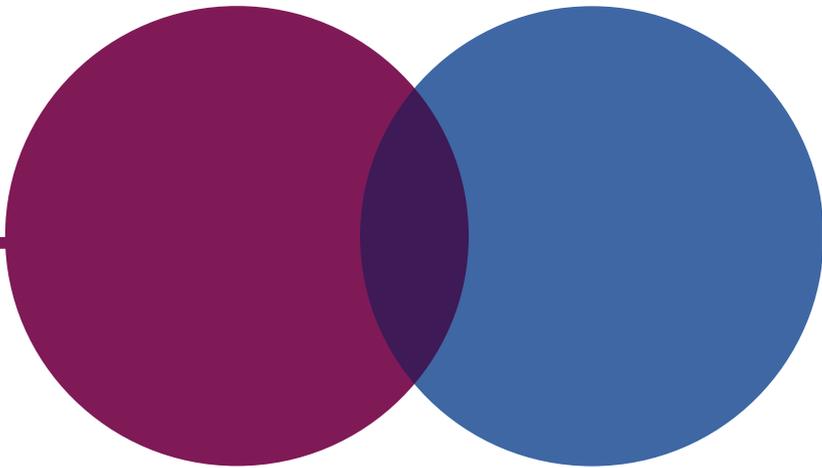




National Audit Office



Crossrail – a progress update

Department for Transport, Transport for London
and Crossrail Limited

REPORT

**by the Comptroller
and Auditor General**

SESSION 2021-22

9 JULY 2021

HC 299



We are the UK's independent public spending watchdog.

We support Parliament in holding government to account and we help improve public services through our high-quality audits.

The National Audit Office (NAO) scrutinises public spending for Parliament and is independent of government and the civil service. We help Parliament hold government to account and we use our insights to help people who manage and govern public bodies improve public services.

The Comptroller and Auditor General (C&AG), Gareth Davies, is an Officer of the House of Commons and leads the NAO. We audit the financial accounts of departments and other public bodies. We also examine and report on the value for money of how public money has been spent.

In 2020, the NAO's work led to a positive financial impact through reduced costs, improved service delivery, or other benefits to citizens, of £926 million.



National Audit Office

Crossrail – a progress update

Department for Transport, Transport for London
and Crossrail Limited

Report by the Comptroller and Auditor General

Ordered by the House of Commons
to be printed on 8 July 2021

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

Gareth Davies
Comptroller and Auditor General
National Audit Office

6 July 2021

Value for money reports

Our value for money reports examine government expenditure in order to form a judgement on whether value for money has been achieved. We also make recommendations to public bodies on how to improve public services.

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

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

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

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



Contents

Key facts 4

Summary 5

Part One

The Crossrail programme 13

Part Two

Why Crossrail's schedule and cost has increased since 2019 24

Part Three

Risks to bringing the Elizabeth line into service 35

Part Four

Delivering the benefits 46

Appendix One

Our audit approach 53

Appendix Two

Our evidence base 55

Appendix Three

£825 million Crossrail loan agreement between government and the Greater London Authority 57

Appendix Four

Lessons from Crossrail 59

This report can be found on the National Audit Office website at www.nao.org.uk

If you need a version of this report in an alternative format for accessibility reasons, or any of the figures in a different format, contact the NAO at enquiries@nao.org.uk

The National Audit Office study team consisted of:

Thomas White, Jennifer Bayliss, Jacqueline Chan, David Molony, Lee Nicholson and Josh Perks, under the direction of Lee-Anne Murray.

For further information about the National Audit Office please contact:

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

 020 7798 7400

 www.nao.org.uk

 @NAOorguk

Key facts

£18.9bn

Crossrail Ltd's current forecast cost of completing the programme, including Network Rail costs, but excluding the new trains and depot.

£1.9bn

the forecast cost increase since we reported in May 2019

Jan 2022 to Jun 2022

Estimated range for when train services are expected to start running on the central section. This is up to 20 months later than when we last reported in May 2019

£18.8 billion

current funding package to complete the Crossrail programme

28%

nominal cost increase to build the railway from the 2010 budget of £14.8 billion

At least 3 years

than the original December 2018 opening date – current expected timing for services to start running on the central section of the Elizabeth line

May 2023

current expected date for full services to run on the Elizabeth line

Three

out of 10 new stations built as part of the programme transferred to the maintainer and ready for operational use, as at the end of May 2021

500,000

Crossrail Ltd's estimate of the number of individual assets needed for the Elizabeth line, such as platform screen doors

200,000

Crossrail Ltd's estimate of the number of assurance documents that must be produced in order to demonstrate the central section can operate safely

£1.37:£1

the sponsors' most recent estimate of the transport benefit-cost ratio in March 2020. This increases to £1.88 when wider economic benefits are included

Summary

The Crossrail programme

1 Crossrail is a complex major 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 41 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) underground and overground rail network and be known as the Elizabeth line.

2 We last reported on the programme in May 2019.¹ We found that there were ways in which Crossrail Ltd, the body responsible for delivering the programme, had been managing the programme that drove unnecessary cost. In particular, Crossrail Ltd had no realistic plan to complete the programme and had chosen a contractual model that made it more complex to deliver. Even when the programme repeatedly missed milestones, the previous Crossrail Ltd management continued to believe it was possible to meet the December 2018 opening date. It compressed the schedule and changed its contractual model resulting in a loss of pressure to control costs. We concluded that the government needed to complete the programme and that Crossrail Ltd needed support and time to develop and deliver revised plans to completion.

3 When we last reported the funding package stood at £17.6 billion and the forecast cost was £17 billion, with the central section due to open between October 2020 and March 2021.² The current funding package agreed in December 2020 is £18.8 billion. This followed announcements in November 2019 and August 2020 that Crossrail required more funding and that the opening date would be delayed. Crossrail Ltd now expects services to run through the central section between January and June 2022. This is 10 to 20 months later than planned when we last reported, and up to three and a half years later than originally planned. Full Elizabeth line services are currently expected to run from May 2023.

¹ Comptroller and Auditor General, *Completing Crossrail*, Session 2017-2019, HC 2106, National Audit Office, 3 May 2019.

² The funding package for Crossrail, and the forecast costs, exclude the cost of procuring new trains and maintenance depot, which TfL funded and has cost around £1.1 billion.

4 The Department for Transport (the Department) and TfL are jointly sponsoring the Crossrail programme (the sponsors). Crossrail Ltd is responsible for delivering the programme. Mass Transit Railway (MTR), a transport operating company based in Hong Kong, will run rail services as MTR Elizabeth line (MTREL) on behalf of Rail for London (RfL), which is responsible for operating the Elizabeth line. Rail for London Infrastructure (RfLi), London Underground and Network Rail, will be responsible for maintaining the different parts of the Elizabeth line. Crossrail Ltd, RfL, RfLi and London Underground are all part of TfL.

5 In late 2018, in response to the significant cost increase and schedule delay, the sponsors appointed a new Chair and Chief Executive of Crossrail Ltd and strengthened their oversight of the programme. Our February 2019 memorandum sets out the governance arrangements at that time.³ In October 2020, the sponsors revised the governance arrangements to streamline decision-making and give TfL greater responsibility for overseeing completion, in line with its role as the long-term operator. TfL's Transport Commissioner is now ultimately accountable for completing Crossrail and delivering the high-level objectives. TfL created new decision-making and oversight boards. Crossrail Ltd is now a management unit within TfL. The Department's role is now principally as the funder of the programme, but it continues to have a role in monitoring and oversight of the programme. It also has a role in approving some changes to the programme, including any that affect the anticipated benefits, and is responsible for work delivered by Network Rail and ensuring integration with other operator services on the wider rail network. We consider it appropriate for sponsors to amend governance arrangements to reflect the stage of the programme.

Scope and purpose of this report

6 This report examines:

- progress on the programme, and the underlying reasons for the cost and schedule increases that have occurred since we last reported.
- the main risks that the sponsors and the Crossrail team must manage to open the Elizabeth line successfully. Our report focuses on opening the central section between Abbey Wood and Paddington.
- what needs to be done to realise benefits from the investment in Crossrail.

7 This report makes recommendations for Crossrail Ltd and the sponsors as the programme nears completion. Appendix Four builds on the learning we set out in our *Lessons learned from major programmes* report, particularly around resetting programmes which have run into difficulty.

³ Comptroller and Auditor General, *A memorandum on the Crossrail programme*, Session 2017-19, HC 1924, National Audit Office, 28 February 2019.

8 This report is not a detailed assessment of the entire programme. It focuses on the most important issues the programme faces to complete the central section and to open the full Elizabeth line. Therefore, we do not examine in detail cost increases and delays on the Network Rail elements of the programme.

9 This report is based on our review of Crossrail Ltd and sponsor documents, assessments by external reviewers and interviews with key figures involved in the delivery and oversight of the programme. The majority of our fieldwork was conducted between November 2020 and April 2021 and was done remotely due to the national lockdowns and social distancing rules in response to the COVID-19 pandemic.

Key findings

10 While the programme has been delayed further since we last reported, significant progress has been made since 2019. The majority of major construction work is complete. Crossrail Ltd is now transferring assets, such as stations, to RfLi and London Underground who, along with Network Rail, will maintain and operate different parts of the railway. MTREL has been running services on the eastern and western ends of the line using new Elizabeth line trains (under the brand name ‘TfL Rail’) since June 2017 and May 2018, respectively and Network Rail has improved accessibility at seven stations.⁴ On 10 May 2021, Crossrail started the first stage of operational testing, known as trial running. It will gradually run up to 12 trains an hour through the tunnels, testing trains, systems and signalling. Crossrail Ltd plans for the second stage of operational testing, trial operations, to begin in autumn 2021 at the earliest. This stage tests how the trains and stations operate in real-world conditions. Once this stage is complete, the railway will be ready to begin services (paragraphs 1.16 and 1.17, and Figure 2).

Reasons for the schedule slipping and cost increasing

11 The revised schedule and budget agreed between Crossrail Ltd and the sponsors in April 2019 was unachievable because the programme was further from being complete than they understood. The new management team hired in November 2018 had to start largely from scratch when setting a revised plan to complete the programme. The programme repeatedly missed milestones throughout 2019 and into 2020 because Crossrail Ltd continued to uncover problems or identify new required work. Despite contractors meeting around 30% of milestones on average throughout 2019 and early 2020, Crossrail Ltd continued to base its plans on more optimistic levels of productivity. In August 2020 Crossrail Ltd produced a revised plan and it continues to work towards the cost estimates and schedule set out in that plan (paragraphs 1.9, 2.3, 2.9 to 2.12, 2.22 and 3.19, and Figures 7, 8 and 9).

⁴ MTREL introduced new trains on the western end in stages between May 2018 and July 2020.

12 The COVID-19 pandemic added further cost and delay, but Crossrail Ltd took the opportunity to improve its planning of remaining work. Crossrail Ltd estimated it paused construction activity for nine weeks from 24 March 2020, following the announcement of the first national lockdown. It estimates that £228 million (15%) of the £1,510 million increase in Crossrail Ltd's costs since April 2019 is a direct result of social distancing and other COVID-19 factors. In response to the delays caused by the pandemic, and the measures required to make its sites and workspaces safe, Crossrail Ltd worked closely with its contractors to plan and re-sequence remaining work, including using dedicated periods of 24-hour a day construction, known as blockades. In August 2020, Crossrail Ltd reported around 2,000 people on work sites, less than 50% of the pre-COVID-19 complement. Contractors met around 90% of milestones on average between September 2020 and April 2021, compared with pre-COVID-19 where around 30% of milestones were met (paragraphs 2.28 to 2.30).

13 Neither Crossrail Ltd, the sponsors nor the contractors appreciated how complex it would be to bring together all of the separate systems and assets required and assure them as safe and working, or how long it would take. The Elizabeth line will be the first fully digital railway to be built and operated in the UK. Bringing it into service requires Crossrail Ltd and its contractors to complete and integrate around 500,000 physical and digital assets, such as fire safety systems or platform screen doors. They must be assured as safe and operational both individually and in combination. There must also be digital operating manuals, guidance and processes for individual elements and the railway as a whole. The work to bring the railway into service was made more complex by the high number of contracts, bespoke designs and a lack of standardisation throughout the programme, as well as needing to integrate three different signalling systems with trains (paragraphs 2.13 to 2.17).

14 Crossrail Ltd did not have sufficiently effective commercial levers with its main contractors to prevent further cost and schedule increases, despite trying a number of initiatives. When we last reported, Crossrail Ltd had begun negotiating fixed-price contracts with its existing contractors for some of the remaining work to improve certainty on costs. Crossrail Ltd needed to incentivise contractors to deliver the work in a timely and efficient manner. Fixed-price contracts can be suitable when the contractor is best placed to manage risks to cost and schedule. However, because the amount of work required kept growing, because contracts were interdependent, and because contractors missed milestones, the incentives Crossrail Ltd put in place during 2019 to encourage productivity could not prevent further cost and schedule increases. Since we last reported, the total costs of the 19 main works contracts still in place have increased by £1.3 billion. As Crossrail Ltd now has a more stable project plan, it has been able to use the plan to set a new commercial strategy, including incentives which better reflect the interdependencies between contracts (paragraphs 2.18 to 2.22, 3.25 and Figure 8).

15 It took longer than Crossrail Ltd expected to fill critical staff vacancies. In our last report, we said that to manage programme risks and contractual arrangements effectively, Crossrail Ltd needed to rebuild its capability and capacity. We also noted that it had found it hard to recruit the skills it needed. It has continued to experience difficulties recruiting certain skills. Crossrail Ltd told us this was because of the specialist nature of the skills required. Senior leadership appointments since our last report have further improved Crossrail Ltd's approach, particularly on the plan to transfer assets to RfLi and London Underground and limiting unnecessary re-work (paragraphs 2.23 to 2.27).

Bringing the Elizabeth line into service

16 Several organisations are now responsible for bringing the Elizabeth line into service, which adds complexity. As the central section approaches the start of passenger services, responsibility for completing, maintaining and operating the Elizabeth line is shared between Crossrail Ltd, London Underground, the newly created RfLi, Network Rail, RfL and MTREL. While Crossrail Ltd, London Underground, RfLi and RfL are all part of TfL, they are legally required to be separate management units with specific responsibilities. Network Rail and the Department, working with TfL, are responsible for integrating Elizabeth line services into the national rail network. We often see programmes have problems when roles and responsibilities change, and when they are shared between different bodies (paragraph 3.2 and Figure 10).

17 Crossrail Ltd has achieved a key milestone by starting trial running, but completing the remaining work during trial running and trial operations is complicated, and creates new risks to cost and schedule. On 27 March 2021 RfLi became legally responsible for the central section routeway, which allowed Crossrail Ltd to begin the trial running stage of testing. This was a significant milestone for the programme and was achieved by the target date. However, Crossrail Ltd must now plan and agree all works taking place on the routeway in advance with RfLi and contractors, rather than planning in isolation, making it more complicated to complete outstanding works. It has decided to do some non-safety-critical work alongside trial running and trial operations, and hand over stations in stages. There is a risk that so much completion work is going on in parallel that it undermines the purpose of moving to trial running. Trial running began on 10 May, and is six weeks behind the 'best case' target date, but is still within the range of dates as set out in the revised August 2020 schedule. (paragraphs 3.3 and 3.6 to 3.12).

18 The current programme cost estimate exceeds available funding. In August 2020, Crossrail Ltd confirmed a further estimated cost increase of between £800 million and £1.1 billion. In December 2020, the Department agreed £825 million of funding. As at May 2021, Crossrail Ltd's cost estimate has increased, although remains within the upper limit of the range announced in August 2020. The current cost estimate is between £30 million and £218 million above the current available funding to complete the programme, with a middle estimate of £120 million over. Crossrail Ltd expects the full line to open in May 2023, but estimates that current funding will be exhausted between July and September 2022. Crossrail Ltd and its contractors are still identifying new tasks that need to be done, which, alongside tasks taking longer than expected to complete, are increasing forecast costs. To better control costs, Crossrail Ltd, is reviewing all new work tasks, and has developed a plan to close some main works contracts sooner by contracting another supplier to complete some of the more straightforward work. It has also agreed with RfLi and London Underground that some residual work to complete the line can be done after it opens. Crossrail Ltd will transfer funding for this work. However, it is not yet clear how much it will ultimately cost, whether the funding is sufficient, or whether this work needs to be done at all. The current middle estimate of the total cost to complete the programme and deliver full east-west services, including Network rail costs, is £18.9 billion, £1.9 billion more than when we last reported (paragraphs 2.3, 3.22 to 3.27, and Figure 7).

