequately reflect interdependencies across the programme. Consequently, Crossrail Ltd had a gap in its understanding of delivery risks and the likelihood of meeting the December 2018 opening date (paragraphs 2.22 to 2.27 and 3.5).

13 During 2015 and 2016, pressures on the programme began to show and continued to escalate through to the end of 2018. There were three main points when costs escalated:

- From 2015, Crossrail Ltd renegotiated some of its main contracts, to settle historical compensation claims and address the delays that had emerged, by aligning contractors' delivery milestones to its revised programme plan. By November 2016 Crossrail Ltd had drawn down substantial contingency and was forecasting that it would need to use contingency held by TfL, later in the programme.
- Soon after Crossrail Ltd revised the delivery plan in 2015, a number of key contracts were behind schedule again. To meet the December 2018 opening date, Crossrail Ltd accelerated work on key contracts, which increased costs.
- In the run up to, and since, Crossrail Ltd's August 2018 announcement that it would not open the central section in December 2018, costs have increased further because completing the programme depended on contractors' workforces being required for longer than planned. Between March 2018 and December 2018, for example, the forecast final cost of the contract to install track and key systems in the tunnels increased by £189 million (25%), from £767 million to £956 million.

The lack of a realistic programme plan and the frequent re-planning meant that the reducing likelihood of delivering in December 2018 and the sharp increase in cost suddenly became apparent in late 2018 (paragraphs 2.20 to 2.25 and case example 2 in Appendix Three).

14 Between 2015 and 2019, there was little pressure on key contractors to deliver the programme efficiently. During 2015 and 2016, some key contracts were moved from a target price to a cost reimbursement basis. This change meant that Crossrail Ltd removed the key incentive on contractors to minimise costs and took on the financial risk itself. The frequent re-planning of the programme, combined with increasing interfaces between contracts, meant that contractors continued to raise compensation events, and costs continued to increase. After it had announced that it would not open the central section in December 2018, Crossrail Ltd began negotiating fixed price contracts for some of the remaining work to improve certainty about costs. However, this form of contract means that Crossrail Ltd risks losing commercial levers to ensure that contractors prioritise completion of Crossrail over other projects and opportunities (paragraphs 2.13 to 2.14 and 3.8 to 3.9 and Box 1).

15 Crossrail Ltd took some decisions that drove unnecessary cost into the programme. In early 2018, to account for delays to the schedule, Crossrail Ltd began carrying out train and signalling system testing and construction activity in alternating time periods, to allow for early sight of potential train and signalling system issues. However, delays to the train and signalling software development meant that few meaningful results could be acquired at this point and took any spare time and space from construction workers on site. Crossrail Ltd also reduced its central programme and risk management capability during 2018, on the basis that they anticipated the programme reaching completion in December 2018. It is currently rehiring staff now that it is clear that significant work remains, although it has faced challenges recruiting the skills it needs (paragraphs 2.21 and 3.10 to 3.11, and case example 4 in Appendix Three).

16 Crossrail Ltd now needs space and time to complete and deliver its plans.

In April 2019, Crossrail Ltd announced that it plans to introduce Elizabeth line services on the central section between October 2020 and March 2021. While it has made progress with the development of a detailed and realistic plan, Crossrail Ltd has not yet completed its assessment of the financial implications of this opening schedule. It is still unclear when the full Elizabeth line service will start. Crossrail Ltd will continue to come under pressure to open the railway, drive down costs and complete the programme as soon as possible. Notwithstanding these pressures, Crossrail Ltd's new executive team should take the time to make sure that this plan is deliverable and prudent (paragraphs 3.5 to 3.7).

Conclusion

17 Until the new services are open to passengers and the final costs of the programme are known, it is not possible to conclude on overall value for money. What we can say is that there are a number of features in the way the programme has been delivered that have driven unnecessary cost. The compressed schedule, the contractual model, the loss of downward pressure on costs, and the absence of a realistic plan were set against an atmosphere where 'can do' became unrealistic. All these factors and many more set out in this report have contributed to underachievement in terms of cost and progress so far.

18 As mentioned at the start of this report, Crossrail must be completed and the new Crossrail Ltd management team needs to be supported in getting that task executed in the most practical and achievable way possible.

Recommendations**For the Crossrail programme:**

- a** Crossrail Ltd should continue to refine its plan to complete the programme, establish a realistic cost estimate, and resist external attempts to influence timetable and cost.
- b** Crossrail Ltd, working with sponsors, should establish a range of scenarios that set out the potential future impacts on the taxpayer, passengers and businesses and develop plans for how further cost increases or delays in collecting revenue will be financed.
- c** Crossrail Ltd should rebuild its capacity and capability to complete the programme in a timely and cost-effective way.

For the Department's other current and future major programmes

- d** We note that the Department has completed a lessons learned exercise and we would encourage it to also apply the lessons to other major projects including High Speed 2.

Part One

The Crossrail programme

Background

1.1 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. In February 2019 we published *A memorandum on the Crossrail programme*,¹ which sets out more background about the programme, and the recent events that have occurred on it.

1.2 The main objectives of Crossrail were to increase rail capacity, reduce crowding and improve connectivity to destinations in London and the south east of England. Crossrail Ltd estimates that the programme will increase capacity in central London by 10%.

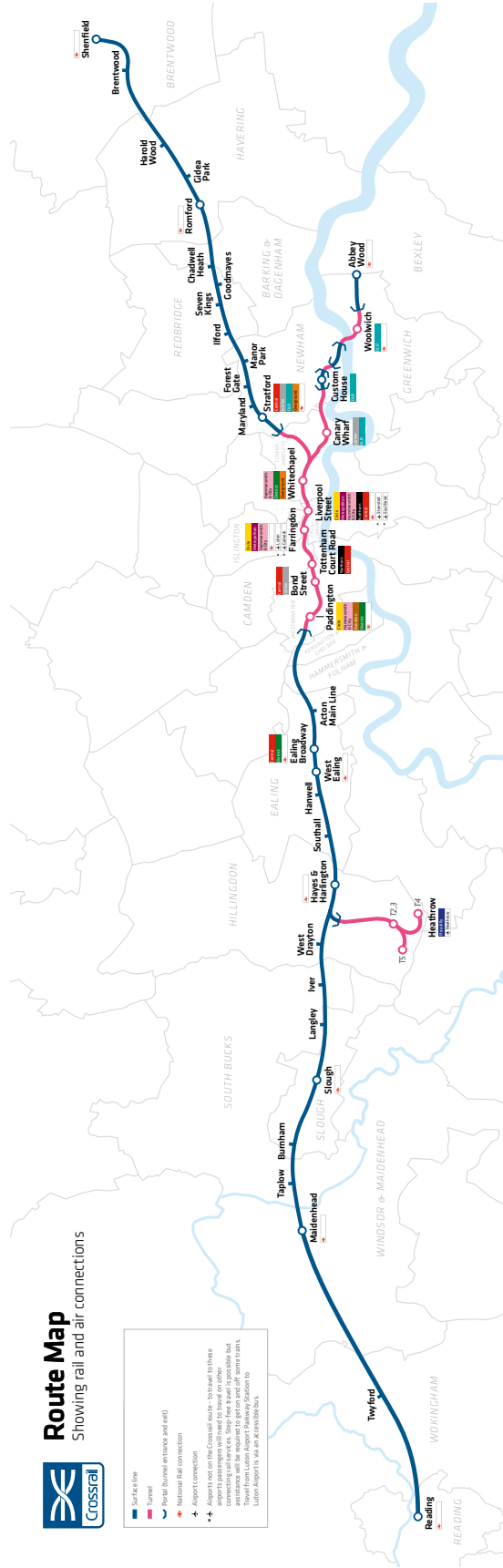
Figure 1 sets out the route of the railway and the stations which Crossrail will serve.

1.3 Crossrail is one of the biggest civil infrastructure projects undertaken in the UK for many years. It is a highly complex undertaking involving:

- the construction of around 26 miles of tunnels beneath London;
- building 10 new, bespoke stations, including eight new underground stations that are substantially bigger than most existing underground stations and have interchanges with underground stations and lines;
- construction work in central London and in enclosed construction sites underground and in built-up areas, which increases the logistical and engineering challenge;
- new electrification work, signalling and improvements to 31 existing stations being carried out on the Great Western and Great Eastern main lines by Network Rail, which together constitutes one of Network Rail's biggest enhancement projects; and
- design and construction of a new fleet of trains and the development of software and equipment to enable the trains to switch between three different signalling systems to ensure safe and efficient services.

¹ Comptroller and Auditor General, *A memorandum on the Crossrail programme*, Session 2017–2019, HC 1924, National Audit Office, February 2019.

Figure 1
The Crossrail route and stations



1.4 MTR-Crossrail began operating services using the new class 345 trains between Liverpool Street and Shenfield from June 2017, and began operating services between Paddington and Heathrow in May 2018. From 2010, sponsors planned for the central section of the railway to open from December 2018, with further staged openings of eastern and western services in 2019.

1.5 In April 2019, based on its completed, revised plan, Crossrail Ltd announced that it will introduce 12 peak-time services an hour on the central section between Paddington and Abbey Wood at some point between October 2020 and March 2021. These services will not initially stop at Bond Street because that station is significantly delayed because of design and delivery challenges. A four trains an hour peak service between Paddington and Reading will start from December 2019. It remains unclear when a full 24 trains an hour service between Heathrow and Reading in the West and Shenfield and Abbey Wood in the east will begin.

Roles and responsibilities

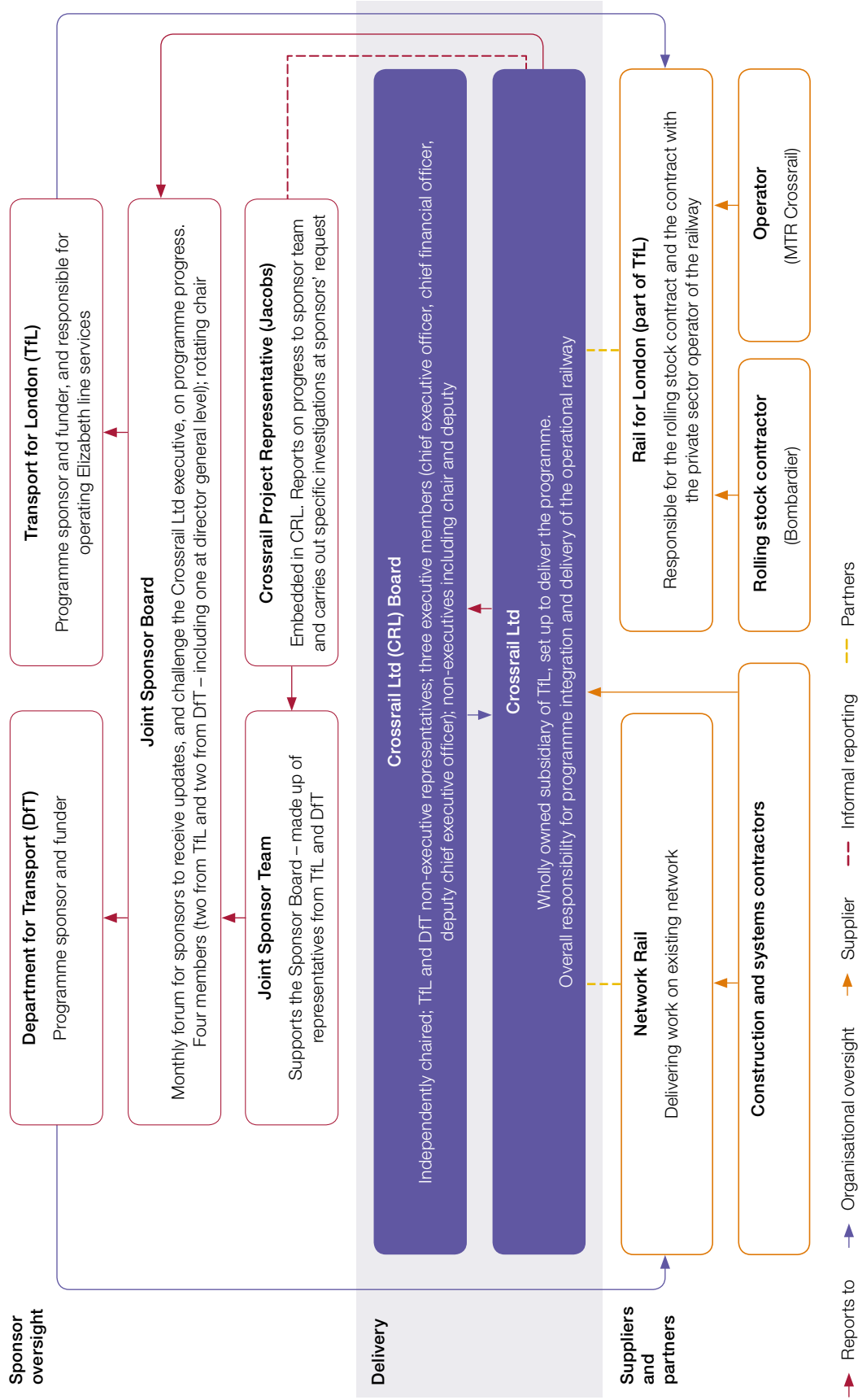
1.6 The Department for Transport (the Department) and Transport for London (TfL) jointly sponsor and oversee the Crossrail programme. Crossrail Ltd is a company wholly owned by TfL and is responsible for delivering the programme safely to cost and schedule. The project development agreement sets out sponsors' high-level requirements for Crossrail, such as service frequency and service levels, as well as the programme's governance and delivery structure (see **Figure 2**).

