



National Audit Office

Report

by the Comptroller
and Auditor General

Department for Transport and Network Rail

Modernising the Great Western railway

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Department for Transport and Network Rail

Modernising the Great Western railway

Report by the Comptroller and Auditor General

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Sir Amyas Morse KCB
Comptroller and Auditor General
National Audit Office

4 November 2016

This report examines planning and programme management of the Great Western Route Modernisation industry programme as a result of significant issues arising on delivery of the programme.

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Key facts

18 to 36 months

minimum delays to electrification to destinations along the Great Western route compared to Network Rail's 2014 plan

£1.2bn

increase in the estimated cost of electrification since 2014. The cost of the wider infrastructure programme, which includes electrification, has risen by £2.1 billion since 2013

Up to £330m

the Department for Transport's current estimate of the increase in its net costs caused by delays to electrification

£5.58 billion current total estimated cost of the Great Western Route Modernisation infrastructure programme including cost increases since 2012-13 (2012-13 prices)

£4.1 billion cost of new Intercity Express trains procured by the Department for Transport (the Department) for the Great Western route over 27½ years (2014 prices, present value)

21,200 the Department's forecast, in 2012, of the increase in passengers arriving at London Paddington per day during the peak period, between 2013-14 and 2018-19 (an 81% increase)

2.4:1 benefit–cost ratio expected by the Department in March 2015, before the electrification programme was reset

1.6:1 our estimate of the benefit–cost ratio taking into account the current forecast cost of the programme and additional costs to the Department

Summary

1 The Great Western Route Modernisation involves complex infrastructure works, new trains and service changes. These aim to improve services along the rail route, which connects London with west and south-west England and south Wales. Trains travelling to London Paddington at peak times are consistently among the most crowded in the country. The Department for Transport (the Department) forecasts that demand along the route will continue to rise. Modernising both infrastructure and rolling stock is intended to increase capacity and provide fast and reliable journeys for passengers.

2 The modernisation is made up of several important, interdependent elements, which were only brought together as an integrated programme in 2015 and are known as the Great Western Route Modernisation ‘industry programme’:

- Network Rail is responsible for the infrastructure programme, including electrification of the main line between London and Swansea. Electrification of a major section of the route, between London and Cardiff, is due to be completed by December 2018. Works on other sections are currently expected to continue until later in the period 2019 to 2024. Other infrastructure works include upgrades to signalling, tracks, stations, bridges and tunnels. Together, these will cost £5.58 billion. Network Rail must also coordinate the works with other railway improvements and keep the tracks available for train services to run.
- The Department for Transport is responsible for setting high-level requirements for rail infrastructure and for funding the work.
- The Department is responsible for commissioning new Intercity Express trains to replace ageing fleets on the main line by the end of 2018, at a cost of around £4.1 billion.
- The Department is responsible for the award and management of the franchise to run train services on the route, and for plans to re-deploy trains from Great Western to other routes.

3 In 2015, the Department and Network Rail identified that the nationwide rail investment programme for 2014–2019 was costing more than planned and taking longer. The most significant cost increases were on the project to electrify the line between Maidenhead and Cardiff, a key part of the Great Western Route Modernisation programme. The Committee of Public Accounts found that the nationwide programme was not deliverable. In large part this was because over half of planned spending was on projects where cost and scope were highly uncertain at the start of the period. The regulator, the Office of Rail and Road, had scrutinised parts of the programme, but the Committee of Public Accounts found that its approach was not robust enough. Borrowing arrangements in place before 2014 meant that Network Rail had only a weak incentive to get initial cost forecasts right.

4 In late 2015 and early 2016, as part of a broader review of its investment programme, Network Rail set a new cost and schedule for electrification. The Department now expects electrification of the route from London to Cardiff to be completed in December 2018, 18 months later than Network Rail planned in September 2014. This had consequences for the plans to introduce new trains on the route and to provide benefits for passengers across the network. The regulator has recently reduced its level of concern about the electrification programme, as Network Rail is currently making progress as planned.

Scope of the report

5 This report looks at the causes of difficulties delivering the programme so far, particularly the reasons for cost increases on electrification. We examine the extent to which the Department and Network Rail are improving their management of the programme and report on the remaining risks to delivery.

Key findings

The case for the Great Western Route Modernisation industry programme

6 There is a good case for increasing passenger capacity on the Great Western route. In autumn 2013, three of the 10 most overcrowded train services in England and Wales were Great Western services into London Paddington. The Department forecasts that passenger demand on the route will grow by 81% between 2013-14 and 2018-19 (paragraph 2.10).

7 Cost increases and recent changes to the new trains order mean that the value for money of the programme needs to be reassessed, and the extent of electrification reconsidered. In March 2015, the Department assessed the programme benefit–cost ratio at 2.4:1, representing ‘high’ value for money in the Department’s methodology. This did not include the cost increases which have become clear since. We estimate this would reduce the benefit–cost ratio to around 1.6:1, which is within the Department’s ‘medium’ value-for-money range. The Department’s decision in May 2016 to procure all the Intercity Express trains as ‘bi-modes’ (capable of either diesel or electric operation) also calls into question whether the full extent of electrification under the programme is still value for money, as all the new trains will now be able to run on non-electrified route sections (paragraphs 2.11 to 2.14).