19 There are still significant issues that could affect the cost and schedule.

Paragraphs 17 and 18 summarise the amount of work remaining and the challenges Crossrail Ltd and RfLi face to complete it. In addition, an important software update to the train signalling and control systems, which is necessary to start the next phase of operational testing, trial operations, is likely to be delayed by between three and eight weeks. Operational testing could also identify problems which can take time to be addressed. There is also work outstanding to complete and hand over stations to RfLi, which is on the critical path to opening the central section. Crossrail Ltd has put in place activities to try to address programme risks. It is currently updating its modelling of potential opening dates and forecast costs, taking into account progress and delays on the programme. It is also reviewing its staged opening plan to try to bring full opening of the Elizabeth line forwards (paragraphs 3.13, 3.14, 3.16, 3.17, 3.19 and 3.21).

Achieving value for money from the Elizabeth line

20 Changes in people’s travel patterns may affect the expected transport benefits of the Elizabeth line. When the Elizabeth line opens, there will be a railway with all the expected stations and interchanges, and train services to support the benefits set out in the business case in terms of improved capacity and connectivity in London and the South East. However, these benefits were based on predicted increases in population and travel demand set in 2011 and 2015, which may be less likely to occur, at least in the short term. Increases in passenger demand have slowed since 2015-16, and the COVID-19 pandemic may have more long-reaching impacts on travel. Opening the line and getting passengers to use it is critical to TfL’s financial planning. TfL’s January 2021 scenario planning indicated an 18% drop in demand for rail by 2031, with a potential longer-term revenue risk of around £150 million a year if demand for the Elizabeth line grows more slowly than expected (paragraphs 4.2 and 4.7 to 4.9).

21 The sponsors need to do more to plan for and deliver wider benefits from the Elizabeth line, such as supporting economic growth. The 2011 Crossrail business case set out a series of wider aims for the completed railway. These included supporting economic growth and regeneration, environmental benefits through people shifting from cars to public transport, and building an accessible railway. It also included benefits it aimed to achieve during construction, such as long-term skills development. The context within which the Elizabeth line will open is different from 2011 – the increase in flexible and remote working being one indicator of change. Economic growth and moving people from cars to the Elizabeth line will require sustained effort and vision over a long period of time. For local regeneration, local stakeholders will need to take a lead. The sponsors have identified and measured benefits achieved during construction. They have also established a series of evaluation studies to help them monitor and evaluate the impact of the line when complete. TfL has a plan for integrating the line into its transport network. We can see some London boroughs thinking about how they will make the most of the line. However, TfL does not yet have a strategy that brings the work it has done together, and a plan for how it realises and maximises all the benefits of the Elizabeth line (paragraphs 4.3 and 4.11 to 4.18).

Concluding remarks

22 Despite efforts to control costs and schedule in 2019, the programme was further from completion and more complicated than Crossrail Ltd or the sponsors understood. This, and the COVID-19 pandemic, resulted in a further forecast cost increase of £1.9 billion and 10 to 20 months of delay since we last reported. There are encouraging signs that the programme is now in a more stable position with a better understanding of the total amount of work required. However, there is still a significant volume of work to complete alongside testing trains, signalling and other assets. Completing the programme relies now on Crossrail Ltd, RfLi, MTREL, TfL, Network Rail and the Department working closely.

23 Major infrastructure projects take years to deliver, during which time there are inevitably economic and societal changes which affect the benefits case for the project. In this case, the Elizabeth line still has the potential to achieve the benefits in the latest approved business case from 2011, but TfL and the Department have not fully thought through how to realise those benefits. In light of the uncertain impact on travel patterns that were already changing before COVID-19, TfL and the Department need to consider what is required to maximise the return on the almost £19 billion cost of constructing the Elizabeth line.

Recommendations

- a TfL should identify the skills and individuals it needs to retain to complete the programme, and those it thinks it will need to retain to run the Elizabeth line effectively once in service.**
- b Crossrail Ltd should work with RfLi to set out a clear plan for handing the Elizabeth line over to RfLi.** The plan should include what work is being transferred into operational testing, what work is being deferred until the Elizabeth line is in service and who is responsible for it, and a process to monitor and report on progress of these tasks, including how much it has cost to complete the railway.
- c TfL and the Department should set out a benefits realisation strategy and plan for the Elizabeth line which they update over time.** This should:
 - set out clearly the intended benefits of the Elizabeth line, including those identified during construction and a way of identifying other benefits not originally identified in the business case.
 - bring together the work they have already done on benefits in one place.
 - set out how benefits will be monitored and measured over time.
 - identify who is responsible for delivering different benefits, and where this is another organisation, who is responsible for influencing that organisation.
 - assess the risks to achieving benefits and the steps TfL and the Department can take to mitigate them.
 - set out governance arrangements for the strategy, including how benefits management will be included in TfL's corporate management information to ensure a strong focus on benefits beyond the delivery phase of the programme.
- d The Department and TfL should examine the types of benefits realised by the Crossrail programme and Elizabeth line, and those benefits expected but not achieved, and take account of their learnings in the business cases and benefits strategies for other major transport programmes.**
- e RfLi should set out a plan to realise and monitor the benefits of running a fully digital railway.**

Part One

The Crossrail programme

Background

1.1 Crossrail is a complex 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. **Figure 1** overleaf sets out the route of the railway and the stations which Crossrail will serve. When it opens, it will be called the Elizabeth line and be part of Transport for London's (TfL's) underground and overground rail network. Our February 2019 memorandum on the Crossrail programme sets out more background about the programme.⁵

1.2 The main objectives of Crossrail were to relieve congestion on the transport network, accommodate future expected travel demand, improve connectivity and reduce journey times, and support economic growth. Crossrail is estimated to increase rail capacity in central London by 10%.

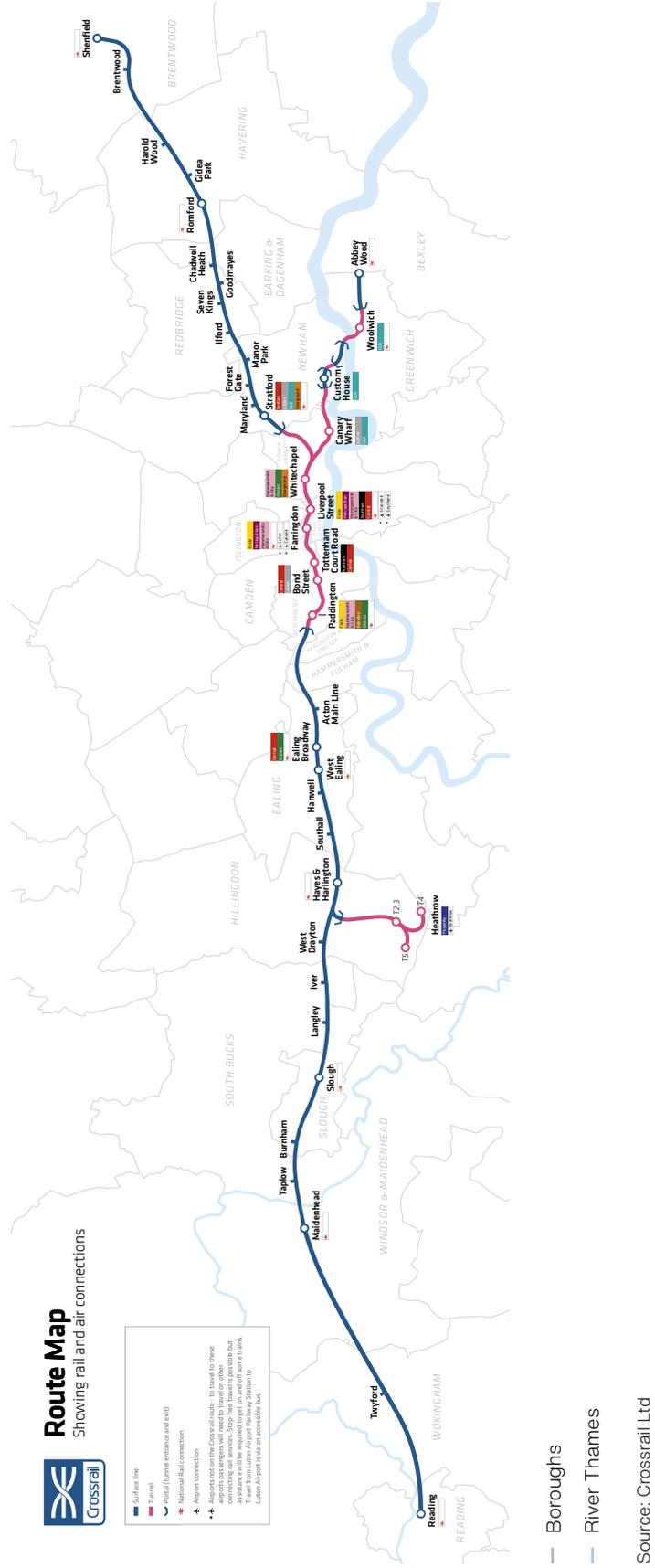
1.3 Crossrail is one of the biggest civil infrastructure projects undertaken in the UK for many years. It involves:

- construction of around 26 miles (42 kilometres) of new rail tunnels beneath London and fit-out of the tunnels including installing track, overhead lines to power the trains, drainage and ventilation systems and cabling and equipment needed to support signalling systems;
- building 10 new, bespoke stations, including eight new underground stations, larger than most existing underground stations with interchanges with underground stations and lines;
- improving existing tracks on the western and eastern ends and providing the overhead lines at the western end required to provide power to and operate the trains, which constitutes one of Network Rail's biggest enhancement projects;
- designing and manufacturing a new fleet of trains with new systems and software, with each train nearly twice the length of a tube train and able to carry 1,500 passengers;

⁵ Comptroller and Auditor General, *A memorandum on the Crossrail programme*, Session 2017-19, HC1924, National Audit Office, February 2019.

Figure 1
The Crossrail route and stations

The Crossrail route runs from Reading in the west to Shenfield and Abbey Wood in the east



- developing software and equipment to enable the trains to switch between three different signalling systems across the existing national network and a new section of underground railway. Crossrail Ltd told us that this is unique anywhere in the world; and
- a range of complex IT systems to support management of the stations, including 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.

1.4 We have reported on the programme three times. In January 2014, we reported on the early stages of the Crossrail programme.⁶ At that time, tunnelling and civil engineering work in the central tunnel section was under way. Our report gave the 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.

1.5 In August 2018, Crossrail Ltd announced that it would not be able to open the central section of the railway in December 2018 as planned and that it would cost more money. In February 2019, we published a memorandum on the programme setting out what had happened.⁷

1.6 In May 2019, we reported on the reasons for the cost and schedule increases. We found that there were ways in which Crossrail Ltd, the body responsible for delivering the programme, had been managing the programme that drove unnecessary cost. In particular, Crossrail Ltd, had no realistic plan to complete the programme and had chosen a contractual model that made the programme more complex to deliver. Even when the programme repeatedly missed milestones, the previous Crossrail Ltd management continued to believe it was possible to meet the December 2018 opening date. It compressed the schedule and changed its contractual model resulting in a loss of pressure to control costs. We concluded that the government needed to complete the programme and that Crossrail Ltd needed support and time to develop and deliver revised plans to completion.⁸

1.7 In August 2020, Crossrail Ltd announced that the programme was further delayed. It stated that the central section would open in the first half of 2022. It did not state when full east-west services would operate, but noted it would be aligned to National Rail timetable changes which occur in May and December each year.

Figure 2 overleaf sets out changes to the timetable for the opening date.

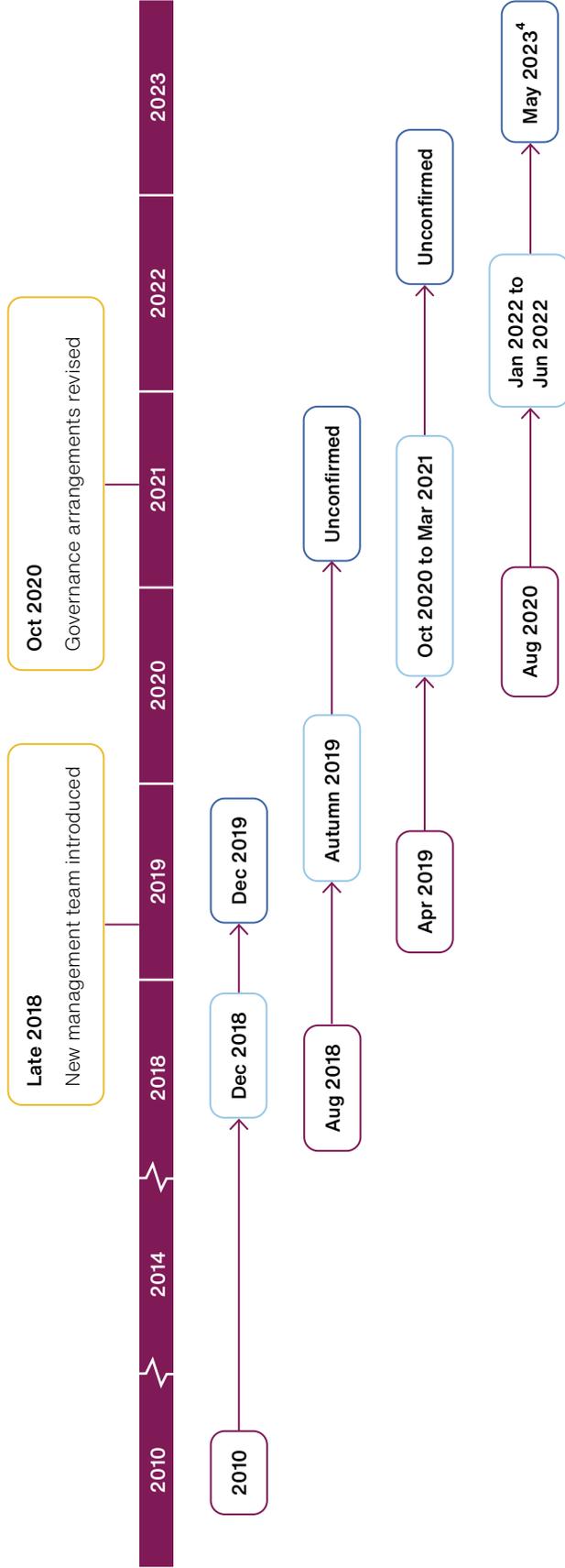
⁶ Comptroller and Auditor General, *Crossrail*, Session 2013-14, HC965, National Audit Office, January 2014.

⁷ See footnote 5.

⁸ Comptroller and Auditor General, *Completing Crossrail*, Session 2017-19, HC2106, National Audit Office, May 2019.

Figure 2
Changes to the expected opening date of the Elizabeth line, since 2010

The expected opening date for the central section and full east-west services has repeatedly slipped since August 2018



□ Schedule announcements □ Expected opening of central section □ Expected opening of full services □ Changes of senior leadership or governance

Notes

- 1 The central section services will run beneath central London between London Paddington in the west and Liverpool Street and Abbey Wood in the east.
- 2 Full services will be between Reading and all passenger terminals of Heathrow Airport at the western ends of the railway, to Shenfield in Essex and Abbey Wood in south-east London at the eastern ends.
- 3 Services have been running on the eastern and western ends of the line using new Elizabeth line trains since June 2017 and May 2018, respectively. MTR Elizabeth line services on the western end introduced the new trains in stages between May 2018 and July 2020.
- 4 Opening of full east-west services must align with National Rail timetable changes which occur in May and December each year. Services could begin sooner, in December 2022, but will depend on progress of earlier stages of the programme.