1.7 The Department and TfL jointly fund the programme. The overall amount of available funding has changed over time. **Figure 3** on page 14 shows the main sources of funding for the programme and how they have changed over time. The funding for Crossrail does not include the cost to build and maintain trains and a maintenance depot, which amounts to an upfront capital cost of around £1 billion, funded by TfL.

1.8 Throughout 2018, the programme began showing signs of distress, until eventually it became clear that the programme could not be delivered as planned. In a written ministerial statement in July 2018, the government announced that a further £590 million would be made available to address cost pressures on the programme. This was followed shortly after by Crossrail Ltd's announcement in August 2018 that it would not be able to open the central section of the railway in December 2018 as planned.

1.9 In response, sponsors commissioned a series of reviews by KPMG into the finance and commercial position and governance of the programme. In December 2018, the emerging findings of the finance and commercial review stated that up to an estimated £2 billion of additional funding would be needed to complete the railway, based on a high-level assessment of Crossrail's management information. In the same month, Crossrail Ltd announced that it could not commit to an opening date for the railway at that time.

Figure 2
The governance and delivery structure



Source: Comptroller and Auditor General, *A memorandum on the Crossrail programme*, Session 2017–2019, HC 1924, National Audit Office, February 2019

Figure 3

Key events in the funding of the programme

Date	Event
2007	Government announces a funding package of £15.9 billion, with expected contributions of £5.2 billion from the Department for Transport (the Department), £2.4 billion from Transport for London (TfL), £2.3 billion from Network Rail and £6 billion from businesses.
2010	Through the Comprehensive Spending Review Crossrail Ltd reduced costs to £14.8 billion by simplifying and resequencing works, agreeing lower contractor prices, and adjusting forecasts in line with the effects of the economic recession. Crossrail Ltd also extended the timetable for full opening from May 2018 to December 2019, to reduce the amount of contingency needed.
July 2018	Written ministerial statement announces an additional £590 million of funding to cover cost pressures on the programme: £300 million for Crossrail Ltd, funded jointly by TfL and the Department, and a further £290 million from the Department for Network Rail's works.
December 2018	A new funding package for the programme is agreed, comprising loans from the Department of £1.3 billion to the Greater London Authority and £750 million contingency to be made available to TfL, as well as a £100 million cash contribution from the Greater London Authority.
2019	Loan funding begins to be drawn down.
2031	Latest point for Greater London Authority loan to be fully repaid.
2033	Latest point for TfL loan to be fully repaid.

Source: National Audit Office analysis of information from the Department for Transport, Transport for London and Crossrail Ltd

1.10 The Committee of Public Accounts took evidence on the delivery of the Crossrail programme in March 2019. The Committee questioned the Department and Crossrail Ltd on the warning signs that the programme was not delivering to plan, what actions the sponsors took to intervene in the programme, the causes of the cost increases and delays, and the risks of further funding for the programme being required.

Our report

1.11 In January 2014, we produced a report on progress with the Crossrail programme. At that time, tunnelling and civil engineering work in the central tunnel section were under way. Our report gave sponsors and Crossrail Ltd credit for the start they had made, while also highlighting that success and value for money depended on risks being managed effectively.

1.12 The Crossrail programme has a long and complex history, involving a range of actors and events. Therefore, we do not intend this report to be an exhaustive account of every aspect of the programme, and we do not intend to apportion blame among its participants. Our aims are to set out:

- why and how the programme ran into difficulty; and
- what Crossrail Ltd and programme sponsors need to do to manage the remaining risks to the programme and deliver the promised benefits to passengers and the economy.

In doing so, we also consider that the lessons in this report could be used to improve control of current and future government infrastructure programmes.

Part Two

How the programme fell into difficulty

2.1 This part examines:

- where and why cost increases and delays occurred; and
- the features of Crossrail Ltd's delivery of the programme that added risk and contributed to delays and cost increases.

Where costs have increased

2.2 Crossrail Ltd's current forecast cost of the Crossrail programme, excluding trains and depot but including Network Rail's works on the existing network and a provision to cover assessed risks, is just over £17 billion. This is around £2.2 billion more than the £14.8 billion of funding agreed by sponsors in 2010, and £600 million less than the current level of agreed funding of £17.6 billion.

Cost increases on the central section

2.3 The increase in programme costs is not the result of a failure of one particular project or contract. Costs on most of the 36 main works contracts on the central section have increased, including contracts for tunnelling, civil engineering, station construction and fit-out, and implementing the systems required to operate the railway and stations. The biggest increases have been on the contracts to install track and key systems in the tunnels and some of the new stations such as Whitechapel, Bond Street and Paddington (**Figure 4**). Whitechapel in particular has seen larger spend than anticipated as a result of difficulties building around existing London underground and overground lines and station architecture.

Figure 4

Changes in the forecast cost of selected contracts on the central section to December 2018

Cost increases have occurred across the programme

Contract	Forecast costs			Cost increases	
	Target at Award (£m)	Jan 2015 (£m)	Dec 2018 (£m)	Award to Dec 2018 (£m)	Award to Dec 2018 (%)
Tunnelling, shafts and portals					
Eastern tunnels ¹	484	754	730	246	51
Western tunnels ¹	490	737	749	259	53
Thames tunnel ¹	196	269	229	33	17
Station Tunnels East – Early Access Shafts and Sprayed Concrete Lining Works ¹	246	360	510	264	107
Pudding Mill Lane Portal Civil Works ¹	52	131	184	132	254
Eleanor Street and Mile End Shafts Civil Works	46	56	255	209	454
Station main civils					
Farringdon Station	239	436	634	395	165
Liverpool Street Station	147	271	374	227	154
Paddington Station	181	339	571	390	215
Bond Street Station	126	182	412	286	227
Whitechapel Station	110	229	659	549	499
Tottenham Court Road Station	98	135	282	184	188
Woolwich Station	70	N/A	234	164	234
Route-wide civil engineering and systems					
Systemwide (Tunnel track and electrical fit-out)	323	360	956	633	196
Platform Screen Doors	27	N/A	63	36	133
Signalling	51	N/A	131	80	157
Communications and Control	43	N/A	139	96	223
Other					
Ilford Stabling Sidings ¹	54	N/A	153	99	183

Notes

- 1 Contracts completed prior to December 2018 and show their final values. The figures for Thames Tunnel and Pudding Mill Lane reflect the costs when they were at 98% and 99% complete respectively – the final 100% figures were not reported in Crossrail's Board reports.
- 2 Target at award denotes the anticipated cost of the contract at award and does not include adjustments for risk. Other cost values are contractors' forecast of final costs which may include adjustments for cost risks where the contract is not yet complete. All values are drawn from Crossrail Ltd board reports.
- 3 All values are in cash prices.
- 4 N/A means that the forecast costs of these contracts was not reported in January 2015.

Source: National Audit Office analysis of Crossrail Ltd information

The cost of work on the existing network, trains and the maintenance depot

2.4 Network Rail has been carrying out surface works on the Great Western main line, between Paddington, Reading and Heathrow Airport, on the Great Eastern main line between Shenfield and Liverpool Street, as well from Abbey Wood to Plumstead. This includes track, signalling and electrification works, and station enhancements including the extension of platforms to accommodate Crossrail trains.

2.5 The current forecast cost of Network Rail's work on the existing network is £2.6 billion, around £300 million (13%) more than its original agreed funding of £2.3 billion, including contingency. The cost of Network Rail's work has increased due to, for example, changes in scope and because the assets that it was working on were in a worse condition than anticipated. Gaining access to the railway to carry out work has also been an issue for Network Rail. Network Rail must operate within limited windows that are negotiated with train operating companies on the live railway. Where changes and remedial works are required, the planned access arrangements must be changed, which can have a substantial impact on how the works are delivered and the cost to carry them out, particularly where additional access is needed.

2.6 While Network Rail's work is nearly complete, risks remain. Network Rail has been engaged in a contractual dispute with one of its main contractors over the price of scope changes. This dispute remains unsettled. Network Rail also had to replace Carillion as a contractor when Carillion went into liquidation in January 2018. Network Rail works have also seen cost inflation due to changes made to station enhancements in the west. The Department and Network Rail are currently assessing the financial impact of these issues.

2.7 Despite delays to the development of the on-board train operating software, and the consequent delay to Transport for London (TfL) accepting delivery of manufactured trains, the cost of this contract has not contributed to overall cost increases because TfL awarded a fixed-price contract to the main contractor, Bombardier Transportation.

Why costs have increased

2.8 Costs have increased on main contracts for a range of reasons. As on any major project delivered through a set of contracts, the common features of the causes of cost increases are change and delay. Crossrail Ltd's reporting of the causes of cost increases between 2013 (the time that we carried out our previous study on the programme) and November 2018 divide the reasons for increases in cost into four main categories: design change; the settlement of contractual 'compensation events'; acceleration or changing the sequencing of works to improve confidence in delivering on schedule; and additional scope. By 2018, these changes had resulted in more than £2.5 billion of increased contract costs funded in part from programme contingency (**Figure 5**).

Figure 5

Main categories of cost increase between 2013 and 2018

Costs have increased due to programme changes and delays

Cause of cost change	Description	2013-14 (£m)	2015-16 (£m)	2017-18 (£m)	Total (£m)
Design change	Changes to the design of specific elements of the construction and fit-out of tunnels and stations.	277	213	225	714
Commercial settlement	Settlement of commercial 'compensation events' due to, for example, delays to contractors' planned start dates.	0	788	148	936
Schedule change	Re-ordering of works and acceleration of works to bring work in line with target completion dates.	190	83	53	326
New scope	Changes to the scope of the Crossrail programme that were agreed between sponsors and Crossrail Ltd, mainly in the early stages of the programme.	193	4	0	198
Other	Includes, for example, the net impact of other increases and reductions in scope and cost increases due to unexpected site conditions.	241	26	70	337
Total		901	1,114	496	2,511

Notes

- 1 The cost increases shown in the table represent costs that Crossrail Ltd had recognised as part of its overall budget. They exclude provision for risks of future cost increases.
- 2 All values are in cash prices.
- 3 Totals may not sum due to rounding.