Source: National Audit Office analysis of Crossrail Ltd data

Roles and responsibilities

1.8 The Department for Transport (the Department) and TfL have jointly sponsored (the sponsors), overseen and funded the Crossrail programme.⁹ The sponsors set up Crossrail Ltd to deliver the programme. Rail for London (RfL), will be the ultimate operator of the Elizabeth line and be responsible for areas such as specifying train frequency and fares. Mass Transit Railway (MTR), a transport operating company based in Hong Kong, will run rail services as MTR Elizabeth line (MTREL) on behalf of RfL and is responsible for day to day management of trains and stations. The line will be maintained by Rail for London Infrastructure (RfLi), except for those parts on the national rail network, which will be maintained by Network Rail. London Underground is responsible for maintaining five of the 10 stations on the central section. Crossrail Ltd, RfL, RfLi and London Underground are all management units of TfL with separate legal responsibilities.

1.9 In November 2018, in response to significant cost increase and schedule delay, the sponsors appointed a new Chair and Chief Executive of Crossrail Ltd. In 2018, they considered there was no realistic prospect but to get the project finished – stopping or pausing the programme would increase costs and delay benefits for passengers. They strengthened their oversight of the programme by commissioning reviews of the programme, bolstered the Project Representative and put additional experienced people in governance positions.¹⁰

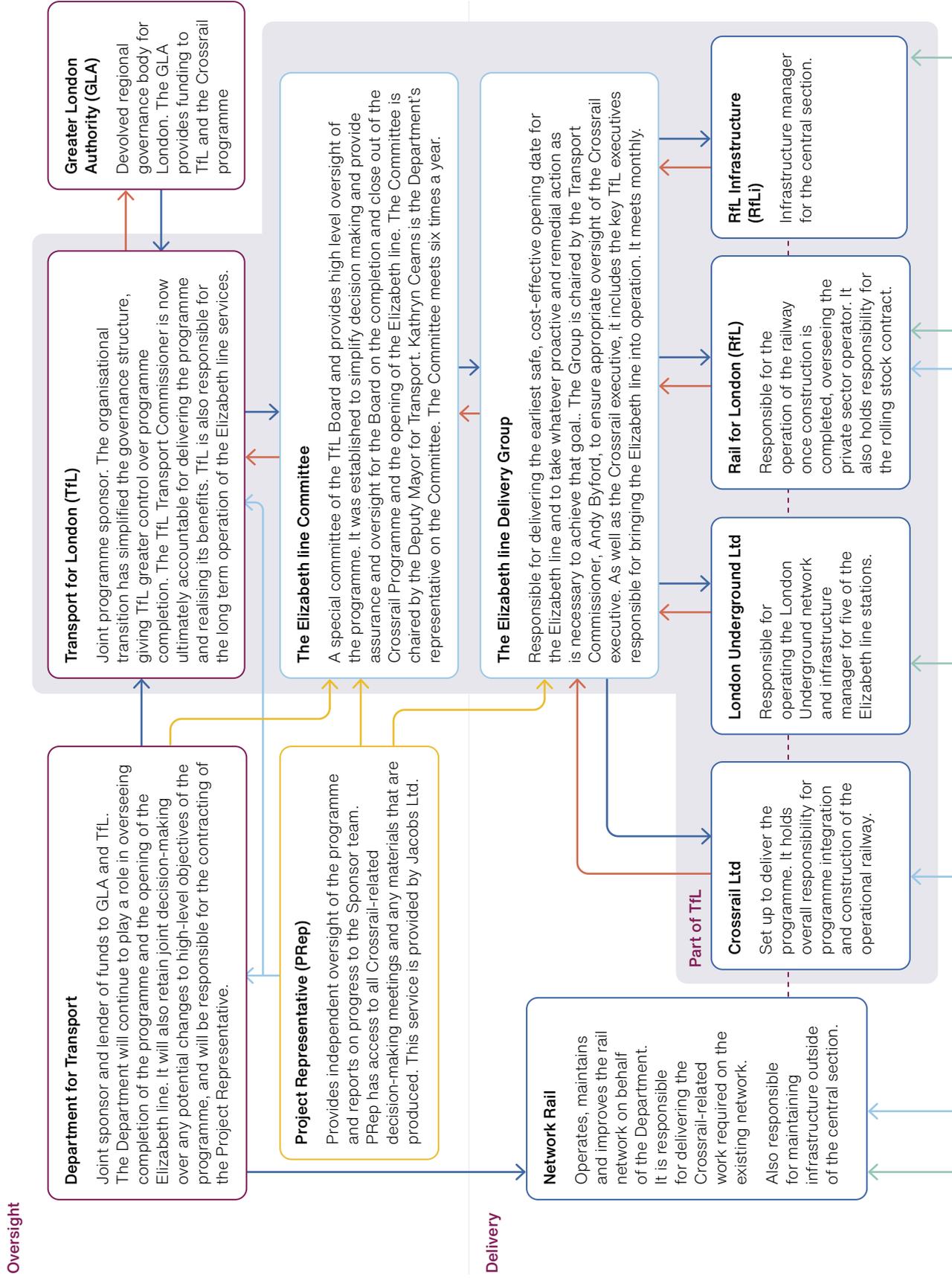
1.10 In October 2020, the sponsors revised the governance arrangements to streamline decision-making and give TfL greater responsibility for overseeing completion (**Figure 3** on pages 18 and 19). TfL's Transport Commissioner became ultimately accountable for completing Crossrail and delivering the high-level objectives. TfL created new decision-making and oversight boards, the Elizabeth line Delivery Group and the Elizabeth line Committee, replacing the Crossrail board and Sponsor board. Crossrail Ltd is now a management unit within TfL. The Department's role is now principally as the funder of the programme, but it continues to have a role in monitoring and oversight of the programme. It also has a role in approving some changes to the programme, including any that affect the anticipated benefits and is responsible for work delivered by Network Rail and ensuring integration with other operator services on the wider rail network.

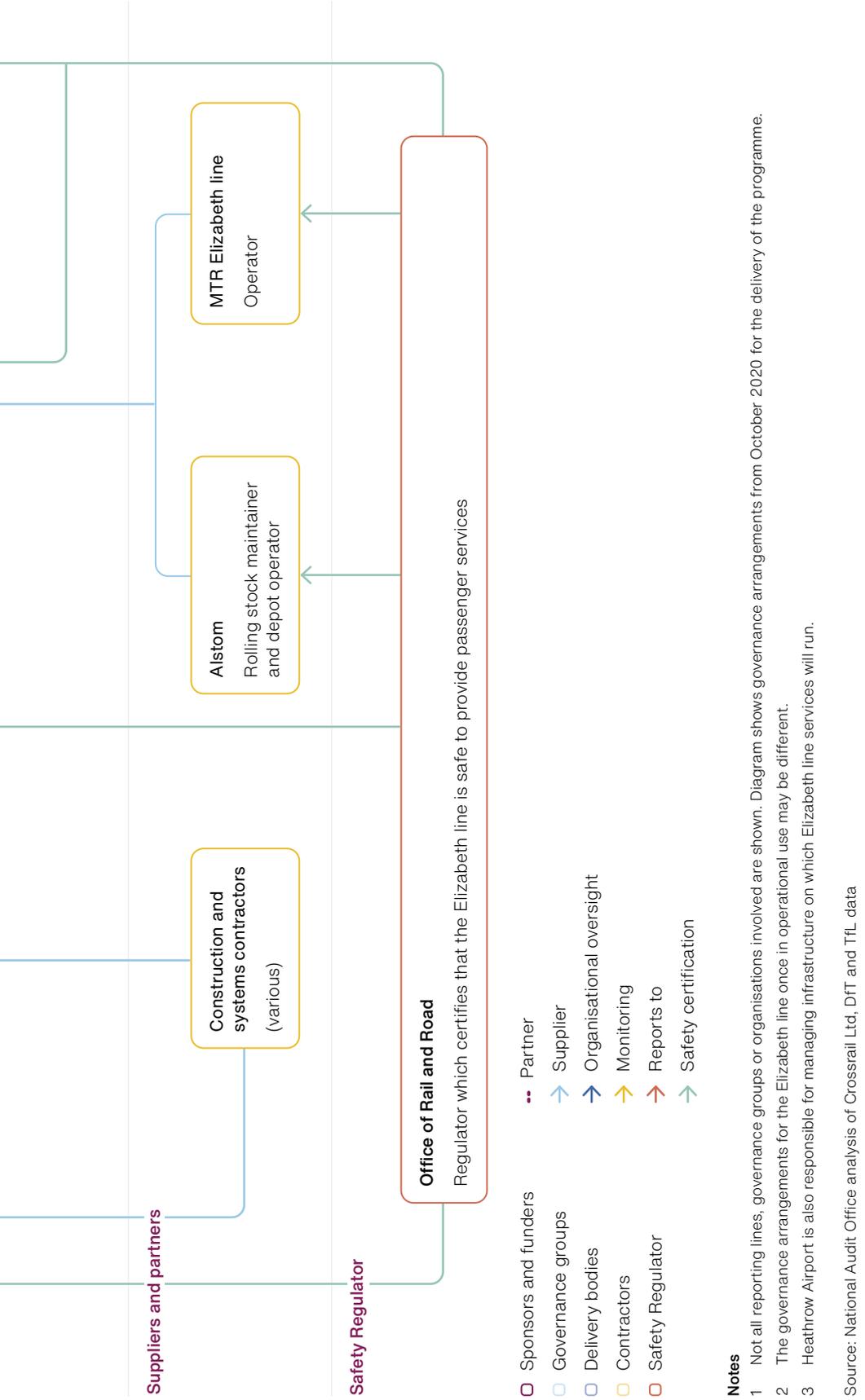
9 HM Government defines a sponsor as “the driving force behind a programme, which provides the investment decision and top-level endorsement for the rationale and objectives of the programme”.

10 The Project Representative is an external expert employed by the sponsors to provide them with independent oversight and advice. See Figure 3.

Figure 3
Crossrail governance arrangements from October 2020

On 1 October 2020, the responsibility for the Crossrail project moved to sit directly with Transport for London to streamline decision making during the final stages of the programme





1.11 The sponsors told us that there are many benefits to the new governance arrangements being brought into effect at this stage of the project lifecycle. TfL will run the railway and maintain the central section through its subsidiaries. There are critical decisions which need to be made to bring it into service, and having Crossrail Ltd within TfL's governance arrangements makes this easier as all decision-makers are side by side and can make decisions together around trade-offs. The sponsors and the Crossrail team told us that the new arrangements added momentum to complete the project.

1.12 We consider that it is appropriate for sponsors to amend governance and oversight arrangements to reflect the stage of the programme.¹¹ The changes help support the programme to completion by ensuring the eventual operators and maintainers of the Elizabeth line work more closely with Crossrail Ltd. To work effectively, particularly as the pressure to open the line increases, roles and responsibilities and how the organisations work together need to be clear and supported with robust management information and a culture of transparency. We explore some of the effects of the governance changes on the programme in Part Three.

Funding

1.13 In May 2019, we reported that the total funding package for Crossrail had increased to £17.6 billion, including Network Rail's works on the existing network.¹² The funding package comprised two increases: £590 million agreed in July 2018; and a further £2.15 billion in December 2018.¹³ In May 2019, Crossrail Ltd estimated the cost to complete the programme, including Network Rail costs, was just over £17 billion, with £600 million funding as contingency to cover assessed risks.

1.14 In November 2019 and August 2020, Crossrail Ltd announced two further forecast cost increases for the areas of the programme for which it was responsible, of between £800 million and £1,100 million.¹⁴

1.15 In December 2020, the Department agreed to provide an additional loan of £825 million to the Greater London Authority to fund the Crossrail programme (Appendix Three). Further increases to the forecast cost of completing works on the national rail network meant Network Rail provided additional funding in July 2019 and July 2020, totalling £390 million.¹⁵ As at May 2021 the total funding available for the programme was £18.8 billion, approximately £1.2 billion more than when we reported in May 2019 (**Figure 4**).

11 Comptroller and Auditor General, *Lessons learned from major programmes*, Session 2019-21, HC 960, National Audit Office, November 2020.

12 TfL funded the Elizabeth line trains and depots itself at a cost of around £1.1 billion.

13 A more detailed breakdown of funding sources to April 2019 is available in Figure 6 of the National Audit Office report, *A memorandum on the Crossrail programme* HC 1924. See footnote 5.

14 The £1,100 million increase represented the upper end of the potential cost increase. Crossrail Ltd modelling indicated an 80% chance the final cost would be below this amount.

15 Additional Network Rail funding comes from existing budgets: £390 million of funding was made available from underspends and efficiencies from Control Period 5 (£250 million) and a change to Network Rail's spending plans for Control Period 6 (£140 million).

Figure 4

The increases in Crossrail funding since January 2014

Funding has increased in response to cost and schedule increases since the National Audit Office (NAO) first reported on Crossrail in January 2014

	Jan 2014	Jul 2018	Dec 2018	May 2019	Dec 2020	May 2021
Funding for Crossrail Ltd ¹ (£m)	12,480			14,960		15,790
Increase (£m)		300	2,150		825	
Funding for Network Rail (£m)	2,300			2,590		2,980
Increase (£m)		290			390 ²	
Total funding to Crossrail programme³ (£m)	14,780			17,570		18,770
Expected opening date of central section (£m)	Dec 2018	Autumn 2019	No commitment made	Oct 2020 to March 2021	Dec 2021 to Jun 2022	Jan 2022 to Jun 2022
NAO report	<i>Crossrail</i>			<i>Completing Crossrail</i>		<i>Crossrail - a progress update</i>

Notes

- 1 A more detailed breakdown of funding sources to April 2019 is available in Figure 6 of the NAO report, *A memorandum on the Crossrail programme*.
- 2 Funding increases were announced in July 2019 (£250 million, from efficiencies and underspends in Control Period 5) and July 2020 (£140 million from changes to Network Rail's spending plans from Control Period 6).
- 3 Total funding does not include Transport for London funding to build and maintain trains and a maintenance depot, which amounts to an upfront capital cost of around £1.1 billion.
- 4 All figures are rounded and therefore may not reconcile in table or with other published data.
- 5 All values are in cash prices.

Source: National Audit Office analysis of Department for Transport and Transport for London data

Programme progress since we last reported

1.16 Since we last reported, Crossrail Ltd and its delivery partners have made significant progress towards completing the assets and infrastructure in the central section:

- From December 2019, MTREL has been running services under the brand 'TfL Rail' using the new Elizabeth line trains on sections of the western end of the line.¹⁶
- All of the approximately 42 kilometres of tracked tunnels in the central section, known as the routeway, has been handed over to the maintainer, RfLi, although some work remains to be completed.
- All 10 ventilation shafts, between the tunnels and surface, and portals, where tunnels come to the surface, have been handed over to the maintainer.
- The 10 new stations are nearing completion and three of these have been handed to London Underground or RfLi, ready for operational use and maintenance.¹⁷
- Network Rail has completed work on seven stations on the western end which has also improved passenger accessibility.
- MTR Elizabeth line has trained 470 drivers and 201 customer experience and control room staff; 85 staff assigned from London Underground, and 80 of the 97 expected RfLi staff had been recruited and have been trained.

1.17 On 27 March 2021, the routeway came under the required safety regulations to allow Crossrail Ltd to start the first stage of operational testing, known as trial running. It will gradually run up to 12 trains an hour through the tunnels, testing trains, systems and signalling. Trial operations follows trial running, which Crossrail Ltd expects to begin in autumn 2021 at the earliest. This tests how the trains and stations operate in real-world conditions using staff and volunteers to act as passengers, and includes staff familiarisation and evacuation training. Crossrail Ltd and the sponsors expect to open the central section between January 2022 and June 2022, with full services operating across the entire east-west route from May 2023.

¹⁶ MTR Elizabeth line has been running services on the eastern and western ends of the line under the 'TfL Rail' brand since May 2015 and May 2018 respectively. The new Elizabeth line trains commenced running in the east in June 2017 and in the west from May 2018 with the new trains operating services to Reading from December 2019 and to Heathrow since July 2020.

¹⁷ Correct as at 31 May 2021.

Scope of this report

1.18 The remainder of this report examines:

- the underlying reasons for the cost and schedule increases that have occurred since we last reported;
- the main risks that sponsors and the Crossrail team must manage to open the Elizabeth line successfully. We focus on opening the central section; and
- what needs to be done to realise benefits from the investment in Crossrail.

Part Two

Why Crossrail's schedule and cost has increased since 2019

2.1 This part examines why the cost and schedule have increased since we last reported and the actions taken by Crossrail Ltd.

Forecast schedule and cost

Schedule

2.2 As we note in Figure 2, the estimated opening dates for the Elizabeth line have moved twice since we reported in May 2019. Crossrail Ltd now expects the central section to open between January 2022 and June 2022, with April 2022 as its middle estimate. This range is between 10 and 20 months later than the earliest opening date announced in April 2019 of between October 2020 and March 2021. It expects the entire railway to open by May 2023. **Figure 5** on pages 25 and 26 sets out how the schedule for the programme has changed.

Cost

2.3 The current forecast cost of completing the programme (excluding new trains and depot costs) is £18.9 billion.¹⁸ This is £120 million more than the current funding of £18.8 billion (see Figure 4). Estimated programme costs at May 2021 include:

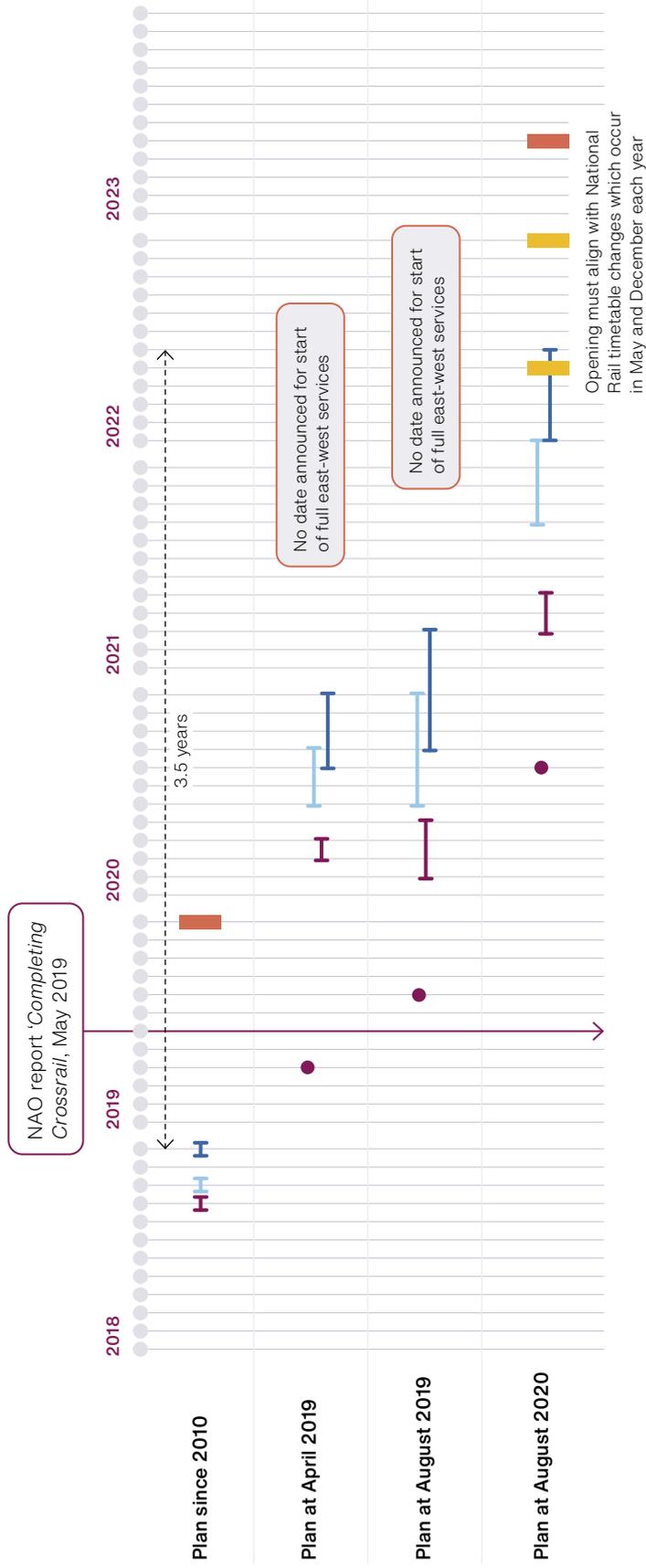
- £15,910 million of Crossrail Ltd costs; and
- £2,980 million of Network Rail costs for works on national rail network.

2.4 The estimated cost of the central section increased by £1,510 million from £14,400 million in April 2019 to £15,910 million in May 2021. In July 2019, the estimated cost breached the budget set in April 2019 (**Figure 6** on page 27).

¹⁸ Forecast is reported at the 50% confidence level, meaning actual cost is equally likely to be above or below this amount.

Figure 5
Slippage of the key milestones needed to begin full Elizabeth line services

The key milestones and overall schedule for the programme has moved twice since we last reported in May 2019



- **Start of trial running** – where empty trains are run through the central section to test signalling and other systems (deterministic to P50 dates)
- **Start of trial operations** – tests how the trains and stations operate in real-world conditions using volunteer passengers, and includes staff familiarisation and evacuation training (deterministic to P50 dates)
- **Opening of central section (known as Stage 3)** – start of services between Paddington in the west and Liverpool Street and Abbey Wood in the east (deterministic to P50 dates)
- **Plan agreed**
- **Opening of Paddington to Shenfield services (known as Stage 4B)** – This is expected in May 2022 or December 2022, depending on progress of the programme
- **Expected start of full east-west services (known as Stage 5B)** – start of services between Reading and all passenger terminals of Heathrow Airport at the western ends of the railway, to Shenfield in Essex and Abbey Wood in south-east London at the eastern ends. This is expected in May 2023 however could begin sooner in December 2022, depending on progress of the programme

Figure 5 *continued*

Slippage of the key milestones needed to begin full Elizabeth line services

Notes

- 1 Opening of full east-west services was not stated in the April 2019 plan or the August 2019 plan
- 2 Deterministic dates do not include any provision for schedule risks and indicate the date if no risk materialises. P50 dates include schedule risks and indicates the middle value of the range of estimates, based on Crossrail Ltd's modelling at the time
- 3 Estimated opening of the central section for the August 2020 plan represents the deterministic date to the 80% confidence date. The 80% confidence date indicates the actual date is 80% likely to be before this date
- 4 Opening of full Elizabeth line is in stages. Each stage refers to a section of the entire Crossrail route and the service frequency that is run on that section. The stages in order of opening are 1, 2A, 5A, 2B, 4A, 3, 4B and 5B. Stages 1 to 2B refer to the eastern and western section and are already in service. Stage 4A includes increased service frequency between Shenfield and Liverpool Street. Stage 3 refers to the central section. Stage 4B refers to Paddington to Shenfield services. Stage 5B refers to full east-west services.

Source: National Audit Office analysis of Crossrail Ltd data

2.5 This rest of this part examines:

- where in the programme cost increases have occurred;
- the underlying issues that have caused cost increases on Crossrail Ltd's part of the programme; and
- how the COVID-19 pandemic has impacted cost and schedule.

Where cost increases have occurred

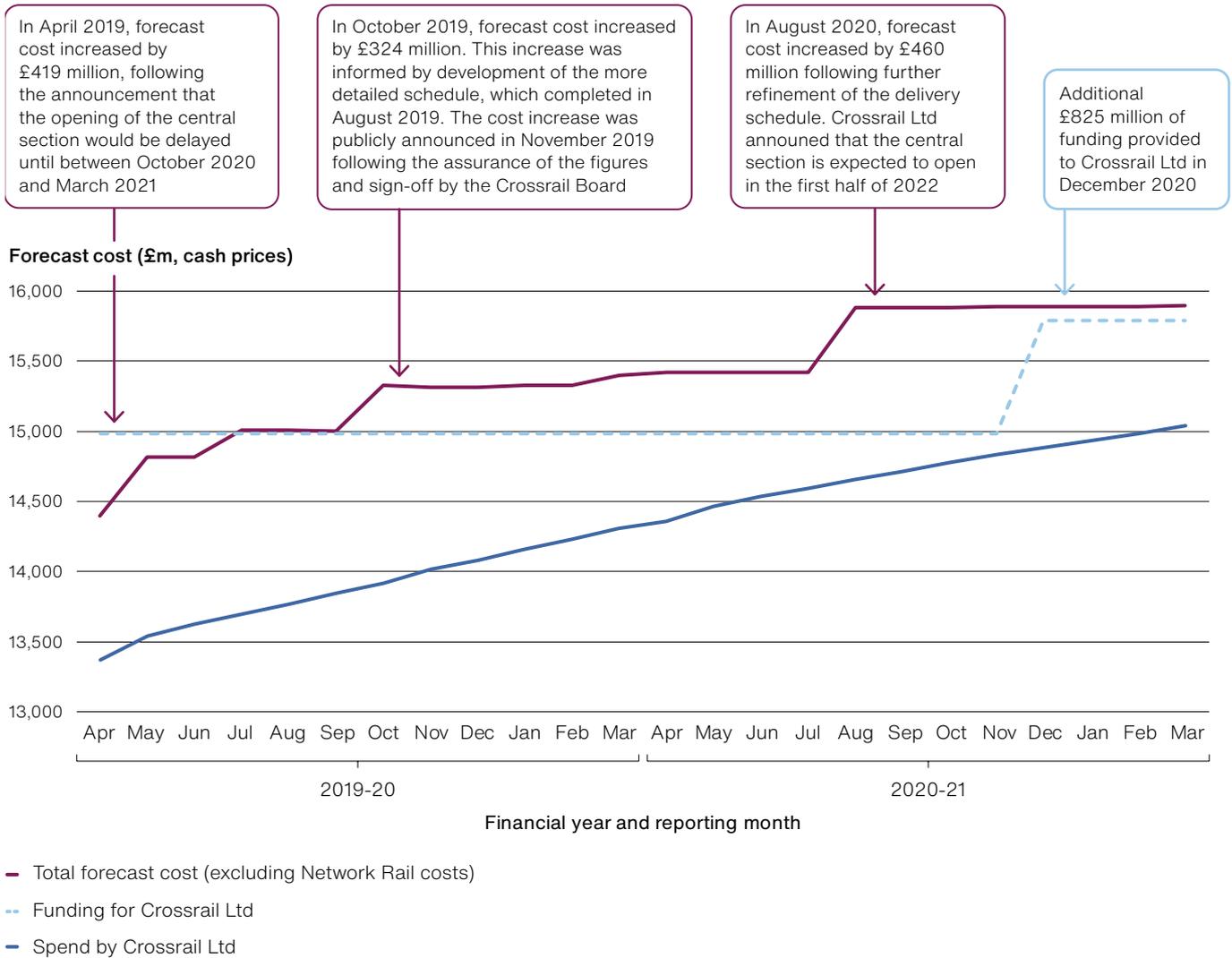
2.6 **Figure 7** on page 28 shows that six of the 36 main works contracts accounted for 74% of the £1,343 million forecast increase in main works costs between December 2018 and March 2021. Three stations account for over 40% of the total increase. It also shows that it has been difficult for Crossrail Ltd to manage costs on the communication and control systems, and railway signalling on the central section.

2.7 Network Rail's forecast cost of completing works on the national rail network has increased by £390 million (15%) since we last reported in May 2019. 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 Elizabeth line trains and work to improve accessibility. Costs have increased predominantly because of delays resulting from the re-tendering of several significant packages of works, and because additional work has been identified. Also, works have taken longer than expected, including to upgrade power systems on the eastern section.

Figure 6

Forecast cost for completing Crossrail, April 2019 to March 2021, Crossrail Ltd funding only

Sponsors have provided additional funding in response to increasing costs



Notes

- Forecast cost excludes Network Rail costs, and cost of new trains and depot.
- Forecast costs are reported at the 50% confidence level meaning actual cost is equally likely to be above or below this amount.
- All values are in cash prices.

Source: National Audit Office analysis of Crossrail Ltd data

Figure 7

Contract cost increases between December 2018 and March 2021

19 of the 36 main works contracts have increased in value since December 2018

Contract	Forecast cost			Contract increase	
	Target at award	At December 2018	At March 2021	Increase since December 2018	Increase since December 2018
	(£m)	(£m)	(£m)	(£m)	(%)
Top 6 contracts by cost increase since December 2018					
Bond street station	111	395	660	265	67
Track, overhead line equipment and logistics	293	939	1,173	234	25
Whitechapel station	110	647	831	184	28
Paddington station	147	538	649	111	21
Communications and controls systems	43	166	263	97	58
Railway signalling and control (central operating section)	51	139	236	97	70
Sub Total	754	2,824	3,812	988	35
Remaining 13 contracts which have increased since December 2018	753	2,289	2,645	356	16
Remaining 17 contracts which have not increased since December 2018	1,707	3,024	3,024	0	0
Total for all 36 contracts	3,214	8,138	9,481	1,343	17

Notes

- 1 March 2021 is latest available data. Total contract increase is less than overall programme cost increase as not all programme costs are included within the 36 main works contracts.
- 2 Target at award denotes the value initially awarded. This does not include risk provisions or allowances for additional scope to meet requirements. All other values are contractor or Crossrail Ltd forecasts of final costs which may include adjustments where risk has materialised or where changes in scope have occurred.
- 3 All values are in cash prices.
- 4 Contracts completed prior to December 2018 show their final values.
- 5 Figures may not sum due to rounding.

Source: National Audit Office analysis of Crossrail Ltd data

The underlying causes of schedule and cost increase on the Crossrail Ltd part of the programme

2.8 In this section, we analyse the underlying reasons why work has taken longer than expected, and why both the cost and schedule have changed since we reported in May 2019. We focus on Crossrail Ltd's part of the programme only. Crossrail Ltd's analysis of why costs have changed (**Figure 8** overleaf) indicate that work taking longer than expected has been the most significant reason for the cost increase, at £934 million, 62% of the total cost increase of £1,510 million.

The programme was further from being complete than Crossrail Ltd realised when it set the revised cost and schedule in April 2019

2.9 Our 2019 report found that Crossrail Ltd did not have a sufficiently detailed delivery plan against which to track progress and it did not adequately reflect interdependencies across the programme. When we last reported the programme was developing a revised schedule to complete the programme and open the Elizabeth line into service for passengers.

2.10 In April 2019, Crossrail Ltd's new management team announced its revised date, based on a high-level plan containing around 300 activities and developed over three months. The April 2019 plan agreed to handover completed assets to Rail for London Infrastructure (RfLi) and other infrastructure maintainers in stages, rather than handing over in one go as initially agreed with sponsors. Crossrail Ltd assessed that while under no pressure from sponsors to announce a revised schedule, the programme needed a target date to focus on and galvanise its contractors. By August 2019, Crossrail Ltd had developed its high-level plan into a detailed schedule including more than 10,000 activities. Both plans used Crossrail Ltd's information and assumed that the planning had identified all work required and that the main physical assets (stations, portals and shafts) were closer to completion than was actually the case.

2.11 Throughout 2019 and 2020, Crossrail Ltd repeatedly uncovered unknown problems with the assets already constructed that it had to resolve. Previous management information did not provide an accurate picture of completeness. Through testing the railway, Crossrail Ltd found that it needed to do more work on some assets because, for example:

- the work had not been done;
- the physical asset was different from that documented;
- the work no longer met current regulations – for example, wiring in some stations, and fire systems in Canary Wharf; or
- they were faulty – for example, fire doors.