Source: National Audit Office analysis of Crossrail Ltd's semi-annual construction reports, June 2013 to November 2018

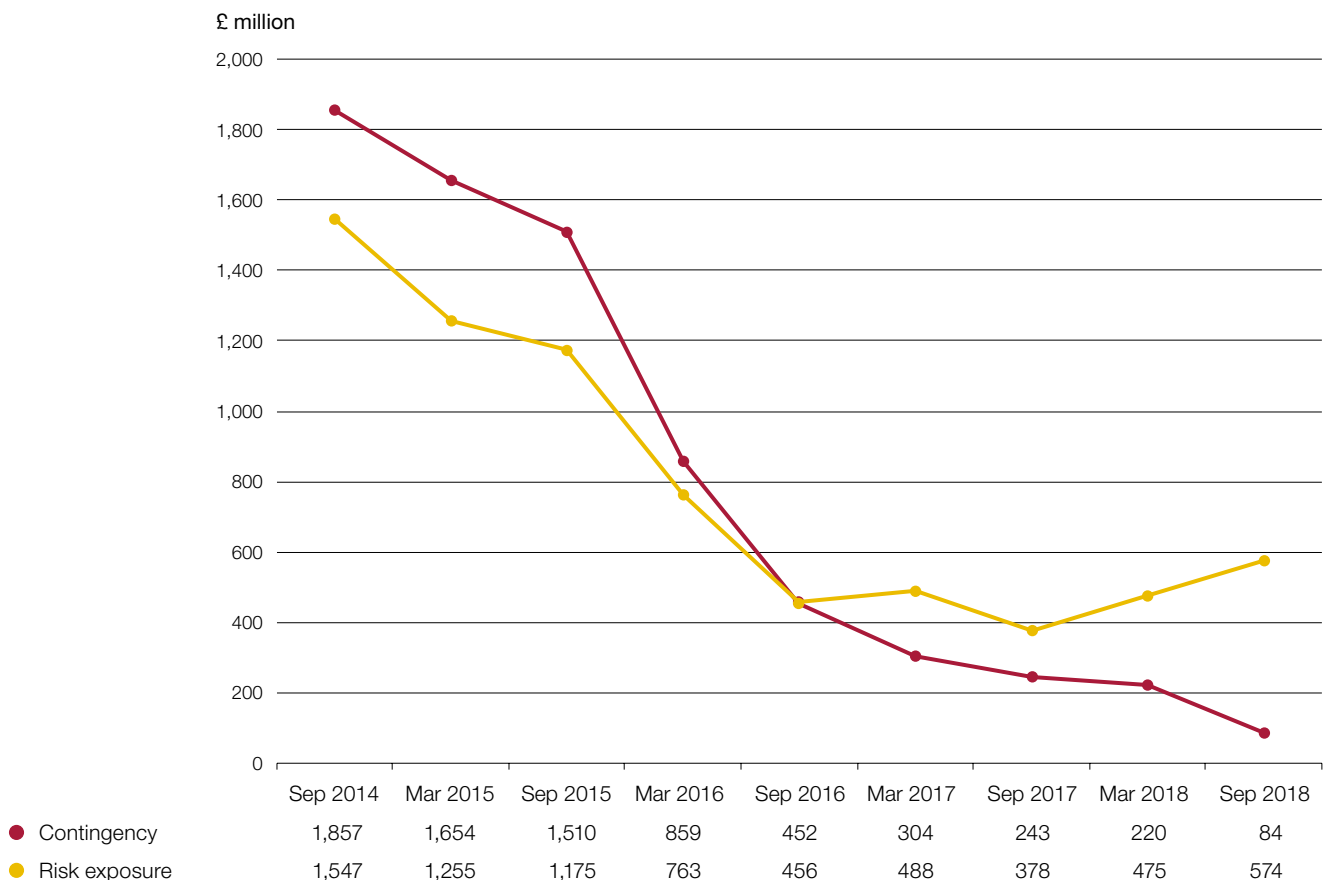
2.9 The increase in costs across the programme, particularly the impact of settling compensation events during 2015 and 2016 resulted in substantial drawing down of Crossrail Ltd's centrally held contingency, which Crossrail Ltd had set aside to manage such risks. By November 2016, Crossrail Ltd had drawn down substantial contingency and its risk exposure exceeded its centrally held contingency. It was also forecasting that it would need to draw on the £600 million of remaining contingency funding available to the programme, which was held by TfL (**Figure 6**).

2.10 A further increase in costs followed Crossrail Ltd's announcement in August 2018 that it would not complete the programme in time to open the central section in December 2018. This is because the extension of the programme schedule meant that contractors would be mobilised for longer than anticipated and Crossrail Ltd began to develop more realistic forecasts of what it would cost to complete the programme.

Figure 6

The relationship between Crossrail Ltd's drawdown of contingency and risk exposure

Crossrail Ltd's contingency fund has steadily diminished to the point in September 2016 where quantified risks first exceeded Crossrail Ltd's centrally held contingency



Notes

- 1 The value of the risk is given at 50% confidence, meaning there is a 50% likelihood of risks materialising at that cost or lower.
- 2 All values are in cash prices.

Crossrail Ltd's commercial settlement of programme change

2.11 As shown in Figure 5, settlement of the compensation events with contractors resulted in nearly £1 billion of cost increase between 2013 and 2018, nearly £800 million of which occurred between 2015 and 2016. Under the terms of the target price contracts that Crossrail Ltd agreed with most of its main contractors, where cost increases occur due to events outside contractors' control, contractors issue notification of a compensation event to Crossrail Ltd. Examples of such events might include access to a work site being delayed, or a design change being instructed by Crossrail Ltd. The compensation event notice requires Crossrail Ltd and the contractor to reach agreement about the nature of the change and any increase to the contractor's target price for the contract.

2.12 By January 2015, contractors had raised 16,000 notices with a backlog of 1,000 yet to be assessed. By January 2016 the number of notices had increased to 21,000, with 1,800 yet to be assessed. Some uncertainty due to commercial discussions is manageable and inevitable on major programmes, but high levels can lead to time being absorbed managing commercial elements of the contract, rather than carrying out productive work. The build-up of compensation events on Crossrail are an indication of the high numbers of interfaces between contractors on the programme, and the prevalence of delays and change caused by poor integration of the work of multiple contractors.

2.13 In 2015 and 2016, Crossrail Ltd negotiated supplemental agreements with contractors, with the aim of settling the backlog of compensation events to increase certainty about the cost of the programme. With these agreements, Crossrail Ltd also aimed to address the build-up of delays that had led to cost increases by resetting the commercial terms and incentives in the contracts. However, the underlying complexity of the challenge to deliver the programme on schedule remained and compensation events continued to accumulate. As shown in Figure 5, during 2017 and 2018, the settlement of further supplemental agreements resulted in a further increase in costs of £148 million.

2.14 As part of its renegotiation of contracts, Crossrail Ltd decided to change the payment terms and allocation of risk on some contracts in an attempt to focus contractors on meeting the December 2018 opening date for the central section. For example, it changed the terms of key contracts to install track and systems and communications and control equipment from target price contracts with financial risk shared between Crossrail Ltd and the contractor, to cost reimbursement contracts with incentive fees for contractors to meet milestones. This change meant that outturn contract costs were inherently less certain and that the financial risk sat with Crossrail Ltd because, while some incentives remained, the main financial incentive for the contractor to control costs was removed.

Features of Crossrail Ltd's management that led to cost increases

2.15 Our analysis of key strategic decisions made during the course of the programme points to three main features of Crossrail Ltd's management of the programme that led to cost increases and the current uncertainty about what the programme will cost and when it will be completed. They are:

- Crossrail Ltd's delivery and commercial strategy;
- the build-up of delays, dependencies and interfaces between contracts and projects; and
- not changing course when there were clear signs that the programme was not on track.

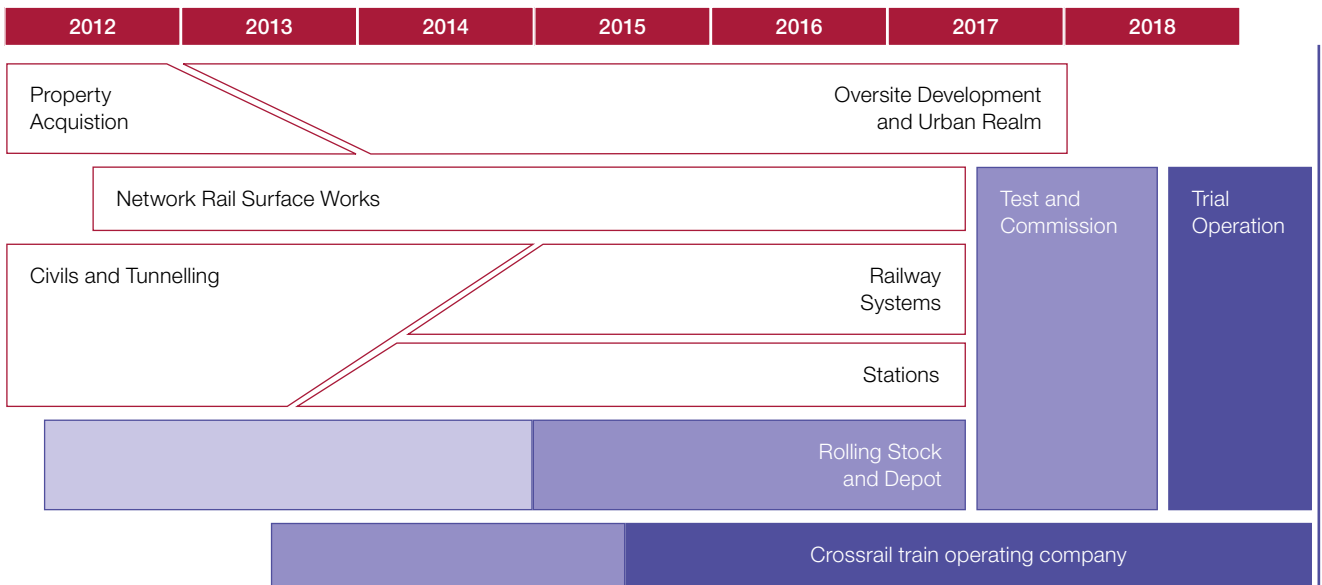
The delivery and commercial strategy

2.16 A defining feature of the Crossrail programme from an early stage has been the commitment of sponsors and Crossrail Ltd to stick to their public target of opening the central section of the railway in December 2018. At an evidence session of the Committee of Public Accounts on 6 March 2019, the current chair of Crossrail Ltd stated that there was "extreme commitment within the project" to meeting the opening date. Given the scale and complexity of the programme, Crossrail Ltd sequenced the main elements of the programme into overlapping phases of activity. This approach meant, for example, that stations would be constructed while tunnels were being bored and fitted out, and that multiple strands of activity, including installation of systems required to operate the railway and completion of stations, would take place at the same time during the latter stages of the programme. A number of stakeholders we spoke to expressed the view that the Crossrail Ltd executive team both recognised the challenges but believed this was an exceptional team capable of delivering exceptional results and overcoming these challenges. **Figure 7** shows Crossrail Ltd's high-level sequencing of main elements of the programme.