Figure 8

Main categories of cost increase between April 2019 and March 2021, Crossrail Ltd funding only

The largest cost increase has been due to changes to the opening schedule

Cause of cost change	Description	Change since April 2019 (£m)
Schedule change	Movement in programme milestones as a consequence of resequencing, acceleration or delay.	934
COVID-19	Additional costs incurred as a consequence of the COVID-19 pandemic.	228
Scope change	Changes made to ensure programme meets sponsor requirements.	154
Productivity	Variation in the achievement of completed tasks compared to planned targets.	126
Commercial settlement	Settlement of commercial 'compensation events' due to, for example, delays to contractors' planned start dates.	30
Other	Includes, for example, the net impact of other increases and reductions in scope and cost increases due to unexpected site conditions.	38
Total		1,510

Notes

- Productivity can also be a significant factor in schedule change. Where productivity has clearly affected schedule, Crossrail Ltd has included these costs within the schedule change category.
- All values are in cash prices.

Source: Crossrail Ltd data from April 2019 to March 2021

2.12 Crossrail Ltd estimates that £154 million (10%) of the cost increase between April 2019 and March 2021 was due to identifying previously unknown volumes of work which was needed to meet the sponsors' requirements (Figure 8).

Crossrail Ltd did not understand the work required to bring a digital railway into service when it set its April 2019 plan

2.13 The Elizabeth line will be the first fully digital railway to be built and operated in the UK. A digital railway means that digital systems control all aspects of the railway, such as air conditioning, lighting, platform doors, ventilation, signalling software and train display systems. Each system is connected and shares data with other parts of the railway. Most of the Elizabeth line systems will be monitored from a control centre in Romford by a small number of staff. Choices made early in the programme to have bespoke designs of stations and limited standardisation across common assets, such as fire doors or CCTV, further increased complexity.

2.14 The pre-2019 Crossrail Ltd management team did not fully understand the scale and type of work required to complete the railway:

- The digital nature of the railway meant that it was complex to understand what work remained. Testing many interconnected assets working together is not straightforward. Making a change to one asset may lead to changes and re-testing of other assets. It is common for such testing activity to take longer than planned. Crossrail Ltd estimates that the central section alone has around 500,000 individual assets, such as fire safety systems or platform screen doors with each station having 80 major systems.
- Crossrail Ltd must produce 200,000 assurance documents to demonstrate the assets and systems operate safely together.¹⁹ Bespoke assets and a lack of standardisation, such as different doors and lighting units between stations, added to the amount of documentation.

2.15 The lack of understanding meant that when the new Crossrail Ltd management team set its revised schedule in April 2019, the volume of work remaining was unclear. For example, management information used by Crossrail Ltd before 2019 did not include measures on completeness of documentation, focusing instead on completeness of construction, making it difficult for the new Crossrail Ltd team to know accurately how complete the programme was when it set its April 2019 plan.

2.16 Crossrail Ltd decided that it must check all assurance documentation. The original, pre-2019 plan had been that contractors would produce assurance documents, and Crossrail Ltd would complete a sample check of around 10%. In 2019 and 2020, the new Crossrail Ltd management team examined previous assurance documents, and often found they were not complete to the standard required, needing additional work to put right. The new Crossrail Ltd team's decision to handover completed assets to RfLi in stages, which it made before it knew the problems with documentation, created additional work. Some assurance documents needed to be updated over time and others could not be fully completed as they required assurance of other, interrelated assets which had yet to be finished.

2.17 Crossrail Ltd and RfLi were not clear on what data RfLi would need to maintain the central section of the Elizabeth line. Crossrail Ltd told us that these data are significantly more complex than is usual owing to the interoperability of the railway, and contractors did not know what data the infrastructure maintainer required. This was in part because RfLi did not exist at the time that some assurance documentation was created. Part Three provides more information on RfLi.

¹⁹ The documentation includes as-built drawings, diagrams and schematics of systems, operating manuals and maintenance schedules, warranties and safety certificates. Data on the asset that can be used to monitor and maintain the asset must also be collected.

Crossrail Ltd found it difficult to reset and incentivise commercial relationships

2.18 As we said in our last report, Crossrail Ltd opted for 36 main works contracts, including separate contracts for each individual station and a range of system-wide contracts. However, the integrated nature of Crossrail has made it difficult to hold a single contractor to account when delays arise. In late 2018-early 2019, Crossrail Ltd renegotiated the terms of the remaining work with its main contractors. For example, it established a fixed price with contractors for some of the remaining work.

2.19 Crossrail Ltd has not found it possible to control costs and incentivise delivery through these fixed-price contracts in the way it had intended. Fixed-price contracts can be suitable to control costs when the contractor is best placed to manage risks to cost and schedule. When Crossrail Ltd agreed new commercial terms from late 2018, sites looked almost complete, and it expected the Elizabeth line to open within 18 months. As we set out in paragraphs 2.10 to 2.17, the amount of work outstanding was underestimated and, in some cases, unknown. Crossrail Ltd added more work to its plans, meaning costs and schedule delay increased. This was compounded by the interdependent nature of the work which meant that new work assigned to one contractor could impact on the work of another.

2.20 It is likely contractors undertook some work which was not strictly necessary to complete the railway, but it is not possible to ascertain how much that might be. We can say that it is likely new senior team appointments, covered in paragraph 2.25 below, and introducing new sign-offs for new work, have resulted in greater challenge and scrutiny over new proposed changes and remaining work required to complete the programme.

2.21 From 2019, Crossrail Ltd introduced various financial incentives alongside its fixed-price contracts to encourage contractors to work together:

- Incentives aimed at getting contractors to work together on specific tasks needing two or more contractors to complete.
- Incentives aimed to align terms in subcontractor contracts with those of main contractors.
- Common incentive frameworks aimed to motivate contractors to work collaboratively to meet interface milestones.

Crossrail Ltd considers that these ultimately had limited success because the incentives became less attractive as more work and cost was added to contracts, or were based on dates which subsequently proved to be unachievable.

2.22 Contractor performance at meeting milestones set by Crossrail Ltd continued to be low, at around 30%. This metric does not entirely reflect contractor underperformance but is also a result of interventions by Crossrail Ltd adding new milestones. The Project Representative, which reports to sponsors on programme progress, repeatedly raised concerns in 2019 and 2020 that Crossrail Ltd was optimistic about how quickly the work to complete the programme could be done and that externally acceptable targets were driving planning, rather than realistic forecasts. It was concerned that Crossrail Ltd did not understand the reasons behind poor productivity. Crossrail Ltd estimates that low productivity is responsible for £126 million of the cost increase. We have seen evidence that Crossrail Ltd has taken action against some of the Project Representative’s concerns, however the Project Representative often has to repeat these concerns due to the time it can take to adequately address them.

It took longer than expected to recruit the people and skills needed

2.23 During 2018, the previous Crossrail Ltd team reduced the number of staff in its central functions (such as risk management, planning, and contract and commercial management) by about one third. It did this because it planned to open the railway in December 2018 and so no longer required the staff. Our previous report said that to manage programme risks and the complex contractual arrangements effectively, Crossrail Ltd needed to rebuild its capability and capacity following the 2018 reduction in staff numbers.

2.24 At the time of resetting the programme in April 2019, the new Crossrail Ltd team and the sponsors did not appreciate the scale of the task to rebuild the organisation and the impact this would have on the programme. Crossrail Ltd told us that in certain areas the programme teams had to be rebuilt. It took Crossrail Ltd longer than expected to recruit the staff needed because there are a limited number of people with the skills needed. Through 2020 Crossrail Ltd continued to recruit to crucial posts.

2.25 Key appointments by Crossrail Ltd and Transport for London (TfL) in 2020 have improved Crossrail Ltd’s approach to completing the programme. For example, senior appointees have introduced: a greater focus on integration; clearer financial reporting; increased challenge to limit unnecessary rework; better planning of how to transfer assets to the operator and maintainer; and ‘construction blockades’, commonly used by Network Rail, to complete the work. They also strengthened the senior leadership team, increasing capacity and focus across the programme.

2.26 Crossrail Ltd uses skilled specialist staff from Bechtel (project delivery partner) and Transcend (programme partner), to work alongside Crossrail staff members in selected key roles, such as programme controls and commercials. Crossrail Ltd considers both organisations provide access to the important skills and experience needed to complete the programme.²⁰

²⁰ Our previous report sets out how Crossrail Ltd used Bechtel and Transcend. Comptroller and Auditor General, *Completing Crossrail*, Session 2017-19, HC 2106, National Audit Office, May 2019, paragraph 11.

2.27 In 2019, the sponsors approved new incentive arrangements for Bechtel by repurposing £34 million of previously unearned incentives to help retain staff and to incentivise achieving the milestones set out in Crossrail Ltd's August 2020 delivery plan. In March 2021, the Chair of the Elizabeth line committee approved changes to Transcend's incentive arrangements. Between the start of the contracts in 2009 and 31 March 2021 Crossrail Ltd paid £531 million to Bechtel and £127 million to Transcend.

Impact of COVID-19 on the programme

2.28 The COVID-19 pandemic has caused further delays. On 24 March 2020, following the first national lockdown, TfL decided to halt non-safety-critical work on Crossrail sites. Crossrail Ltd estimates that it lost nine weeks of construction, although some activities, such as assuring documentation, continued as staff worked from home. In August 2020 Crossrail Ltd reported around 2,000 people on work sites, less than 50% of the pre-COVID-19 complement.

2.29 Crossrail Ltd estimates social distancing and other COVID-19 factors increased direct costs by £228 million (15% of the £1,510 million cost increase since April 2019). However, quantifying the total cost of COVID-19 on the programme is difficult, due to those indirect impacts which are hard to measure, such as additional time needed to complete work in a socially distanced way. Also, many contractors used the furlough scheme rather than charging for costs during closure of sites. Crossrail Ltd created a payment scheme of approximately £10 million, using Cabinet Office guidance, to provide direct payments to contractors to retain the key skills needed and avoid them moving to other programmes.

2.30 Work to re-plan the programme following the national lockdown has had a positive impact on the programme. Crossrail Ltd worked with contractors to plan how to restart construction with fewer contractor staff on site. This included using dedicated periods of 24-hour a day construction, known as blockades. Crossrail Ltd reported that contractors were more productive as a result of the detailed planning. The percentage of milestones met was 90% on average between September 2020 and April 2021, well above the average 30% over the programme to that point.

2.31 The COVID-19 pandemic also allowed Crossrail Ltd to activate a clause in the contract for Bond Street station. The clause, available to both parties, allowed for termination of the contract following prolonged suspension of construction works. In June 2020, Crossrail Ltd and Costain Skansa JV entered into an agreement to terminate the main construction contract at Bond Street and Crossrail Ltd brought the work in-house. Crossrail Ltd appointed a new contractor, Engie, to carry out care and custody duties for the site while Crossrail Ltd completed the remaining works. While cost reduction was not the primary purpose of this change, Crossrail Ltd estimates this may save £20 million to £30 million.

Part Three

Risks to bringing the Elizabeth line into service

3.1 The process of bringing the Elizabeth line safely into service consists of many interrelated and overlapping activities, including:

- completing outstanding building work, such as fitting out stations;
- testing assets and systems to ensure they work together;
- providing detailed assurance documentation and manuals; and
- handing over the responsibility of assets and systems to the operator and maintainers of the Elizabeth line.

3.2 Many organisations must work together to bring the line into service. This includes: Crossrail Ltd and its contractors; Network Rail; Rail for London Infrastructure (RfLi); London Underground; MTR Elizabeth line (MTREL); and the Office of Rail and Road. **Figure 9** overleaf describes their roles and responsibilities. In our work across government we often see problems where roles and responsibilities change and where they are shared across different bodies. It is vital that Transport for London (TfL) ensures effective working relationships across these bodies.

3.3 On 27 March 2021, the central section routeway came under the required safety regulations to allow Crossrail Ltd to start the first stage of operational testing, known as ‘trial running’.²¹ At this point, RfLi became legally responsible for the routeway. This was a significant milestone for the programme and was achieved by the target date. Trial running is where the operator and Crossrail Ltd run empty trains through the central tunnelled section to test signalling and other systems. On 10 May 2021 Crossrail Ltd and the operator began to run four trains an hour through the central section with the aim of running 12 trains an hour by the end of trial running.

²¹ The ‘routeway’ is the tracked section on which the trains run.

Figure 9

Organisations involved in bringing the Elizabeth line into service

Many organisations must work together to bring the line into service

Organisation	Role
Design and construction	
Crossrail Ltd (an operational unit of Transport for London (TfL))	Responsible for designing and delivering the Crossrail programme and providing the required safety assurance documentation.
Maintenance	
Network Rail	Responsible for upgrading the eastern and western surface sections, in addition to its wider responsibility for the national rail network. Responsible for 3 stations (Paddington (surface), Reading and Liverpool Street (surface), including construction of Abbey Wood in the central section.
London Underground (an operational unit of TfL)	Responsible for maintenance of five of the stations (Bond Street, Tottenham Court Road, Farringdon, Liverpool Street and Whitechapel). Responsible for setting out expected safety requirements.
Rail for London Infrastructure (RfLi) (an operational unit of TfL)	Responsible for maintenance of the central section routeway, including four of the stations (Paddington, Canary Wharf, Custom House and Woolwich). Responsible for setting out expected safety requirements.
Operation	
Rail for London (an operational unit of TfL)	Responsible for operating the Elizabeth line.
MTR Elizabeth line (MTREL)	Responsible for operating services on the Elizabeth line and 28 stations on behalf of Rail for London.
Alstom (formerly Bombardier Transportation)	Responsible for providing and maintaining the new Elizabeth line trains and the depot at Old Oak Common.
Regulation	
Office of Rail and Road	Safety regulator, responsible for certifying Elizabeth line is safe for passengers, including that the operators and maintainers have appropriate safety standards.

Note

- 1 Crossrail Ltd, Rail for London (RfL), Rail for London Infrastructure (RfLi) and London Underground are legally required to be separate management units within Transport for London.

Source: National Audit Office analysis of Crossrail Ltd data

3.4 The next stage is ‘trial operations’, which requires volunteer passengers to simulate how the Elizabeth line and stations operate in real-world conditions, including staff familiarisation and evacuation training. Once the simulations are complete, the assurance documents agreed, and assets and systems handed over to the maintainers and operator of the line, the Elizabeth line is considered safe to open for passenger services (**Figure 10** on pages 38 and 39). When the Crossrail programme closes, RfLi will assume responsibility for the ongoing future design and modification of the Elizabeth line.

3.5 This part examines what remains to be done to successfully bring the Elizabeth line into service and our assessment of the risks and challenges. It covers:

- completing the remaining work;
- managing the cost and schedule; and
- managing the railway in service.

Completing the remaining work

3.6 In April 2019 Crossrail Ltd decided to change the approach to testing and handover of assets to the operator and maintainer that had been set out in the original delivery plan. Instead of completing, testing and handing over major assets, such as a whole station, in one go, it decided to hand over individual parts of each asset in stages.

3.7 Crossrail Ltd decided on a staged approach in an attempt to maintain progress on the programme. The start of trial running is a key milestone for the programme and is a critical period of testing to uncover issues that Crossrail Ltd must deal with before entering service. The staged approach allowed for trial running, and other key milestones, to be met without having to wait for other non-critical work to complete.

3.8 Crossrail Ltd told us that it considered that anything not critical to entering trial running could be delayed if needed. There are risks that the sponsors and Crossrail Ltd will need to manage as a result. In our previous report, we noted that in order to try to meet the December 2018 opening date Crossrail Ltd decided to start testing before other systems were ready, which reduced the availability of worksites for contractors to complete construction, exacerbating delays and cost increases.²²

²² Comptroller and Auditor General, *Completing Crossrail*, Session 2017–2019, HC 2106, National Audit Office, May 2019, paragraph 2.21.