2.17 Crossrail is being delivered through contracts with private sector design, engineering, and construction companies and an extensive supply chain of small contractors and suppliers of equipment and specialist skills. In 2008, Crossrail Ltd produced a delivery and procurement strategy, which included the key features of the commercial and contractual approach. Crossrail Ltd's commercial approach was dictated by, for example, the scale of the programme; however, it also introduced high levels of risk related to design and delivery, and interface risk that Crossrail Ltd would have to manage itself. **Box 1** on page 24 sets out the key features, rationale and risks of the commercial and contracting approach.

Figure 7
The main phases of the Crossrail programme

Multiple activities would take place at the same time



Note

1 Oversight Development and Urban Realm refers to works to develop sites above and around stations.

Source: Crossrail Ltd

Box 1

Crossrail Ltd's commercial and contracting approach

The commercial approach introduced risks to the programme**The approach****Contractual packages**

Award 36 separate main contracts for the main works, including separate contracts for each individual station and a range of system-wide contracts.

Rationale

Crossrail Ltd went for a large number of main contracts because of the size and complexity of the Crossrail programme.

Risks

The number of contracts created high numbers of commercial interfaces to manage. Crossrail Ltd felt that it was best placed to manage these interface risks rather than rely on and incentivise main contractors to manage them in the supply chain

Design strategy

Awarding contracts to build the main tunnelling and civil engineering works based on detailed designs developed by Crossrail Ltd, but awarding contracts to both design *and* build the systems required to operate the railway and stations, based on a high-level conceptual design developed by Crossrail Ltd.

Crossrail Ltd decided not to develop a detailed design for all the contracts to fit-out stations and tunnels and install systems because it wished to benefit from involving contractors in the process from an early stage.

The approach introduced the risk of conflicting designs between contractors and the potential for contractual change and delays while design work is resolved. Because Crossrail Ltd was responsible for integrating the overall programme, it bore much of the risk and impact of cost increases resulting from inconsistency of designs for different elements of the programme.

Train and signalling systems

Sponsors decided that Crossrail Ltd should run the procurement of a contractor to design, build and maintain the class 345 trains, but that Rail for London, a subsidiary of TfL, would hold the commercial relationship with the contractor during the construction of the trains and their operational life. Crossrail Ltd procured and managed the contract to install and operate the signalling hardware at the trackside and developing signalling software required to communicate with the systems on the train.

Sponsors considered that because TfL was paying for the trains and would be managing the contract with the supplier when they were operational, TfL was best placed to manage the contract.

Having separate bodies hold the commercial relationships for two critically dependent contracts increased the challenge of managing them effectively.

Contractual form

For 33 of the 36 main works contracts, Crossrail used a contractual form (the NEC 3 option C contract), which set a target price for the required work, supported by a schedule that set out the activities that contractors needed to complete. Financial risks are allocated through the stipulation that contractor and Crossrail Ltd would share equally the upside of any cost savings or the downside of any cost overruns relative to the target price. Crossrail Ltd chose to use fixed price contracts on works to transport excavated material from the construction sites by river to Wallasea, and to install platform screen doors in stations.

Crossrail Ltd adopted this form of contract because, for example, it encouraged a collaborative relationship between client and contractor and early settlement of disputes, because it facilitated a fair allocation of risk, and because it had been used recently on the construction of the venues and infrastructure for the London 2012 Olympic and Paralympic Games. When events outside the contractor's control, such as unexpected ground conditions or scope changes occur, the contracts allow the contractor to raise compensation events to increase the target price.

This form of contract depends on contractors meeting deadlines to handover work sites to other contractors to minimise the volumes of change and compensation events that require commercial agreement between parties. It also requires tight control and management by the client (Crossrail Ltd).

Note

- 1 NEC is a family of contracts, developed by the Institution of Civil Engineers, that are designed to support project management and define legal relationships between client and contractor.

2.18 Crossrail Ltd is responsible for managing and integrating the entire programme and providing TfL with an operational railway. In 2009, Crossrail Ltd awarded contracts to two project management companies to support it to manage the programme:

- In March 2009, Crossrail Ltd appointed Transcend Ltd, a joint venture between CH2M Hill, AECOM and Nichols Group, as the programme partner, responsible for strategic programme management. At the time of award, Crossrail Ltd estimated the cost of the contract to be around £100 million.
- In April 2009, Crossrail Ltd appointed a team led by Bechtel as its project delivery partner to act as lead contractor, responsible for coordinating the activities of other contractors on the central section of the railway. When it awarded the contract, Crossrail Ltd estimated that it would be worth around £400 million.

2.19 Rather than keeping its commercial project partners at arms' length and accountable for the overall delivery of the programme (as the Olympic Delivery Authority had done with its commercial delivery partner), in 2011, Crossrail Ltd integrated contractors from the two partner firms within the central Crossrail team. The objective was to create a seamless team to encourage collaboration and bring private sector expertise into the programme. Alongside its decision (Box 1 on page 24) to award 36 main contracts, this meant that Crossrail Ltd had few commercial levers to drive management and integration of the overall programme, and took on all the risk of doing so itself.

Dependencies and interfaces between contracts and projects

2.20 As set out above, dependencies between contracts and projects has been a feature of the delivery strategy and had led to high levels of compensation events and increased costs during 2015 and 2016. As the programme progressed, the volume of dependencies between contracts and elements of the programme increased for the following reasons, adding to the risk that Crossrail Ltd would not be able to meet its target opening date and cost:

- delays to station contracts, the installation of track and systems in tunnels, and the development of signalling software on the train meant that critical work was pushed later into the programme schedule than planned;
- Crossrail Ltd's and sponsors' continued focus on the December 2018 opening date for the central section meant that they did not mitigate interface risk by extending the programme schedule; and
- increasing pressure on the likelihood of meeting the December 2018 opening date meant that Crossrail Ltd and contractors attempted to accelerate work on key contracts by increasing the workforce.

Crossrail Ltd's announcement in August 2018 that it would not complete the programme in time to open the central section in December 2018 resulted in an extension of the time that contractors would be on site, and further sharp cost increases.

2.21 Appendix Three includes four case examples that illustrate how the issues above manifested themselves on specific critical contracts. Examples of the issues that emerged include:

- access to work sites for contractors installing systems in the tunnel and station was delayed by late handover of assets by, for example, station contractors. Between February 2017 and December 2018, the forecast cost of the contract to install track and key systems in the tunnels increased by 80% from £532 million to £956 million. The forecast cost of the contract to provide communication and control systems equipment increased by 20% from £116 million to £139 million between April 2018 and December 2018;
- the acceleration and then prolongation of the contract to construct and fit-out Paddington Station resulted in an increase in forecast costs of 27%, from £449 million to £571 million between January 2018 and December 2018; and
- the development of software on the trains did not result in increases to the direct cost of the contract because the contract was based on a fixed price. However, delays to the readiness of the train and the signalling system and Crossrail Ltd's decision to commence signalling integration testing on the incomplete railway before the delayed train and signalling software was sufficiently developed reduced the availability of worksites for contractors to complete construction and fit-out work, which further exacerbated delays and cost increases.

Crossrail Ltd's approach to managing cost increases and delays

2.22 Throughout the programme, Crossrail Ltd's emphasis in reports on progress presented to the Crossrail Ltd board and sponsors was on what had been achieved and how much of the programme had been completed, rather than on the level of risk to successful delivery that remained in the programme. That said, our analysis of the condition of the programme between 2015 and 2018 is based on information contained in those reports.

2.23 By 2015, delays to the contracts and changes to the design had led to cost increases and the renegotiation of contracts onto new terms. At this time, Crossrail Ltd also produced a plan and programme schedule to reset the programme baseline when productivity and progress on the key contracts had fallen behind plan, and on which to base its management of the programme.

2.24 The ‘Master Operational Handover Schedule’ (the handover schedule) set out the milestones that individual contractors needed to achieve if Crossrail Ltd were to achieve its main target of opening the central section in December 2018. However, the handover schedule was a set of more or less separate plans for each of the main elements of the programme. It was not a detailed, bottom-up plan that reflected the work remaining, set out the logical and most efficient sequencing of all remaining activities across individual contracts, and highlighted dependencies between projects and contracts, and delivery risks across the entire programme.

2.25 Crossrail Ltd updated the handover schedule in 2016, 2017 and 2018. In these updates, it established a new baseline with more challenging milestones to meet the December 2018 opening date for the central section. The case examples in Appendix Three show how the progress against the handover schedule on critical contracts diverged from plan soon after each iteration of the handover schedule. Crossrail Ltd’s assumptions about the level of progress that was achievable bore little resemblance to the historic progress that contractors had made.

2.26 Crossrail Ltd was clear that the handover schedule was intended to be used to manage contractors and increase the speed of delivery on a programme that had fallen behind plan. It also presented it as the critical path. At the February 2018 Sponsor Board, the then programme director at Crossrail Ltd told sponsors that the handover schedule “...has always been ambitious and intended to drive behaviour” and that “if all the Tier 1 contractors’ programmes were simply added together the programme would end in 2020”.

2.27 Applying pressure on contractors to improve performance to meet deadlines is useful and understandable. However, the absence of an integrated, realistic plan to sit alongside the ambitious handover schedule meant that Crossrail Ltd had a critical gap in the information available to manage risks to complete the programme efficiently and effectively. It meant Crossrail Ltd did not have an effective tool to enable it to, for example:

- fulfil its role as the integrator of the various elements of the programme;
- establish the most cost-effective way to deliver the programme; and
- make key decisions such as when it should aim to open the railway.

Part Three

Completing the programme and delivering the benefits

3.1 In the context of the overall programme, the bulk of construction work on Crossrail is complete. Crossrail Ltd and Network Rail had spent around £16 billion on the programme by March 2019. Tunnelling work completed in 2015, and the trains have been ordered, with some already in service. Network Rail has also lengthened platforms and enhanced stations and signalling on the existing network in readiness for the new Crossrail services.

3.2 There remains a significant amount of work for Crossrail Ltd to carry out before it and Transport for London (TfL) can open all of the new services to passengers and deliver the intended benefits of the investment that sponsors have made. In March 2019 Crossrail Ltd reported that:

- Delays to the installation of equipment required for testing of communications and control systems have continued.
- It has performed 116 tests of the trains and signalling systems on the railway against a target of 270. In January 2019, Crossrail Ltd started main dynamic testing some 11 months later than planned. Testing is identifying fewer issues than Crossrail Ltd expected, but fewer tests are being undertaken owing to a lack of resources in the main systems contract and slow progress in developing the train and signalling system software.
- It is a long way behind its targets for gaining certification that equipment on the railway and in stations is functioning correctly. For example, across all of the stations on the central section, Crossrail Ltd had completed only 27% of pre-commissioning certificates and partial acceptance certificates (stages of certification that demonstrate when equipment has been tested to a certain level).

3.3 Crossrail Ltd and TfL will also need to work closely to transfer operation of the railway to TfL and to bring the Elizabeth line into passenger service. This will involve integrating Elizabeth line services with the national rail network and the Great Western and East Anglia rail franchises, including new timetables.

3.4 This part of the report examines the key risks that Crossrail Ltd and sponsors need to manage in order get the programme back under control and deliver the intended benefits of the programme.

Resetting the programme

A new programme plan

3.5 Crossrail Ltd started to produce a detailed, realistic, bottom-up plan in late 2018, setting out a logical sequence of activities, interdependencies and schedule risks covering all remaining activities. In April 2019 Crossrail Ltd announced that it had produced a new plan for the introduction of new services on the central section, although it is still unclear when a full 24 trains an hour service between Heathrow and Reading in the West and Shenfield and Abbey Wood in the east will commence. It is important to have an agreed plan that sponsors and contractors are signed up to because:

- without a plan, Crossrail Ltd could not make important decisions such as when the railway will open;
- given the close relationship between cost and schedule, there remains uncertainty about the cost of the programme and the risk that the costs will increase above the current £17.6 billion of available funding;
- until there was an agreed plan, Crossrail Ltd could not reset contracts with its contractors, nor was it able to sequence activities across contracts, which means that it could not effectively monitor the risks to delivery across the programme; and
- without the plan, the Crossrail Ltd board, and sponsors, could not monitor progress on the programme, nor could they hold Crossrail Ltd to account.

3.6 In April 2019, based on its revised plan, Crossrail Ltd announced that it will introduce 12 peak-time services an hour on the central section between Paddington and Abbey Wood at some point between October 2020 and March 2021. These services will not initially stop at Bond Street because the work on that station is significantly delayed.

3.7 Crossrail Ltd intends to align its revised programme plan with the individual contract plans that each main contractor has produced. It also intends to have its programme plan independently assured.

Commercial relationships

3.8 Crossrail Ltd has identified the relationship with its suppliers as one of the top strategic risks to completion of the programme. Productivity levels are behind expectations and costs are rising. To regain control of costs and prevent them from escalating further, Crossrail Ltd needs to incentivise contractors to deliver the remaining work in a timely and efficient manner. The new programme plan should help to provide clarity to contractors about the work remaining and when it needs to be done, and provide a stronger basis for agreeing contractual terms that support cost-effective delivery.

3.9 Since the end of 2018, Crossrail Ltd has been renegotiating the terms of the remaining work with its main contractors. For example, it has established a fixed, lump sum price with contractors for some of the remaining work. This is understandable, given the need to improve certainty about the cost to deliver remaining work and to arrest the sharp cost increases that have occurred since the announcement of the delay to the opening of the central section. However, this form of contract means that Crossrail Ltd risks losing commercial levers to ensure that contractors prioritise completion of Crossrail over other projects and opportunities.

Capability and capacity in Crossrail Ltd

3.10 In order to be able to manage programme risks and the complex contractual arrangements effectively, Crossrail Ltd needs to rebuild its capability and capacity in a number of disciplines. During 2018, Crossrail Ltd reduced the number of staff in its central functions, such as risk management, planning and contract and commercial management, as it pursued its demobilisation plans in accordance with its aim to meet the December 2018 deadline. All of these functions are critical to completing the programme efficiently and effectively.

3.11 The company now recognises that it still needs skills and has started to recruit. It has hired a head of risk and plans to increase the team from one person to five, and has reinstated its audit and assurance committee, which it disbanded in 2018. It has increased the size of the planning team by 15 to 34. It is also re-establishing its external affairs team. Crossrail Ltd has, however, struggled to recruit the skills it needs. Its capacity to manage the programme effectively remains a key risk. It told us it has 143 vacancies in its central delivery teams, including project delivery teams to work with main contractors to deliver the programme, and a further 33 vacancies across other areas of the programme.

The relationship between Crossrail Ltd and sponsors

3.12 While Crossrail Ltd is responsible for delivering the programme, sponsors have an important role to play to ensure that their investment delivers for passengers and taxpayers as a whole. The project development agreement sets out the relationship between sponsors and Crossrail Ltd and includes measures by which sponsors could exercise control. By June 2017, as a consequence of the high degree of autonomy provided to Crossrail Ltd, sponsors considered that the contractual remedies available would not improve the likelihood that the programme will be delivered successfully.

3.13 In 2018, as a response to cost increases and delays, at Crossrail Ltd's suggestion, sponsors increased their non-executive representation on the Crossrail board, and their project representative. They also commissioned three reviews by KPMG,² and have taken action in response to those reviews, and the Department and the Infrastructure and Projects Authority have carried out a lessons learned exercise about the governance and delivery of the programme and other transport related programmes. The sponsors have made some changes to the project development agreement in response to the loan agreement discussed below. It is not clear what further changes sponsors plan to make to the project development agreement to ensure that they have sufficient oversight and appropriate levers to act to protect their investment.

Risks remaining

Risks to delivering the benefits of Crossrail

3.14 Sponsors' main objectives for Crossrail were to increase rail capacity in London and the South East of England and improve connectivity. The main benefits identified in the 2011 business case³ are:

- **Passenger travel time savings** – forecast as a £6.6 billion benefit. Shorter journey times are a significant benefit of Crossrail. The value is highly dependent on assumptions and forecasts about journey times, consumer behaviour, passenger income, journey purpose, and use of and demand for the service. Crossrail is also expected to significantly improve connections across London and the South East.
- **Congestion relief** – forecast as a £5.3 billion benefit. Congestion relief refers to the benefits from relieving crowding on trains and platforms, and reducing train delays caused by platform congestion and the impact on station crowding relief. This benefit also includes time savings for motorists arising from fewer vehicles on the roads. As with passenger travel time savings, this benefit depends on the use of and demand for the service, and the value of time used to monetise this benefit.
- **Net additional revenue for TfL** – forecast as a £7.4 billion benefit. Forecast revenue is highly dependent on consumer behaviour, demand for the service, the fares that are charged to passengers and how these fares are predicted to grow over time.
- New trains and stations will also improve accessibility and service quality.

2 KPMG's reviews were: a finance and commercial review, to establish the extent to which Crossrail Ltd's financial modelling reflects the true state of the finances of the programme; a governance review, to assess how governance and oversight of the programme had been working, and to make recommendations for improvement; and to validate the Department's timeline of events between November 2017 and October 2018, to help the Department to learn lessons for future major programmes. The KPMG reviews can be found at: <https://tfl.gov.uk/corporate/publications-and-reports/crossrail-project-updates>

3 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>

3.15 It is likely that Crossrail will still deliver substantial benefits for passengers. However, since 2011, there have been changes to some of the assumptions underpinning the economic case as set out above:

- The delay to opening the railway means that passengers will not experience the benefits of reduced journey times, increased connectivity or reduced congestion, for longer than they expected.
- The cost to build the railway has increased by around 19%. In 2011, sponsors and Crossrail Ltd expected Crossrail to produce £1.97 of benefits for every pound spent on building, maintaining and operating the railway, or £3.10 including wider benefits from increased economic activity following completion of Crossrail. In April 2019, the Sponsor Board examined indicative analysis of the potential impacts of the cost increases and delays on the benefit–cost ratio for the programme. The analysis showed that Crossrail could produce around £1.50 of benefits for every pound spent or around £2 including wider benefits. The analysis carried out was not a full economic appraisal. We have not audited this analysis for this report.
- Demand for and revenues from public transport in London, and on the national rail network, have been lower than TfL and the Department expected in recent years. This suggests that assumptions about the benefits from journey time savings, congestion relief and revenue generation could be lower than expected in 2011.

3.16 In addition, the delay means that it will take longer for TfL to receive revenue from Crossrail. TfL's assumption in its 2018 business plan was that the delay to opening would cost it up to £600 million in lost revenue from 2019-20 to 2023-24, on the basis of a central section opening as late as mid-2020.⁴ Should the programme take longer than this to complete, as Crossrail Ltd currently expects, the impact on TfL's finances will be greater.

3.17 Overall, TfL's operating revenue growth has slowed from an average of 6% a year between 2012-13 and 2015-16, to nil between 2016-17 and 2017-18.⁵ The wider rail network has also seen a slowdown in revenue growth. The Government also decided to discontinue its general grant funding to TfL from 2018. In 2013, TfL's grant was more than £1 billion, and in the last year of funding, 2017-18, it was £255 million.

3.18 TfL has been trying to reduce costs since 2016 to address its slowing revenues. The revenue shortfall from Crossrail's delay, as well as the potential need to service the contingency loan discussed below, has meant that it has had to go further and cancel planned investment in the transport network. This includes station enhancements at Camden Town station, as well as a new signalling system to increase capacity on the Piccadilly line.

⁴ The mid-2020 opening scenario was a financial planning assumption stated by TfL's Chief Finance Officer in January 2019 Greater London Authority Budget and Performance Committee. Minutes can be found here: <https://www.london.gov.uk/moderngov/ieListDocuments.aspx?CId=129&MIId=6576&Ver=4>

⁵ Information TfL's on historic revenue growth is taken from TfL's annual reports for the years 2012-13 to 2017-18. Quoted revenue figures include revenue from operations and commercial development, but excludes grant income. The annual reports are available at: <https://tfl.gov.uk/corporate/publications-and-reports/annual-reports-past-years> and <https://tfl.gov.uk/corporate/publications-and-reports/annual-report>

Risks from financing the cost increases

3.19 Based on the high-level assessment of the funding required to complete the programme in KPMG's Finance and Commercial Review, the Department, TfL, the Greater London Authority (GLA) and HM Treasury agreed a funding package for the programme's completion. The guiding principle of this funding package was that London should pay for the cost increases, as it will be the primary beneficiary of the Elizabeth line.

3.20 The funding package comprises two loans from the Department: one of £1.3 billion to the GLA, and a further contingency loan of £750 million to TfL. The GLA also agreed to make a further cash contribution of £100 million, subject to enhanced powers to extend the use of the Mayoral Community Infrastructure Levy (MCIL) being granted. The interest rate for the GLA loan is 0.8% above that of government bonds. The TfL loan is structured in tranches which have interest rates above that of government bonds of 0.8%, 0.9% and 1% respectively. The funds can be drawn down gradually, as required, up to February 2021. The GLA and TfL must repay their loans by 2031 and 2033 respectively, although it could be earlier should the loans be fully used or the balance no longer be required.

3.21 The GLA plans to pay back its loan using its existing arrangements for retaining business rates, as well as receipts from the MCIL.⁶ Given that the current funding package was based on a high-level assessment, until Crossrail Ltd completes its new schedule for the remainder of the programme, it is unclear whether the programme will need further funding, which would make TfL's financial position more challenging still.

3.22 The loan packages also carry conditions for the sponsors and Crossrail Ltd to determine which recommendations of the KPMG governance review they will implement and require Crossrail Ltd to provide cash and funding forecasts each month to the sponsors. HM Treasury has agreed to reprofile the Department's budget to cover the short-term impact of issuing the loans.

Risks to wider passenger services

3.23 Delays to services on the central section also have knock-on impacts for the introduction of Elizabeth line services between the Great Eastern and Great Western main lines. Services operating on the surface railway must make applications as part of the national timetabling process, and the delay to Crossrail introduced risks to those services planned to be introduced from May and December 2019. MTR-Crossrail, the Elizabeth line operator, has submitted a timetable bid to operate services between Paddington and Reading from December 2019 to secure its planned service patterns, and there are already services on the Great Eastern Main Line. The date at which through Elizabeth line services will operate has not yet been confirmed.

⁶ For information on the MCIL, go to: www.london.gov.uk/what-we-do/planning/implementing-london-plan/mayoral-community-infrastructure-levy

Appendix One

Our audit approach

1 This study examines the causes of the cost increases and delays to the Crossrail programme and whether Crossrail Ltd and the sponsors (the Department for Transport (the Department), and Transport for London (TfL)), have protected value for money in delivering Crossrail. The key areas we reviewed were:

- whether Crossrail Ltd managed the programme effectively; and
- whether the sponsors have appropriately managed the wider implications of the increased costs and delays.

2 Our audit approach is summarised in **Figure 8**. Our evidence base is described in Appendix Two.

Figure 8

Our audit approach

The objective of government

Crossrail is a strategic priority for the Department for Transport (the Department) and a major capital programme to deliver new rail services in the South East of England. Crossrail Ltd and the sponsors expect that Crossrail will increase rail capacity in central London by around 10% and provide new journey options from the surrounding region.