Figure 10

An overview of the main activities needed to bring the central section of the Elizabeth line into service

Bringing a railway into service is complex with a large amount of safety documentation and interdependencies between systems and organisations

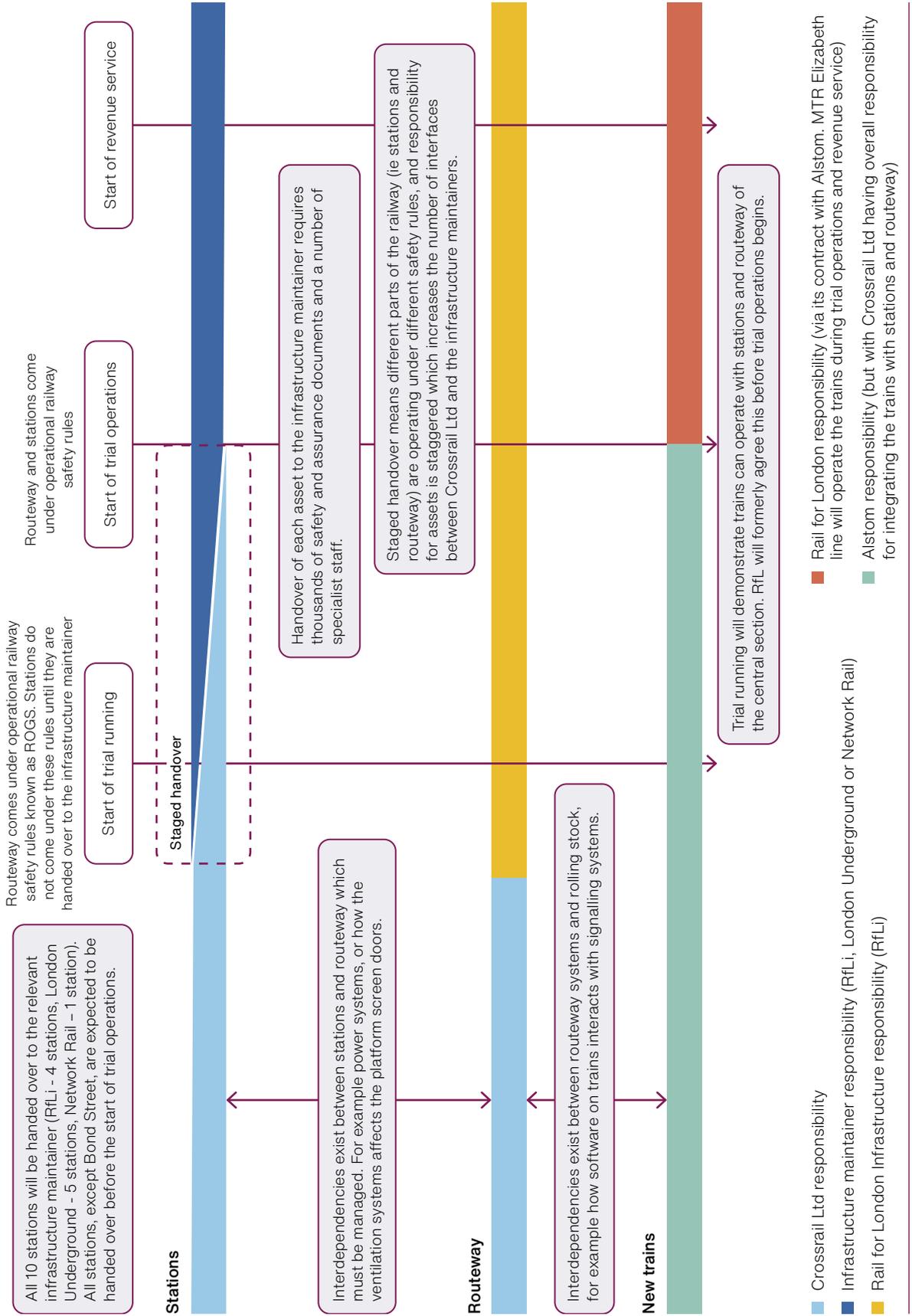


Figure 10 *continued*

An overview of the main activities needed to bring the central section of the Elizabeth line into service

Notes

- 1 Figure demonstrates the central section only.
- 2 Operational railway safety rules refer to Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS).
- 3 Crossrail Ltd will complete each station and hand over the eventual infrastructure maintainer. By May 2021 Crossrail Ltd had handed over three of the 10 new stations.
- 4 All stations, except Bond Street, must be completed and handed over to the infrastructure maintainer before the start of trial operations. Bond Street will not yet be completed by this stage, but will have reached the safety standard to allow trial operations to begin.
- 5 Routeway includes shafts and portals; railway systems such as track, signalling and electrical power; and the civil engineering.
- 6 Alstom (formerly Bombardier Transportation) provides and maintains the new Elizabeth line trains via a contract with Rail for London (RfL), which has overall responsibility. Crossrail Ltd is responsible for integration of the trains with other assets on the central section such as the routeway signalling and stations. Once Crossrail Ltd can demonstrate the integration is effective, the software configuration will be duplicated on the trains already in service on western and eastern ends.

Source: National Audit Office

Role and relationship with RfLi

3.9 The central section routeway is now under the safety rules of an operational railway, meaning Crossrail Ltd and its contractors must agree access with the asset maintainer, RfLi, to carry out work. To run trains through the routeway for trial running, the line must be operated and maintained under the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS), the regulatory regime for rail safety, overseen by the Office of Rail and Road. The regulations require RfLi to maintain a safety management system and hold a safety certificate or authorisation indicating the safety system has been accepted by the Office of Rail and Road. Crossrail Ltd, therefore, can no longer determine its own schedule for works on the routeway, and must now follow RfLi's timetable, making a good working relationship vital.

3.10 Moving from a construction programme to an operational railway is a significant change. RfLi has worked with Crossrail Ltd to reduce the handover risks. By March 2021, RfLi had recruited and trained the minimum number of staff required to begin trial running. The start of trial running was around six weeks later than the 'best case' date, although still within the expected range. Crossrail Ltd told us that the six-week delay was because Crossrail Ltd needed to carry out critical maintenance activities, and RfLi and its staff needed to establish the regular maintenance processes and asset data required to operate the railway. In addition, because the routeway had transitioned to operational railway safety rules (see paragraph 3.9), Crossrail Ltd's freedom of access to carry out works was reduced.

Managing the volume of work to be completed during the trial running stage

3.11 In February 2021 Crossrail Ltd estimated that it had around 4,500 tasks remaining. The Project Representative, which reports to the sponsors on progress of the programme, raised concerns that a significant and increasing amount of work is now planned to be completed during trial running and trial operations. By March 2021, the tasks remaining had fallen to around 3,700; however, of these, approximately 350 were new, unexpected tasks. Crossrail Ltd told us that most of the remaining physical works are minor. However, some significant technical fixes remain, such as work to fix the tunnel ventilation system and platform screen doors. Crossrail Ltd must also complete the required assurance documentation.

3.12 It will be more complicated to complete the additional work during trial running because all work and testing must be done under railway safety rules (paragraph 3.9). This requires precise scheduling and additional safety procedures and training. There could also be an impact on costs if this additional work takes longer to complete during trial running.

Managing handover of the central section stations

3.13 By May 2021 Crossrail Ltd had handed over three of the 10 new stations to RfLi and London Underground; however, it continues to perform some minor construction work.²³ The remaining stations, except for Bond Street, are expected to be handed over before the next stage of operational testing, trial operations, begins.

3.14 There is still a significant amount of testing and assurance work to complete the remaining stations and hand them over. Depending on when the central section opens between January 2022 and June 2022, Bond Street may not yet be complete for passenger services. The original handover plan did not recognise the limited number of people with specialist skills needed for the assurance work to hand over stations. Crossrail Ltd now has a more realistic plan to complete the remaining construction work and handover, focusing on two stations at a time and prioritising the order of stations based on the volume of work. Usually, TfL would bring into service one new, or newly refurbished, station a year. Crossrail Ltd told us that since entering into the new safety rules (paragraph 3.9), access to critical areas has been a significant challenge which continues to impact the handover of stations.

Issues arising from operational testing

3.15 One of the aims of trial running is to identify unknown issues, and therefore could have an impact on cost and schedule. A key aspect is also to demonstrate the reliability of trains and other systems. Crossrail Ltd expects trial running to last at least six months. It has set aside time in the schedule as contingency. As at May 2021, approximately six weeks of the contingency has been used due to delays in starting the testing timetable for trains to run through the tunnels.

²³ Custom House was handed over to RfLi in May 2020, Farringdon and Tottenham Court Road were handed over to London Underground in March and May 2021, respectively.

Signalling and software

3.16 In May 2019, we reported that, related to other delays in the programme, the development of the software and onboard signalling system required to operate the trains, and the signalling equipment in the tunnels, had been significantly delayed. Since we reported, Crossrail Ltd and Rail for London (RfL) have now taken a formal role in ensuring the two contractors coordinate design and development of the systems so that the different components work together. Contractors have made significant progress with the signalling system ready for operational testing, although with some operational restrictions while they complete the software. The forecast cost for railway signalling and controls in the central section has increased 70% since we last reported, from £139 million in December 2018, to £236 million (Figure 7).

3.17 An important, pre-planned, software update is expected in summer 2021. It will build upon the existing software version in use for trial running. This update will provide full functionality of the train signalling and control systems to enable the expected 24 trains an hour to run to allow the start of trial operations. However, the software is currently delayed by between three and eight weeks. Any unexpected bugs in the software update can take time to fix and could cause further delays or restrict testing. The start of passenger services is dependent on this update going well and there being sufficient time to demonstrate railway safety.

Maintaining critical staff

3.18 Crossrail Ltd faces challenges retaining critical staff to complete any outstanding construction and assurance work, and ensure operational testing can be delivered. Crossrail Ltd has identified 140 staff within key roles which it considers critical to the eventual opening of the central section. As the programme draws to a close, it is not unusual that staff, especially those with key skills, will choose to begin a new role elsewhere with more long-term certainty. Crossrail Ltd is working on incentives to retain these staff. There are also skills and knowledge that will be important for TfL in operating the Elizabeth line. There is no plan as yet to transfer these individuals or their knowledge to operational roles within TfL.

Managing the cost and schedule

3.19 It took until August 2020 for Crossrail Ltd to develop indicators to more accurately capture the work outstanding and to set a more robust plan. The August 2020 plan has remained more stable and planned milestones have largely been achieved. It incorporates the delays as a result of COVID-19; a more realistic sequencing of the work to complete the stations; and a more realistic workforce plan that took account all of the 'pinch point' skills, such as fire safety engineers. As at May 2021, Crossrail Ltd was further refining its plan of work, to provide greater detail on how to complete the operational testing work needed to complete all stations. This update is expected in July 2021 and may result in further estimated cost and schedule changes.

3.20 The cost estimate has remained largely stable in the six months following the August 2020 update to the delivery plan. **Box 1** and **Figure 11** set out Crossrail Ltd's approach to estimating its forecast cost and schedule. However, within this relatively stable estimate, Crossrail Ltd has been managing cost pressures. The estimate contains provisions for risks, such as a task taking longer than expected. If such a risk materialises, the risk provision is used and becomes a cost, but the total estimate remains unchanged. If the risks do not materialise, the provision is retired and the total estimate reduced.

3.21 Crossrail Ltd data shows that risks are being retired but are being replaced with new, unexpected risks for which there is no provision. Between August 2020 and March 2021, Crossrail Ltd retired £141 million of risk, however, £134 million of new risk was identified. In March 2021, 39% (£350 million) of the remaining costs related to a provision for the impact of risks. Throughout 2020, the single largest financial risk which the programme was managing was the schedule being delayed. Crossrail Ltd has put in place activities to try to address programme risks – these include construction blockades and measures such as those in paragraphs 3.24 and 3.25.

3.22 Crossrail Ltd estimates the central section will open between January and June 2022, with a middle estimate of April 2022 (Figure 11). Full east-west services are currently expected to open in May 2023. Opening of full east-west services is not presented as a range because it must align with national rail timetable changes which take place in May and December each year. Crossrail Ltd estimates that opening the central section in April 2022 will result in a final cost which is £120 million more than the current funding. Opening the central section by January 2022, the best case scenario, would result in a final cost which is £30 million over current funding. Crossrail Ltd estimates that funding will be exhausted between July and September 2022, depending on programme progress. TfL, DfT, HM Treasury, the Greater London Assembly (GLA) and Crossrail Ltd have agreed to meet approximately every three months to review cost estimates and consider what additional funding may be needed.

Box 1

Crossrail Ltd's approach to estimating programme cost and schedule

Crossrail Ltd undertakes modelling to calculate a range of potential cost and schedule estimates for the programme, which reflect the uncertainties and risks it is managing. The National Audit Office considers it good practice for programmes to calculate a range of cost and schedule estimates which narrow over time as programme uncertainties reduce.

In August 2020, Crossrail Ltd performed a comprehensive review of the programme cost and schedule and used this information to update its modelling.

Crossrail Ltd uses three main data points from the range of estimates in its model when planning and reporting programme costs and schedule: deterministic, P50 and P80 (see Figure 11 opposite), to set challenging targets, report to the sponsors, and inform its financial planning and required funding.

Crossrail Ltd expects to finalise the next comprehensive review of the programme cost and schedule in July 2021 (see paragraph 3.19). This update will reflect the actual performance against the August 2020 plan, including the impact of delays to trial running and expected delays to the software updates.

Figure 11

Range of forecast cost and schedule estimates at May 2021

Crossrail Ltd uses three data points to manage and report on the programme

	Data point		
	Deterministic	50% confidence interval (P50) estimate	80% confidence interval (P80) estimate
Definition	Based on known data, and assumes most work will go as planned. It can be considered the 'best case' scenario.	P50 means that 50% of cost and schedule estimates in the model exceed this value, and 50% are below this value. It represents the middle value of the range of estimates.	P80 means that the probability of the final cost and schedule being less than P80 is 80%. It represents the upper end of the range but is not the 'worst case' scenario.
Primarily used by Crossrail Ltd for	Setting challenging targets to encourage and monitor performance.	Reporting to the sponsors.	Informing potential funding requirements.
Estimated opening date of central section	January 2022	April 2022	June 2022
Opening of full east-west services	December 2022	May 2023	May 2023
Estimated cost to complete Crossrail	£15,820 million	£15,910 million	£16,008 million
Current available funding	£15,790 million	£15,790 million	£15,790 million
Forecast difference between funding and estimated cost	£30 million	£120 million	£218 million

Notes

- 1 Cost and schedule estimates are accurate as at May 2021.
- 2 Current funding includes the additional £825 million funding provided to the programme in December 2020.
- 3 At the time the £825 million funding was awarded, the deterministic opening date was December 2021 and the deterministic cost was £15,769 million, which was £21 million below the £15,790 million funding.
- 4 Opening of full east-west services must align with National Rail timetable changes which occur in May and December each year, therefore are not directly equivalent to a deterministic, P50 or P80 date.

Source: National Audit Office analysis of Crossrail data

Actions to control costs

3.23 On average, the programme has spent approximately £56 million a month between October 2020 and March 2021, primarily on the programme's Tier One contractors. To control costs, the programme must close down some contracts with its Tier One contractors as soon as possible.

3.24 In an attempt to reduce cost, Crossrail Ltd has developed plans to transfer some of the more straightforward work to a new general works contractor, enabling Crossrail Ltd to close down those contracts with Tier One contractors as soon as possible. This work will be paid from Crossrail Ltd's funding. As the programme approaches the start of passenger services, any outstanding residual work will in turn be transferred to RfLi and London Underground, along with funding from Crossrail Ltd, and may be completed after the line opens. It is not yet clear how much this residual work will ultimately cost, whether the provided funding is sufficient, or whether this work needs to be done at all.

3.25 In September 2020, Crossrail Ltd established a programme-wide commercial strategy based on the programme's schedule of tasks. It told us that instead of incentivising contractors to meet milestones that may pass if other contractors do not complete their tasks, incentives and milestones are joined together to reward contractors for working together and ensure milestones remain relevant.

Managing the railway in service

3.26 TfL has a number of costs for the Elizabeth line which must still be met, despite delays to opening. In July 2014 TfL signed a contract with MTR on the assumption that services on the central section would begin in December 2018, followed by full east-west services in December 2019. This contract contained fixed costs, such as training the expected 470 drivers to operate the trains along the entire Elizabeth line. Services are currently operating from Paddington to Heathrow Airport and Reading, and Liverpool Street to Shenfield under the 'TfL Rail' brand.