How this will be achieved

The project was due for completion in December 2018; however, the final completion date is now currently unknown. Crossrail involves:

- construction of 10 new, bespoke stations;
- 26 miles of new tunnels between Paddington and Canary Wharf, and at Woolwich;
- the enhancement of the existing network, including electrification and station improvements on the Great Western and Great Eastern Main Lines; and
- a fleet of new class 345 trains running on tracks incorporating three different signalling systems.

Our study

This study examines the causes of the cost increases and delays to the Crossrail programme and whether Crossrail Ltd and the sponsors, the Department and Transport for London (TfL), have protected value for money in delivering Crossrail.

Our evaluative criteria

- Crossrail Ltd has managed the programme effectively.
- Sponsors have appropriately managed the wider implications of increased costs and delays.

Our evidence
(see Appendix Two for details)

- We assessed how Crossrail Ltd has managed the programme by – reviewing and analysing key programme reports and management information; and interviewing key staff from Crossrail Ltd, sponsors and contractors to the programme.
- We assessed the sponsors management of the wider implications of the increased costs and delays by reviewing and analysing documents held by sponsors.

Our conclusion

Until the new services are open to passengers and the final costs of the programme are known, it is not possible to conclude on overall value for money. What we can say is that there are a number of features in the way the programme has been delivered that have driven unnecessary cost. The compressed schedule, the contractual model, the loss of downward pressure on costs, and the absence of a realistic plan were set against an atmosphere where ‘can do’ became unrealistic. All these factors and many more set out in this report have contributed to underachievement in terms of cost and progress so far.

As mentioned at the start of this report, Crossrail must be completed and the new Crossrail Ltd management team needs to be supported in getting that task executed in the most practical and achievable way possible.

Appendix Two

Our evidence base

- 1 We reached our conclusions on whether Crossrail Ltd and the sponsors have protected value for money in delivering Crossrail following our analysis of evidence collected between December 2018 and April 2019. Our audit approach is outlined in Appendix One.
- 2 We examined whether Crossrail Ltd has managed the programme effectively:
 - We assessed key programme reports and programme management information.
 - We analysed internal and external progress and forecast reviews of the programme.
 - We conducted interviews with key staff from the Crossrail Ltd team and contractors working on the project.
- 3 We examined whether the sponsors have maintained effective governance over the programme:
 - We reviewed key sponsor reports, meeting minutes, and foundational documents.
 - We held interviews with key staff from the sponsors and their representatives at Crossrail Ltd to obtain further information about their governance of the programme and relationship with Crossrail Ltd.
- 4 We examined whether the sponsors have appropriately managed the wider implications of increased costs and delays:
 - We reviewed key sponsor reports and communications relating to action taken in the lead up to and following the public announcement of the delay to the central section opening.
 - We held interviews with key staff from the sponsors, including their new representatives within the Crossrail Ltd governance structure to obtain further information about the sponsors' management of the wider implications of the increased costs and delays.
 - We analysed contracts and agreements relating to the financing of the programme.

Appendix Three

Case examples

Case example 1 – construction of Paddington Station

1 Crossrail Ltd awarded the contract to build the new Crossrail station at Paddington in July 2011. The station was built by a joint venture between Costain and Skanska. The contract included the construction and fit-out of the stations and installation of mechanical and electrical equipment to enable the operation of the station. At the time the contracts were awarded, Crossrail Ltd were aiming for Paddington to cost around £181 million.

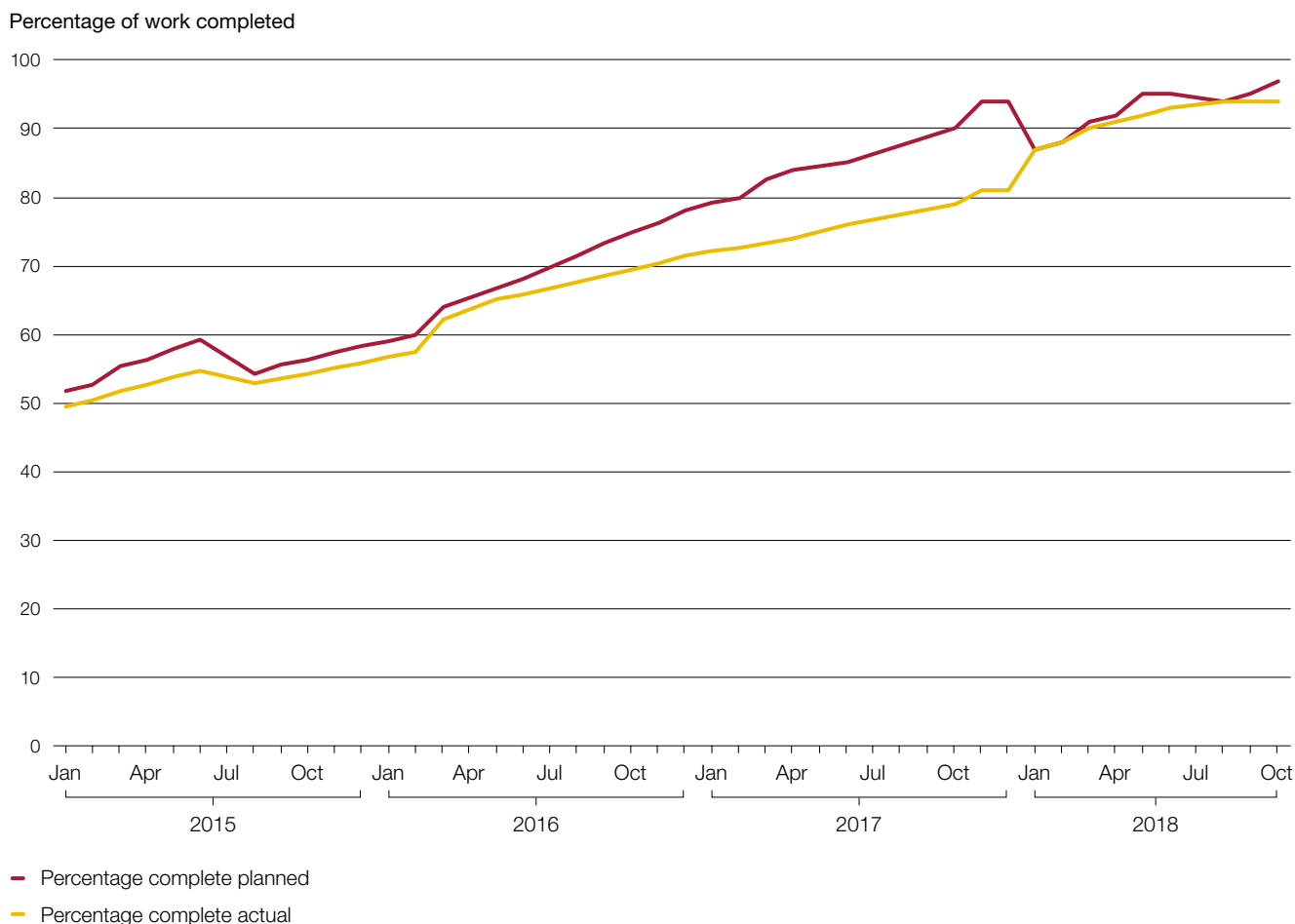
Delays to delivery of the contract

2 Progress on Paddington Station began to diverge significantly from plan from March 2016, with the gap increasing until December 2017 when completed work was reported at 81% against the planned 94% (**Figure 9** overleaf). The plan was re-baselined in January 2018 bringing the plan and actual completion rates in line for the first time. However, planned productivity rates could not be sustained and by March 2018 the actual work had once again fallen behind the plan. As at October 2018, reported progress was 94% complete against the plan of 97%.

3 Various factors caused schedule delays over the life of the contract. The complexity of interfaces with systemwide contractors (those who deliver works across the entire route) led to substantial amounts of design change, which contributed to delays to the design works. These design delays had knock-on effects on the subsequent delivery of mechanical and electrical works at the station.

Figure 9
Progress against plan on the Paddington Station contract

Progress on Paddington Station has typically remained behind the planned schedule



Note

1 The dips in the planned progress line reflect the rebasing of the programme plan when Crossrail Ltd revised the Master Operational Handover Schedule.

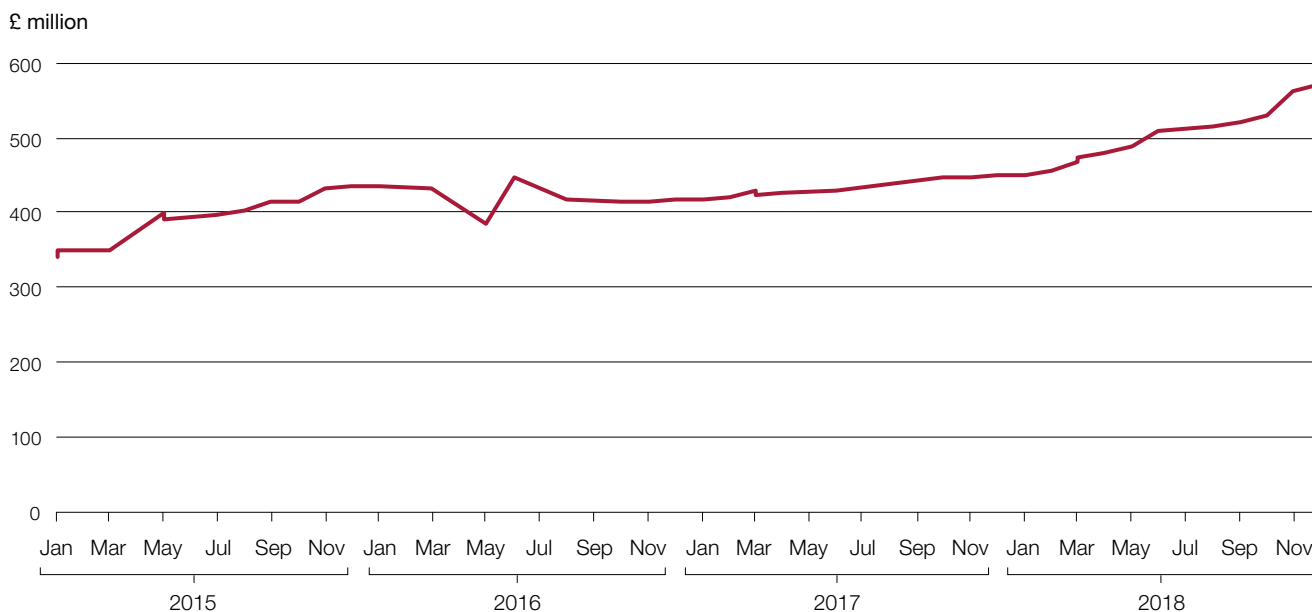
Source: National Audit Office analysis of Crossrail Ltd information

Cost increases

4 The forecast cost of the contract was £339 million in January 2015, increasing to £449 million by January 2018, due to issues that emerged between March 2015 and January 2016 (**Figure 10**). Issues included revisions to the contractor’s bottom up forecast and design, which led to rework and inefficiency. The 21% increase in forecast costs that occurred between March 2018 and December 2018 (£473 million to £571 million) is the result of Crossrail Ltd’s efforts to accelerate the programme to meet the December 2018 end date. As figure 10 shows, this had little impact on productivity, and the prolongation of the contract once Crossrail Ltd had decided to delay the opening of the central section in August 2018. In December 2018, Crossrail Ltd also began to develop more realistic forecasts of what it would cost to complete the programme.

Figure 10
Forecast final cost of Paddington main works

The forecast cost of Paddington Station has increased by £232 million since January 2015



Notes

- 1 The costs given are the contractor view of forecast of total defined cost, as reported in the Crossrail’s board reports each month.
- 2 Costs are given in cash terms.