3.27 It may be difficult to track the final cost of completing the Elizabeth line. As part of the staged handover approach, Crossrail Ltd handed over some outstanding work to RfLi and London Underground. It is not clear whether this work will be completed at a later date, or be left as it is if not considered critical to run the railway. Some of this work may be included in the residual works contracts as part of Crossrail Ltd's plans to demobilise its main contractors, however, it is unclear how much any rectification work will cost, nor whether funding for this will be provided from the existing Crossrail budget.

3.28 It is not clear whether the high cost of Crossrail will translate into reduced long-term maintenance cost reductions. RfLi will use a new and sophisticated digital system to maintain the central section. The system will monitor the condition of the routeway and relevant stations and automatically create maintenance work plans, helping to predict what work is needed and when, reducing the need for physical inspection. The system's data requirements have added complexity in the work to complete the programme. There is no baseline or comparator to determine whether this system will reduce maintenance costs in future.

3.29 Following the start of passenger services, there will need to be further software updates as part of the manufacturer's usual software update cycle. Crossrail Ltd and RfLi are working through an agreement to secure a long-term support arrangement, including regular software updates that ensure the software does not become out of date and take into account the specific needs of the Elizabeth line.

Incorporating the Elizabeth line into the national rail network

3.30 The sponsors must ensure that new services are introduced with minimal disruption to the national rail and London underground networks. The Office of Rail and Road's review examining the causes of the disruption following the introduction of the new May 2018 timetable showed how critical planning is when introducing new services.²⁴ For the Elizabeth line to come into service successfully will require all those involved to be clear about their role and how it relates to the roles of others; a plan for staged opening of the line; and plans for how it will work with London Underground services and with passenger and freight operators on the national rail network.

3.31 Crossrail Ltd, Network Rail and the sponsors are working on a detailed plan for how the progressive opening of services across the entire Elizabeth line will be completed and how the line will fit within the national rail network. They have improved governance arrangements to bring all those involved in the Elizabeth line together. However, it is critical that work on the end to end plan continues at pace and with close reference to the progress of the programme. This is to both limit the risk of disruption and to ensure the Elizabeth line starts to achieve benefits from full opening.

²⁴ Office of Rail and Road, *Independent Inquiry into the timetable disruption in May 2018*, September 2018.

Part Four

Delivering the benefits

4.1 This part examines the Department for Transport (the Department), Transport for London (TfL) and Crossrail Ltd's approach to delivering the benefits of the Crossrail programme.

The case for Crossrail

4.2 The Greater London Authority's predictions of London population and employment growth, and Transport for London's forecasts of transport demand, set in 2010, are central to the strategic case, which sets out the need for Crossrail. The core transport benefits were to:

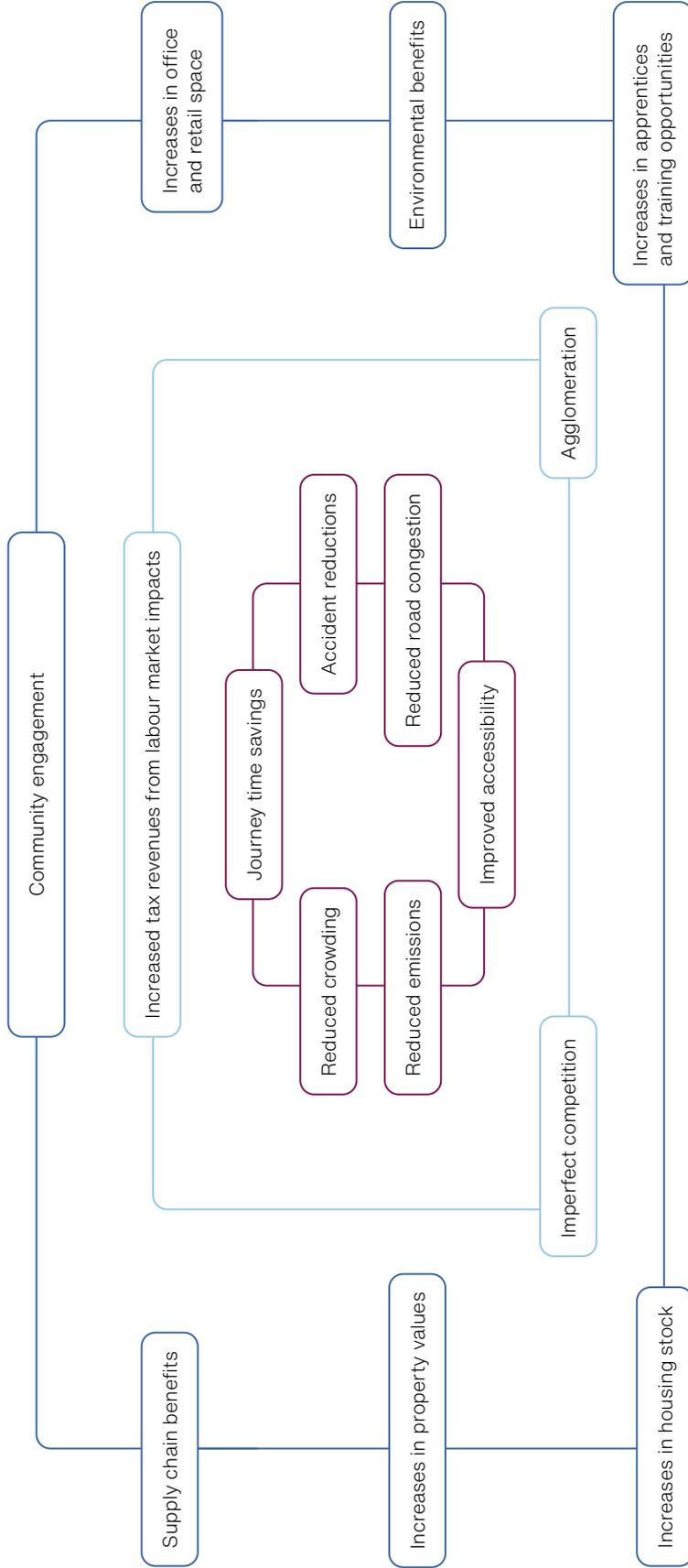
- relieve congestion on the transport network;
- accommodate future expected travel demand; and
- improve connectivity and reduce journey times across London and the South East.

4.3 Crossrail was also expected to achieve wider benefits. The sponsors intended that improved transport links would support economic growth by improving access to employment centres, such as London's West End and Canary Wharf, and encouraging regeneration around stations where improved access to the labour markets and customers attracts private sector investment. They aimed to improve accessibility to the railway with step-free access throughout, and to support carbon reduction aims by moving people from driving cars to using the Elizabeth line. The sponsors also aimed for Crossrail to achieve significant benefits during construction such as increasing construction skills through employment programmes. **Figure 12** sets out some of the expected benefits of the Crossrail programme.

Figure 12

Potential benefits of the Crossrail programme

There are three types of benefits from the Crossrail programme, but not all can be monetised in a benefit cost ratio



□ Transport benefits □ Wider economic benefits □ Further programme benefits

Monetised benefits included within the 'economic case' of a business case

Notes

- 1 Agglomeration benefits result from businesses becoming more productive due to improved transport links connecting them together.
- 2 Tax revenues benefits arising from labour market impacts includes benefits from workers moving to more productive jobs, or where businesses have greater access to the labour market, as a result of improved transport links.
- 3 Imperfect competition benefits are a result of reducing transport costs to businesses which can increase output and profitability.
- 4 The economic case is part of a business case which monetises the expected value to society of a project or programme.
- 5 The figure is not a definitive list of all the potential benefits of the Crossrail programme.

4.4 The benefit-cost ratio includes those benefits that can be monetised. While there are also benefits to doing a major programme that cannot be easily monetised, it is useful to look at how the benefit-cost ratio has changed over time as it indicates the impact of changes, such as scope, cost and schedule, on a programme. There may also be changes to appraisal methodologies and assumptions. A reducing benefit-cost ratio, particularly at the stage Crossrail is at, does not necessarily mean that a project was not worth doing. However, it would indicate that it is even more important for the sponsors to plan to maximise the benefits of investment, and learn lessons for how they develop future business cases.

4.5 The sponsors have updated Crossrail's business case over time. In the last published business case in 2011, just before main works started, the sponsors estimated that Crossrail would deliver £11,025 million (2002 prices) of net transport benefits, such as journey time savings, over the 60 year appraisal period.²⁵ They expected Crossrail to produce £1.97 of transport benefits for every pound spent on building, maintaining and operating the railway, and £3.10 for every pound when including wider economic benefits.

4.6 In March 2020, following the cost increases reported in April and November 2019 (see Figure 6 on page 37), the sponsors reviewed the benefit-cost ratio of the Crossrail programme using a number of scenarios to reflect forecast cost increase and schedule delay. Using the scenario closest to the current plan, the transport benefit-cost ratio was £1.37 for every £1 spent, which the Department's business case guidance considers low value for money. The wider economic benefits ratio was £1.88 per £1 spent, which is considered medium value for money. This scenario was based on benefits and travel demand assumptions made in 2015 using a draft business case and therefore the benefit-cost ratio today could be different. We have not audited this analysis for this report.

²⁵ There was a further update in 2015 to assess the changes to the case from extending the Elizabeth line to Reading and Heathrow, but it was not formally approved. For more information on previous business cases, see: Comptroller and Auditor General, *Crossrail*, Session 2013-14, HC 965, National Audit Office, January 2014.

Achieving the benefits

Changes to passenger demand

4.7 Realising the planned transport and wider benefits are highly dependent on passengers using the railway. In the 2011 business case, TfL forecast a 35% increase in travel demand to 2031. In the draft 2015 business case, TfL forecast that 245 million passengers would use the railway each year by 2031. However, growth since 2015-16 in passenger journeys on the national rail network within and to/from London has slowed and London Underground journey numbers are relatively stable.²⁶ Passenger demand is complex to forecast. In an evidence session on rail franchising, the Department told the Committee of Public Accounts it had identified 50 to 60 factors affecting demand.²⁷

4.8 TfL estimates that there is longer-term revenue risk of around £150 million a year if demand for the Elizabeth line grows more slowly than expected. It is not yet clear how the COVID-19 pandemic may affect long-term travel patterns. At the start of 2021, TfL's long-term demand planning indicated an 18% drop in demand for rail as of 2031 in the most likely scenario, compared with what was expected before the pandemic.²⁸ It is continuing to analyse post-pandemic scenarios to assess the impact on the business case and on TfL's financial position.

4.9 Generating revenue from the Elizabeth line is critical to TfL's financial plans. TfL's 2021 Financial Sustainability Plan assumes that the Elizabeth line will generate a significant net operating surplus by 2022-23.²⁹ However, that will depend on when the line opens, how many passengers use it and the cost to operate the railway. When we last reported, TfL's 2018 business plan assumed that the delay to opening would cost it up to £600 million in lost revenue from 2019-20 to 2023-24, based on a central section opening as late as mid-2020. In December 2020, TfL reported a £200 million expected impact on revenue following the announcement that the central section would be further delayed to the first half of 2022.

26 Office of Rail and Road, Data table 1550, Regional passenger journeys, London, data to 2019-20. Accessed May 2021. Available at: <https://dataportal.orr.gov.uk/statistics/usage/regional-rail-usage/table-1550-regional-passenger-journeys-london/>; and Transport for London, Public transport journeys by type of transport, data to 2019-20. Accessed May 2021. Available at: <https://data.london.gov.uk/dataset/public-transport-journeys-type-transport>.

27 HC Committee of Public Accounts, *Rail franchising in the UK*. Twenty-Fifth Report of Session 2017-2019, paragraph 19.

28 Transport for London, Financial Sustainability Plan, January 2021.

29 See footnote 28.

Benefits during construction

4.10 The sponsors and Crossrail Ltd have measured benefits from the construction stage, which were identified in the business case. These may have indirect economic impacts, but were not included in a benefit-cost ratio. Crossrail Ltd's Sustainability Summary 2018 says that the programme has delivered more than 1,000 apprenticeship starts and 4,706 job starts for local/unemployed people, and that it has supported 55,000 jobs during construction with 62% of suppliers outside London.³⁰ Crossrail Ltd and Network Rail have worked with schools near the Crossrail route to provide work placements, workshops for students studying STEM subjects (science, technology, engineering and mathematics) and networking opportunities for those interested in the construction industry. Crossrail Ltd has also identified environmental benefits, such as the development of the nature reserve at Wallasea Island.³¹

Wider benefits

4.11 Since 2016, the sponsors have commissioned several technical studies, collectively known as the Crossrail Evaluation Study, to provide a baseline to track and evaluate the potential benefits. These studies covered areas such as commercial and residential property values, passenger journey types, and construction impact, environmental, crime, economic, demographic, property, planning and regeneration indicators.

4.12 The sponsors have also commissioned some specific appraisals of benefits, for example reviewing the benefit-cost ratio when the cost and schedule increased, analysing revenue forecasts, and identifying areas that may see economic growth as a result of Crossrail.

Planning for benefits

4.13 When the Elizabeth line opens, there will be an accessible railway with all the expected stations and interchanges, and train services to support the transport benefits outlined in the business case. Services are already running on the eastern and western ends of the line. Since 2010, sponsors have stated that Crossrail will contribute £42 billion of benefits to the UK economy. However, realising the planned benefits and supporting economic growth depends on passengers using the railway, and related activities, such as private sector investment, over which the sponsors have varying levels of control and oversight.

³⁰ Crossrail Ltd, *Sustainability Summary 2018*, July 2018.

³¹ Excavated material from Crossrail tunnelling was used to help create a wetland bird reserve.

4.14 Based on our *Framework to review programmes*,³² our report *Lessons learned from Major Programmes*³³ and the Infrastructure and Projects Authority’s *Guide to effective benefits management*,³⁴ we would expect sponsors to have a benefits management strategy and plan which is kept up to date over time and sets out:

- a baseline against which benefits can be measured over time;
- how the benefits being measured relate to the objectives in the business case, updating for newly identified benefits as well as disbenefits;
- a benefits realisation and evaluation plan;
- who is responsible for delivering which benefits, the levers available to sponsors and governance arrangements, as well as the information it will need to evaluate benefits;
- what other activities are required to capitalise on the opportunities presented by the programme and the risks that may affect the sponsor’s ability to realise benefits;
- a risk management strategy that assesses the risks of not achieving key benefits and sets out potential mitigating actions; and
- how benefits should also be revisited and retested at key stages of the programme, particularly where a programme takes a long time to deliver, or where assumptions change.

4.15 Having a strategy helps sponsors to monitor progress, determine where to focus their efforts, make trade-offs and decisions, and assess how the benefits for a programme may have changed. It also enables them to identify and collect the information they need. A clear plan will help identify which benefits are within a sponsor’s control to deliver and which are dependent on other factors, such as private sector investment or local authorities.

4.16 While the sponsors have put some plans in place to measure and monitor benefits, there is no clear overarching benefits management strategy or plan for Elizabeth line. To have one would help identify the expected benefits, how these have changed, who is responsible, and help identify further benefits not previously considered. The primary focus appears to have been on delivering the programme, with any plan for benefits to follow post-opening. The sponsors have started work on its benefits management strategy and plan since our discussions during fieldwork on what we would expect to see based on our experience.

32 National Audit Office, *Framework to review programmes*, April 2021. The framework draws on National Audit Office experience from around 200 reports and brings together the key questions we ask when we review major programmes.

33 Comptroller and Auditor General, *Lessons learned from Major Programmes*, Session 2019–2021, HC 960, National Audit Office, November 2020.

34 Infrastructure and Projects Authority, *Guide to effective benefits management*, October 2017.

4.17 The sponsors, principally TfL, have some levers within their control, for example train service patterns and integration with other public transport such as buses. In 2017, the sponsors increased the number and frequency of planned services on the Elizabeth line. The Mayor's London Plan sets out plans to integrate the Elizabeth line into the wider transport network, including how it uses the bus network to encourage passengers onto the line. The Department is working on its plan to integrate the line into the wider national rail network (paragraph 3.31). The London Mayor is responsible for fares policy, another important lever. Other levers are outside the sponsors' control, such as those encouraging economic growth, which will depend on local authorities and businesses investing in local areas. Local economic growth and regeneration requires sustained effort and vision over a long period, as well as buy-in from local stakeholders. We can see that some local Borough plans are considering how to use the line in future to encourage development.