Source: National Audit Office analysis of Crossrail Ltd information

Case example 2 – the installation of track and key systems in the tunnels

5 In April 2013, Crossrail Ltd awarded the contract to install track, overhead lines to power the trains and other systems including drainage and ventilation in all the Crossrail tunnels on the central section, to a joint venture between Alstom, Costain and TSO. At the time the contract was awarded, Crossrail Ltd expected it to cost £323 million.

Delays to delivery of the contract

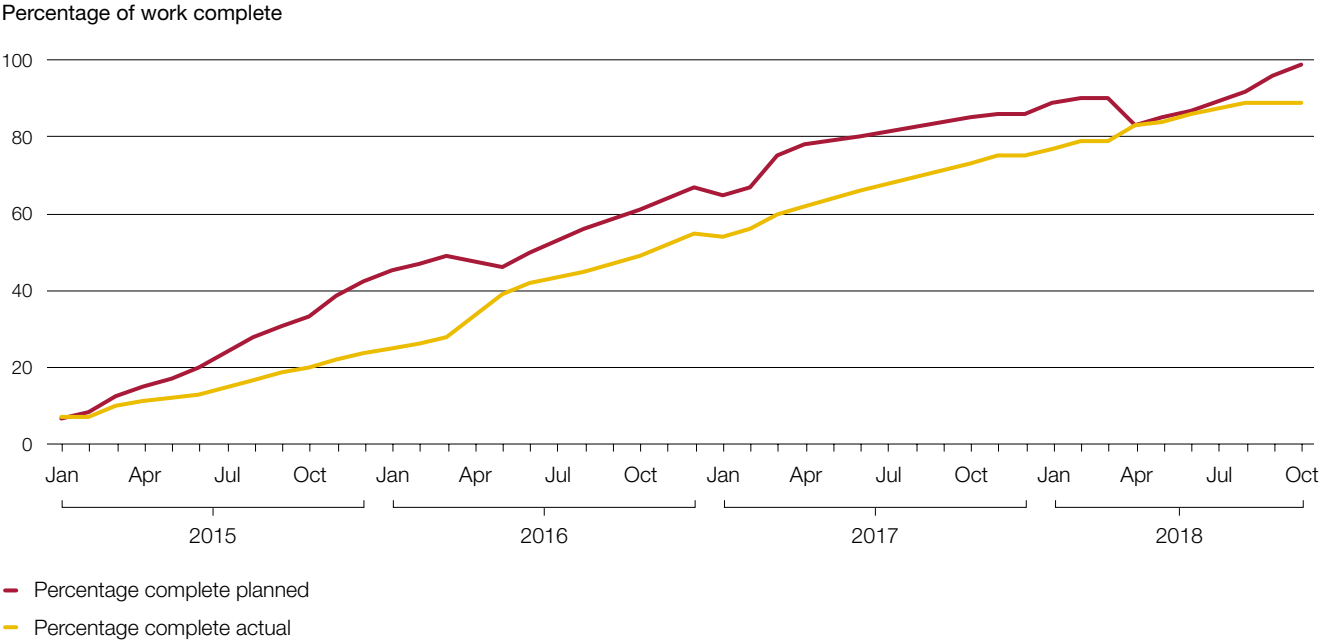
6 The contract experienced delays from the early stages of delivery (**Figure 11**). By March 2016, 28% of the work had been completed, compared to 49% in the plan. At this point (and at various points during the programme), Crossrail Ltd revised the programme plan to bring it back in line with actual progress. As the chart shows, progress on the contract has repeatedly and consistently diverged from each revised plan, meaning that the plan was not a realistic reflection of prior performance.

7 The causes of the delay have varied throughout the contract's life. However, there are common themes. In the early stages of the contract, in 2015, initial delays were attributed to the deferral of procurement activities and delayed design work. From June 2015, further schedule delays were reported to be due to access issues resulting from delays to work at stations, which required a significant change in the contractor's proposed approach to installing track and overhead power lines. For example, in December 2015 delays were attributed to access issues to Paddington, Bond Street, Whitechapel, Tottenham Court Road, Canary Wharf, Custom House and Westbourne Park stations. Access issues to various sites continue to be a recurring cause of schedule slippage from then on.

8 The issues set out above contributed to lower than expected productivity. For example, in March 2016 the laying of track was reported as behind schedule, with 11 km laid compared to a planned 14.6 km. Throughout 2018, schedule delays were mostly attributable to the ongoing productivity issues, partly related to unreliable access to work sites. Overall, delays to schedule created a sustained gap between planned and achieved work that was never successfully closed.

Figure 11
Progress against plan on the systemwide installation contract

Work on the systemwide installation contract has consistently lagged behind schedule since January 2015



Note

1 The dips in the planned progress line reflect the rebasing of the programme plan when Crossrail Ltd revised the Master Operational Handover Schedule (MOHS).

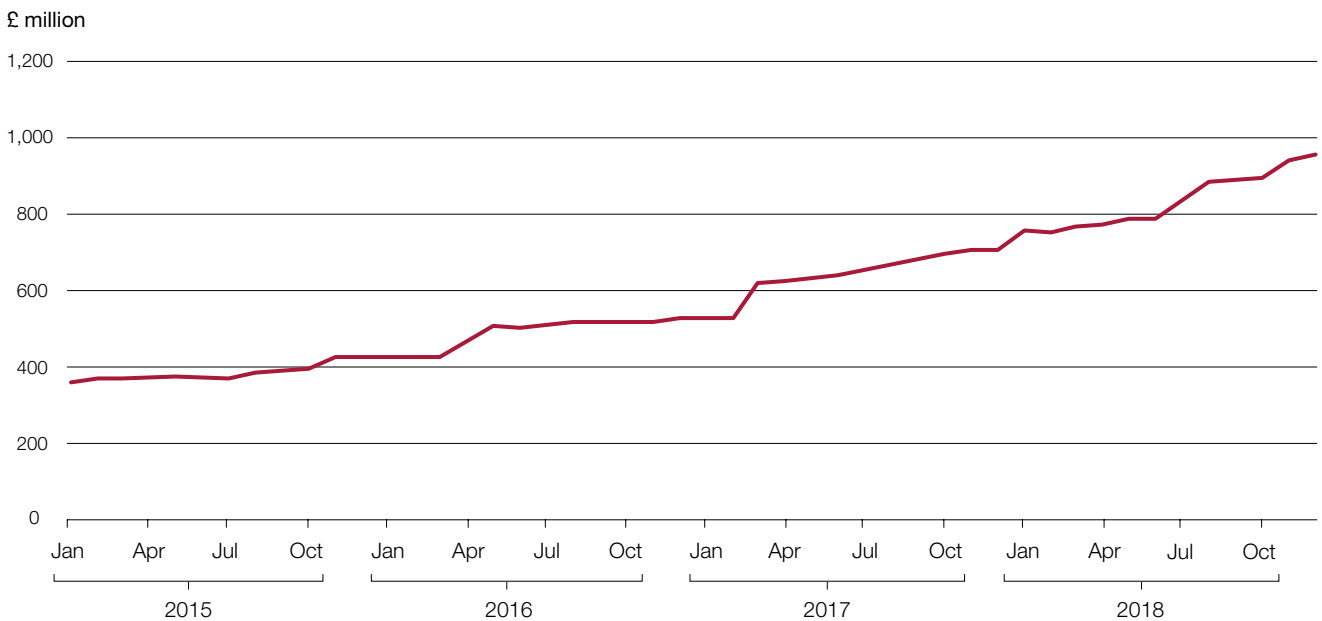
Source: National Audit Office analysis of Crossrail Ltd information

Cost increases

9 The issues associated with delivery of the contract also resulted in increased costs. Between February 2017 and March 2018, the forecast cost of the contract increased by £235 million (44%) from £532 million to £767 million (**Figure 12**). The causes of the cost increases against the original plan are varied, and include additional construction and design due to lower than expected productivity, and access delays, instructed changes in scope, and corrections to the contractor’s forecasts. Between March 2018 and December 2018, the forecast final cost of the contract increased by a further £189 million (25%) from £767 million to £956 million. As with Paddington station, this last cost increase was partly due to Crossrail Ltd’s unsuccessful attempts to accelerate productivity with additional resource during 2018 and the prolongation of the contract after the August 2018 announcement that the opening date would be delayed. Crossrail Ltd began to develop more realistic forecasts of what it would cost to complete the programme.

Figure 12
Forecast final cost of systemwide installation contract

The forecast cost of the systemwide installation contract has increased by £596 million since January 2015



Notes

- 1 The costs given are the contractor view of forecast of total defined cost, as reported in the Crossrail Ltd’s Board reports each month.
- 2 Costs are given in cash terms.

Source: National Audit Office analysis of Crossrail Ltd information

Case example 3 – the installation of communications and control equipment

10 In March 2013, Crossrail Ltd awarded the contract to design, test and commission key communications and control systems in Crossrail's central section to Siemens plc. The contractor was dependent on station construction contractors for installation in all but two stations. The communications and control systems being provided under this contract include CCTV and public address systems at stations, customer information displays, staff and emergency services radio systems and data networks to transfer information to and from the Elizabeth line control centre. At the time the contract was awarded, Crossrail Ltd was aiming for the contract to cost around £43 million.

Delays to delivery of the contract

11 Delivery of the contractual requirements in line with the plan to open the central section in December 2018 was highly dependent on the main station contractors installing the required infrastructure and equipment to enable all the communications systems to be tested and commissioned. Crossrail Ltd's programme reports show that installation of this equipment and handover to the communications and control contractor for testing and commissioning were significantly delayed. Actual progress with delivery of the contract fell behind the planned level of progress by the middle of 2017 and the gap continued to grow throughout 2017 and 2018 (**Figure 13** overleaf).

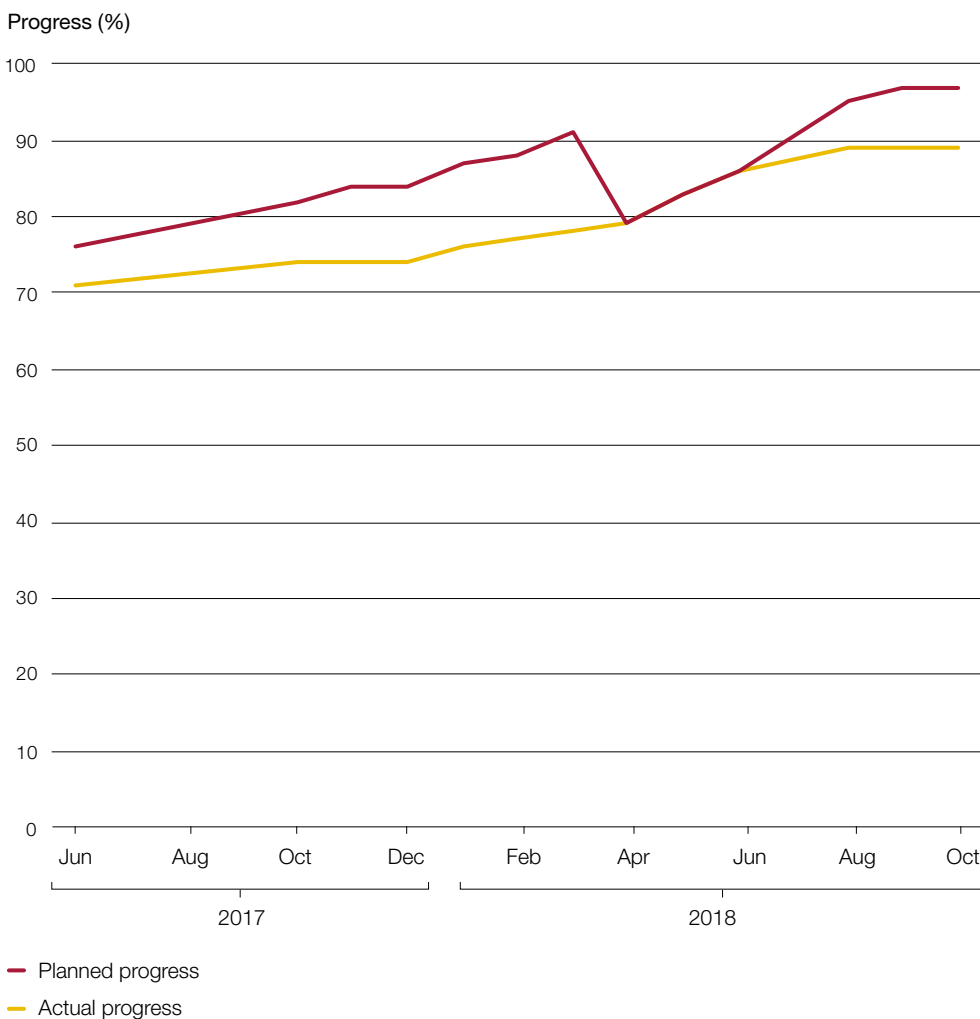
12 The causes of cost increases included delays to the availability of work sites, and the availability of stations. One of the key specialisms required for delivery of the contract was for technicians to test and commission the systems, including Supervisory Control and Data Acquisition (SCADA) devices, that enable remote control of systems in the stations and tunnels. Siemens' initial plan was for approximately 30 technicians to move between the stations and commission the devices sequentially. However, as completion of the installation of required infrastructure was delayed, Siemens was requested to significantly increase the number of technicians working on the programme in order to mitigate the delays and meet the handover schedule. During 2018 the number of technicians required to complete testing work in the reduced timeframe increased, with 160 being required by October 2018.

13 During 2018, Siemens was unable to recruit technicians from the limited pool available as quickly as required. In August, Siemens had 88 technicians available against a requirement of 144. However, further delays to the installation of equipment to test led to the divergence between actual progress and planned progress in the chart overleaf. The ramp-up of resources to accelerate delivery of the contract, the prolongation of the time that these resources were required, and the higher than expected cost of the technicians themselves led to a 20% increase in costs (from £116 million to £139 million) between April 2018 and December 2018 (**Figure 14** on page 45).

Figure 13

Progress against plan on the communications and control contract

Progress of the communications and control contract has consistently performed behind schedule



Note

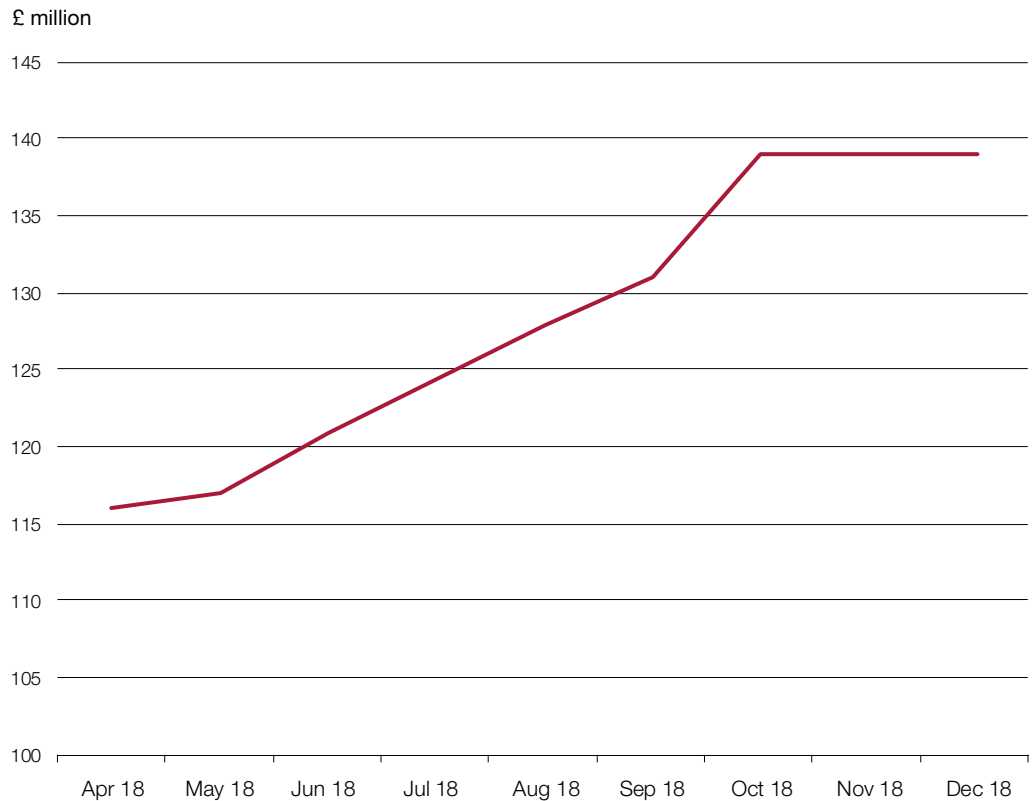
1 The dips in the planned progress line reflect the rebasing of the programme plan when Crossrail Ltd revised the Master Operational Handover Schedule (MOHS).

Source: National Audit Office analysis of Crossrail Ltd information

Figure 14

Forecast final cost of the contract to install and test communications and control equipment

The cost of the contract has increased by £23 million from April 2018 to December 2018



Notes

- 1 The costs given are the contractor view of forecast of total defined cost, as reported in the Crossrail Ltd's Board reports each month.
- 2 Costs are given in cash terms.

Source: National Audit analysis of Crossrail Ltd information

Case example 4 – the delivery of the train and signalling systems

14 Bombardier Transportation is responsible for manufacture of the trains and developing the onboard software and systems to operate them. Siemens is responsible for installation and software development of lineside signalling systems in the central section

15 Development of the software and on-board signalling systems required to operate the trains has been significantly delayed. In July 2017, Crossrail Ltd raised an Adverse Event Notice to the sponsors, stating that the opening of services on the western section (stage 2) and the central section (stage 3) were at risk. There have also been delays to testing of the train due to delays to the installation of signalling equipment in the tunnels and station in the central section.

16 Delays were made worse in October 2017, when a transformer connection failed, meaning that the central tunnel could not be electrified as planned. This delayed the start of dynamic testing of the train with the signalling system by three months and presented a significant problem for the schedule, as this signalling integration testing was essential for the central section opening in December 2018. Unlike the station and system implementation contracts, the delays to the development of the train had little direct impact on the cost of the programme because Transport for London had signed a contract with Bombardier Transportation for a fixed price of around £1 billion, and the cost of the trains and depot are accounted for outside the programme budget for Crossrail.

17 The accumulated schedule pressure from the infrastructure delays, and the delayed start to dynamic testing, meant that by early 2018 there was little time remaining to carry all the testing required to gain the required assurance that services could be operated safely and effectively. In order to meet the December 2018 opening date for the central section, Crossrail Ltd planned to carry out both construction and dynamic testing in parallel. Crossrail Ltd did this to ensure that any early issues with the train and signalling software could be found and resolved. However, because the train and signalling software had not been developed to the required level, this testing proved to be of limited use. It also added to the compression in the programme as testing took up spare time and space on the Crossrail station and tunnel sites, which could have been used to make progress with construction and installation of systems.

Report by the Comptroller and Auditor General

Completing Crossrail

HC 2106 Session 2017–2019

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CORRECTION

On page 12 of the report, we propose changing the first sentence in paragraph 1.4 from:

1.4 Crossrail began operating services from June 2017 between Liverpool Street and Shenfield, and two trains an hour from Paddington to Heathrow in May 2018.

to:

1.4 MTR-Crossrail began operating services using the new class 345 trains between Liverpool Street and Shenfield from June 2017, and began operating services between Paddington and Heathrow in May 2018.

The revised paragraph should read:

1.4 MTR-Crossrail began operating services using the new class 345 trains between Liverpool Street and Shenfield from June 2017, and began operating services between Paddington and Heathrow in May 2018. From 2010, sponsors planned for the central section of the railway to open from December 2018, with further staged openings of eastern and western services in 2019.

Figure 4 on page 17 of the report, two columns under 'cost increases' should both say, to Dec 2018, not to Jan 2018, and the note should also say to December 2018: See the corrected Figure 4 below.

Figure 4

Changes in the forecast cost of selected contracts on the central section to December 2018

Cost increases have occurred across the programme

Contract	Forecast costs			Cost increases	
	Target at Award (£m)	Jan 2015 (£m)	Dec 2018 (£m)	Award to Dec 2018 (£m)	Award to Dec 2018 (%)
Tunnelling, shafts and portals					
Eastern tunnels ¹	484	754	730	246	51
Western tunnels ¹	490	737	749	259	53
Thames tunnel ¹	196	269	229	33	17
Station Tunnels East – Early Access Shafts and Sprayed Concrete Lining Works ¹	246	360	510	264	107
Pudding Mill Lane Portal Civil Works ¹	52	131	184	132	254
Eleanor Street and Mile End Shafts Civil Works	46	56	255	209	454
Station main civils					
Farringdon Station	239	436	634	395	165
Liverpool Street Station	147	271	374	227	154
Paddington Station	181	339	571	390	215
Bond Street Station	126	182	412	286	227
Whitechapel Station	110	229	659	549	499
Tottenham Court Road Station	98	135	282	184	188
Woolwich Station	70	N/A	234	164	234
Route-wide civil engineering and systems					
Systemwide (Tunnel track and electrical fit-out)	323	360	956	633	196
Platform Screen Doors	27	N/A	63	36	133
Signalling	51	N/A	131	80	157
Communications and Control	43	N/A	139	96	223
Other					
Ilford Stabling Sidings ¹	54	N/A	153	99	183

Notes

- Contracts completed prior to December 2018 and show their final values. The figures for Thames Tunnel and Pudding Mill Lane reflect the costs when they were at 98% and 99% complete respectively – the final 100% figures were not reported in Crossrail's Board reports.
- Target at award denotes the anticipated cost of the contract at award and does not include adjustments for risk. Other cost values are contractors' forecast of final costs which may include adjustments for cost risks where the contract is not yet complete. All values are drawn from Crossrail Ltd board reports.
- All values are in cash prices.
- N/A means that the forecast costs of these contracts was not reported in January 2015.

Source: National Audit Office analysis of Crossrail Ltd information

We propose changing paragraph 14 on page 46 from:

14 Bombardier's development of the software and on-board signalling systems required to operate the trains has also been significantly delayed. In July 2017, Crossrail Ltd raised an Adverse Event Notice to the sponsors, stating that the opening of services on the western section (stage 2) and the central section (stage 3) were at risk. This is because it has taken Bombardier and Siemens around 18 months longer than originally planned to develop and test the train and signalling software to operate Crossrail's three separate signalling systems. There have also been further delays to testing of the train due to delays to the installation of signalling equipment in the tunnels and station in the central section.

to:

14 Bombardier Transportation is responsible for manufacture of the trains and developing the onboard software and systems to operate them. Siemens is responsible for installation and software development of lineside signalling systems in the central section.

15 Development of the software and on-board signalling systems required to operate the trains has been significantly delayed. In July 2017, Crossrail Ltd raised an Adverse Event Notice to the sponsors, stating that the opening of services on the western section (stage 2) and the central section (stage 3) were at risk. There have also been delays to testing of the train due to delays to the installation of signalling equipment in the tunnels and station in the central section.

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