4.18 It is important that the sponsors bring the work they have done together into a plan to achieve the benefits of the almost £19 billion of investment in Crossrail. The context within which the Elizabeth line will open is different from that envisaged when the sponsors began the programme. We can see that, for example, remote and flexible working had increased even before the COVID-19 pandemic. The government's aim to achieve net zero carbon emissions by 2050 means that the sponsors will need to focus on moving people from driving cars to using public transport. In addition, we do not know whether the COVID-19 pandemic will have long-term impacts on travel.

Appendix One

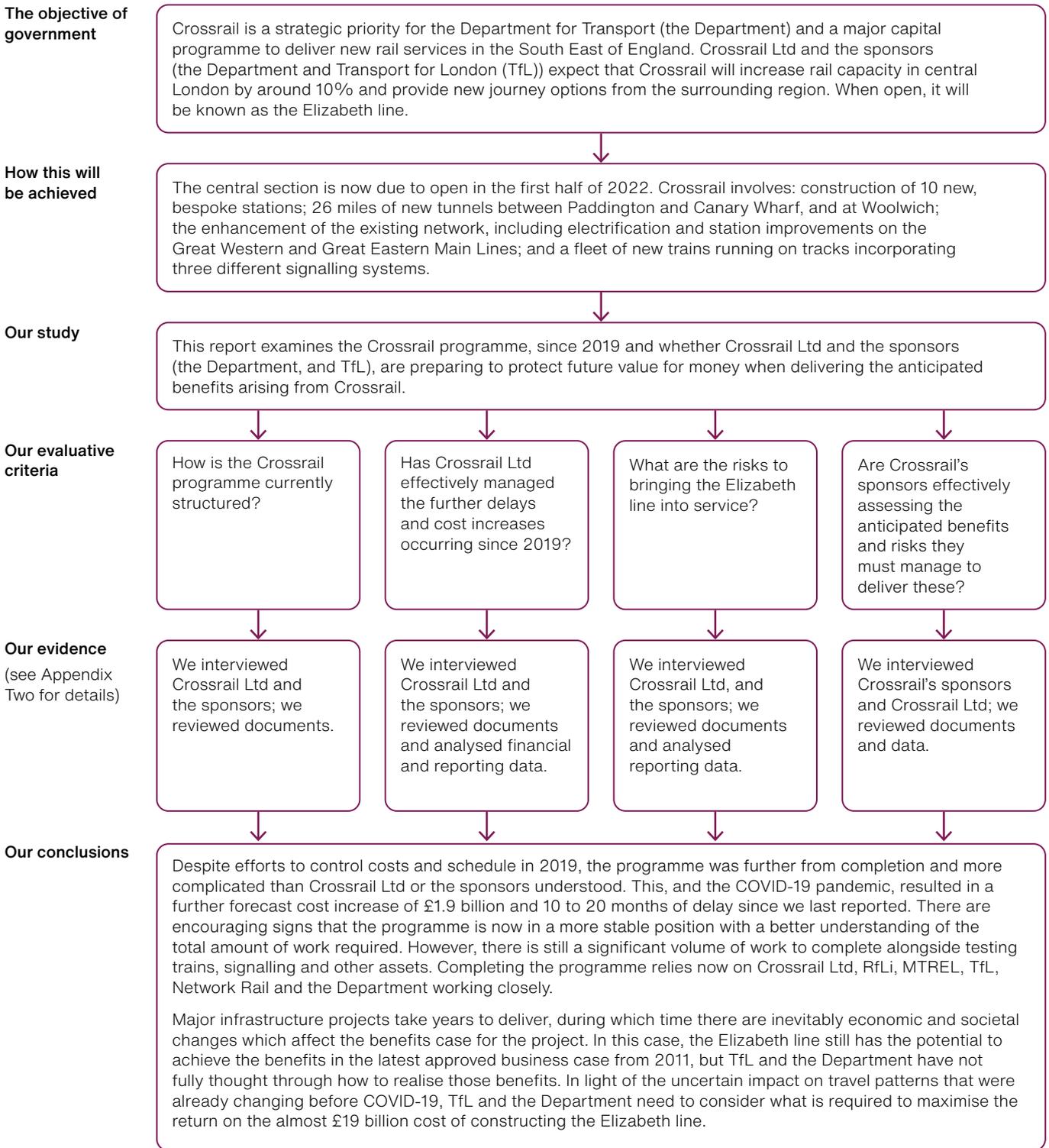
Our audit approach

1 This report examines the Crossrail programme since 2019 and whether Crossrail Ltd and the sponsors (the Department for Transport (the Department) and Transport for London (TfL)) are preparing to protect future value for money when delivering the anticipated benefits arising from Crossrail:

- We provide an overview of the Crossrail programme (Part One).
- We assess the underlying reasons for the cost and schedule increases that have occurred since we last reported (Part Two).
- The main risks that the sponsors and the Crossrail team must manage to open the Elizabeth line successfully. Our report focuses on opening the central section between Abbey Wood and Paddington (Part Three).
- What needs to be done to realise benefits from the investment in Crossrail (Part Four).

2 Our audit approach is summarised in **Figure 13** overleaf. Our evidence base is described in Appendix Two.

Figure 13
Our audit approach



Appendix Two

Our evidence base

- 1** We reached our independent conclusions on whether Crossrail Ltd and the sponsors have protected value for money in delivering Crossrail following our analysis of evidence collected between November 2020 and May 2021. Our audit approach is outlined in Appendix One.
- 2** We applied an analytical framework with evaluative criteria. It considered how Crossrail Ltd and sponsors have managed the programme since May 2019 when we last reported, what risks remained to bringing the Elizabeth line into service, and how the sponsors and Crossrail Ltd were planning to realise benefits.

Interviews

- 3** We interviewed key senior staff across Crossrail Ltd. These meetings covered roles and responsibilities; funding, forecast cost and schedule; programme delivery; operations; completing the documentation; commercial arrangements; skills and capability; the impact of COVID-19; operational testing; completing the programme and bringing it into operation; and delivering the benefits.
- 4** We interviewed representative members of Crossrail Ltd's board on challenges remaining in the programme and programme complexity.
- 5** We interviewed a range of senior staff from Crossrail's sponsors (the Department for Transport (the Department) and Transport for London (TfL)) – involved in oversight of programme progress and benefits.
- 6** We interviewed independent relevant parties on programme progress including the Infrastructure and Projects Authority, the Project Representative, and the Crossrail review team at KPMG.

Data analysis and document review

- 7** We reviewed a large number of documents to build our understanding of the programme and its development since 2019. Documents included: independent review reports; board minutes and related papers; progress updates; risk reports; commercial and funding papers; dashboard updates; briefing papers; and ministerial updates. Values for estimated cost and funding are in cash prices unless otherwise stated.

In Part Two of our report

8 We analysed data on funding to assess how the funding package had increased since the original funding package in 2014. We interviewed Crossrail Ltd's finance team when developing our analysis.

9 We analysed forecast cost data to demonstrate how reported costs have increased since 2019. We also analysed cost data to establish which categories of cost had increased and by how much. We interviewed Crossrail Ltd's finance team when developing our analysis.

10 We analysed milestone and schedule data to establish further delays announced to the programme since we last reported. We interviewed Crossrail's programme delivery team when developing our analysis.

11 We analysed data on slippage in the programme against data on key milestones in the programme plan. We interviewed Crossrail Ltd's programme delivery team when developing our analysis.

In Part Three of our report

12 We analysed documents providing details of the activities needed to bring a railway into service and Crossrail Ltd's reporting information. We interviewed senior people at Crossrail Ltd and Rail for London Infrastructure.

In Part Four of our report

13 We considered what good practice regarding programme benefits looks like, including reviewing previous National Audit Office work, and the Infrastructure and Projects Authority's *Guide for effective benefits management in major projects*, October 2017.

14 We analysed data on programme costs and benefits. We interviewed TfL's team leading on Crossrail's benefits and economists at the Department carrying out benefits modelling. The benefit-cost ratios used in the report reflect the value of time used by the Department to calculate benefits. TfL uses a different value of time which is higher than that used by the Department.

Appendix Three

£825 million Crossrail loan agreement between government and the Greater London Authority

1 In August 2020, Crossrail Limited’s board identified that a further £800 million to £1,100 million of funding was required to complete the programme. The range reflected provisions for risk to reflect remaining uncertainties in the programme.

2 Government held a view that London ought to meet the funding shortfalls because London will benefit most from the Elizabeth line. In December 2020, the Greater London Authority (GLA) agreed to borrow £825 million from the Department for Transport (the Department), to continue to fund the programme. The £825 million loan comes on top of the £1.3 billion loan provided by the Department to the GLA in December 2018. A further £750 million loan by the Department to Transport for London (TfL), and a £100 million contribution by the GLA to the programme, was also agreed at this time. Our 2019 report, *Completing Crossrail*, contains further information on the previous loan.³⁵ The additional £825 million brought total funding to Crossrail Ltd to £15,790 million.³⁶

3 The negotiations on the final loan amount between the government and the GLA were based on Crossrail Ltd’s estimates of remaining costs, and forecast modelling on what GLA could prudently borrow. This included hiring an independent financial services organisation to carry out an assessment and debt capacity test, and agreeing an element of risk share in arriving at the final figure.

4 The TfL Transport Commissioner committed to take all possible steps to complete the project within the additional £825 million available. At the time that funding was awarded, Crossrail Ltd’s cost estimate was between £15,769 million and £16,035 million. This was between £21 million below and £245 million above the £15,790 million total funding. The government and GLA agreed to continue to review funding requirements to complete the project and to challenge TfL to identify a full range of options for Crossrail Ltd efficiencies to help minimise costs. However, all parties recognised that further funding may be required.

³⁵ Comptroller and Auditor General, *Completing Crossrail*, Session 2017-19, HC2106, National Audit Office May 2019, Figure 3 and paragraphs 3.19 to 3.22.

³⁶ Funding is for Crossrail Ltd only. It does not include funding for Network Rail costs on the Crossrail programme.

5 The £825 million loan will be paid for by extending the Business Rate Supplement for Crossrail by three years to 2041 and the Mayoral Community Infrastructure Levy by 10 years to 2043, with the option of a two-year extension, to pay for this increased borrowing. If rate supplement and levy revenues are insufficient to fund the full repayment by 2045 the government has agreed to write-off up to £325 million of the loan. If revenues are greater than forecast, GLA has agreed to pay back early.

6 As at May 2021, the lowest cost estimate to complete the programme had increased to £15,820 million, which is £30 million above the current funding (Figure 11). The Department, TfL, HM Treasury, GLA and Crossrail Ltd have agreed to meet approximately every three months to review cost estimates and what additional funding may be needed, and when.

Appendix Four

Lessons from Crossrail

1 There are a great many lessons that can be learned from the experience of Crossrail, for rail programmes specifically, but also for other complex programmes. Our 2019 report on Crossrail featured in both *Lessons learned from major programmes*,³⁷ and in our *Framework to review major programmes*.³⁸ In this Appendix, we develop further the learnings from Crossrail, identified in the course of completing this report.

On delivering a programme

2 This report concentrated on the latter stages of completing and bringing the Elizabeth line into service. However, many of the learnings we identify have their roots far further back in the programme. Crossrail is the UK's first fully digital railway and we also identify specific learning from bringing a digital programme into service.

3 Delivery bodies should ensure that programme designs are as mature as possible before starting construction, to reduce the number of changes which could have knock-on impacts throughout the life of the programme. Where possible, they should standardise components and designs. They should ensure contracts include relevant clauses to encourage this standardisation, to keep risks low and more manageable. This is particularly critical for a digital programme where different classes of assets need to be integrated (paragraph 2.13).

4 Where it is not possible to wait until programme designs are sufficiently mature, programme sponsors and delivery bodies must recognise and plan to mitigate the risks that immature and bespoke designs create where many assets have to be integrated (paragraph 2.13).

³⁷ Comptroller and Auditor General, *Lessons learned from major programmes*, Session 2019-20, HC960, National Audit Office, November 2020.

³⁸ National Audit Office, *Framework to review major programmes*, April 2021.

5 Delivery bodies must have a vision and plan for how a programme will be brought into service from an early stage, which should be kept up to date throughout the design, build and testing phases. It should be agreed with the eventual operator and maintainer as early as possible. The plan should include:

- what elements will need to be integrated, how that should occur, who should be responsible for doing so and what sort of management information and incentives will be needed to ensure this happens (paragraph 2.17 and 3.9 to 3.12); and
- the role of different contractors in bringing it into service, and the risks and opportunities presented by the chosen contractual model. For example, a high number of main works contracts on a programme requiring many assets to be integrated may make it more difficult to close contracts, leaving contractors carrying out a long tail of minor work that must be managed (paragraphs 2.11, 2.14, 2.16 and 2.19 to 2.30).

Planning from an early stage should enable the delivery body and decision-makers to consider what will be needed to bring the programme into service when having to make decisions or trade-offs throughout the programme.

6 For programmes with a significant amount of digital assets that need to work together, delivery bodies should plan very early on how the assurance documentation and paperwork vital to making a case for operational use of the asset are planned into the schedule and develop appropriate metrics to measure progress (paragraphs 2.14 to 2.17).

7 Delivery bodies should develop management information that allows them to know the difference between when a contractor has completed its work and had it assured, and when an asset or capability is complete and ready for use, which may bring together the work of several contractors (paragraphs 2.11, 2.14 to 2.16 and 3.19).

On resetting a programme

8 The building blocks to successfully recovering a programme are the same as those needed for a successful programme from the outset. This includes a robust schedule, senior executive capacity, skills plan and robust cost to completion. It can be more challenging to put these in place where a programme has gone off-track. Programme sponsors should ensure that these are in place and scrutinised before committing to continue with a programme. From our review of how Crossrail Ltd and its sponsors recovered the programme, we identify the following learnings.

9 When setting a revised cost estimate, schedule and critical path, programme sponsors and delivery bodies need to assess the state of the programme and understand what went wrong originally. They should then develop a realistic plan reflecting how those things that have gone wrong in the past may continue to affect the programme (paragraphs 2.9 to 2.16).

10 Depending on the complexity, stage and extent of failure on a programme, programme sponsors should recognise that it may take more than one attempt to set a schedule and cost that remains stable. Programmes that have gone off-track may have particularly deep-seated issues that only come to light over time. They must allow time to set revised cost and schedule estimates, and balance scrutiny and challenge with support (paragraphs 2.9 to 2.16, 3.19 and 3.20).

11 Programmes may benefit from carefully considering the benefits and risks from stopping a programme and re-planning, against recovering it 'in-flight'. Evidence of the risks and benefits of each course of action should be documented, and the basis of the decision set out (paragraphs 2.9 to 2.16 and 2.28 to 2.30).

12 For programmes that are being re-set it can be particularly challenging to get the right skills in place. These programmes may need skills urgently that are scarce. It may be difficult to get people to join a programme that is in trouble. For Crossrail, staff had been demobilised and in some areas Crossrail Ltd had to rebuild teams from scratch. Delivery bodies and sponsors should assess the skills required to recover and complete the programme, consider these in the critical path, and set a plan to address key skills gaps with mitigation actions. Critical skills gaps to focus on are:

- technical skills, particularly in highly specialist areas where achieving schedule milestones depends on these skills; and
- senior appointments with the appropriate skills and experience to critically examine a programme and establish work remaining, to motivate staff and contractors, and deal with external pressure (paragraphs 2.23 to 2.25 and 3.18).

13 Delivery bodies and sponsors should recognise the risk of previous behaviours continuing, such as optimistic planning and reporting. They should ensure there is greater challenge to call out optimistic planning, including independent challenge and scenario planning to assess likely impacts of risks materialising (paragraphs 2.22, 2.30, 3.7, 3.8, 3.11, 3.12 and 3.21).

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

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



National Audit Office

Design and Production by NAO External Relations
DP Ref: 009320-001

£10.00

ISBN 978-1-78604-381-8



9 781786 043818