Programme management prior to 2015

8 Before 2015, the Department did not plan and manage all the projects which now make up the Great Western Route Modernisation industry programme in a sufficiently joined up way. In 2007 the Department decided to buy high-speed diesel trains for the route under its Intercity Express Programme, to replace ageing trains and increase capacity. This changed in 2009, when the Department announced that the line would be electrified and that it would buy a combination of electric and bi-mode high-speed trains. The Department's objectives could only be met by working with Network Rail and the train operator, to complete the electrification and other infrastructure works and introduce new trains. The Department did not produce a business case bringing together all the elements of what became the Great Western Route Modernisation industry programme until March 2015. This was more than two years after ordering the trains and over a year after Network Rail began work to electrify the route (paragraphs 2.2 to 2.4 and 2.9).

9 The 2012 schedule for the infrastructure programme was unrealistic.

Network Rail has had to carry out a complex set of infrastructure works, on a working railway that passes through heritage areas and areas of outstanding natural beauty. When the Department entered into a contract to buy the Intercity Express trains, creating fixed deadlines for electrification, Network Rail had only just identified that it would need to develop a new type of electrification. The electrification timetable was not based on a bottom-up understanding of what the works would involve (paragraphs 2.6 and 2.7).

10 In 2015 Network Rail replanned the infrastructure programme after it became clear that costs were increasing and the schedule could not be met. Electrification between Maidenhead and Cardiff is now expected to cost £2.8 billion. This is an increase of £1.2 billion (70%) against the estimated cost of the programme in 2014 (£1.7 billion against Network Rail's 2013 estimate). The cost of other elements of the programme has also increased. The estimated cost of other Great Western projects that were in the programme's scope in 2013 has increased by £446 million (28%), to £2.0 billion. This in part reflects the fact that 2013 plans were at an early stage of development, and the expected costs of work were therefore uncertain (paragraphs 1.5, 3.2 and 3.3).

11 The cost increases arose, in part, because assumptions in Network Rail's 2014 cost estimate were unrealistic. Network Rail was too optimistic about the productivity of new technology. It underestimated how many bridges it would need to rebuild or modify. It also underestimated the time and therefore costs needed to obtain planning permission and other consents for some works, for example those which could affect protected species or listed buildings. It needed more than 1,800 separate consents for such works (paragraphs 3.6 and 3.7).

12 Failings in Network Rail's approach to planning and delivering the

infrastructure programme further increased costs. Network Rail did not work out a 'critical path' – the minimum feasible schedule for the work, including dependencies between key stages – before starting to deliver electrification. It failed to manage the technical challenges and risks of using new technology, specifically a new design for the electrification equipment and a new 'factory train' for installing the equipment and its supporting steel structures. Network Rail did not conduct sufficiently detailed surveys of the locations for the structures, which meant that some design work had to be repeated (paragraphs 3.7, 3.8 and 3.11).

The impact of delays

13 Delays to the electrification programme will cost the Department up to

£330 million. The Department intends to vary its order of Intercity Express trains so that they can operate under both diesel and electric power. The Department will also receive less income from the Great Western franchise between September 2015 and March 2019. This is because the train operator will bear the costs of providing extra trains and leasing depots, as well as higher running costs from operating diesel trains for longer, while receiving less revenue from passengers than expected (paragraphs 4.1, 4.8 and 4.11).

14 Some passengers in the north and west of England may have to wait

longer to see improvements in services. Passengers across Britain will benefit from trains being reallocated once the new trains on Great Western are introduced, but the Department has had to revise its plans for train reallocations because of the delays to the Great Western Route Modernisation. The Department has worked hard to protect existing passenger services in the Thames Valley (branches off the main line between London and Newbury). But under the new plan passengers in the west may have to wait up to two years longer than expected to see improvements such as increased capacity. Passengers in the north may have to wait an additional nine months to see improvements due to a combination of the revised plans and delays to infrastructure works there. As at November 2016, the government had not yet confirmed the new plan (paragraphs 4.6, 4.7 and 4.10).

Improving programme and project management

15 Network Rail is implementing a major 'Enhancements Improvement Programme' to address systemic failings that it identified as contributing to the

cost increases on the electrification programme. In July 2016, the regulator reported that Network Rail was making 'good progress' in delivering these improvements. These include cost estimation, monitoring arrangements and governance. Network Rail is also taking steps to strengthen its collaboration with contractors and the wider rail construction industry (paragraphs 3.8 to 3.12).

16 The programme management arrangements that the Department and Network Rail began to put in place in 2015 provide a platform for better, more efficient delivery. In February 2015, the Department and Network Rail established a programme board, meaning key stakeholders in the infrastructure, new train and franchising elements of the programme can be involved in decision-making. The Department now has a clear senior responsible owner for the programme, who chairs the programme board. The board is supported by a Network Rail programme office. This has been in place since April 2014, and aims to provide an integrated view of the programme. The effectiveness of the programme management arrangements depend on transparency and collaboration between all parties (paragraphs 2.15, 2.17 and 3.10).

Future risks

17 Weak programme management information has undermined the programme board's effectiveness. Management information has not been of the standard we have seen on other major programmes. The information that the programme board has received about costs and schedule for the infrastructure programme has not been based on an earned value management approach, in line with best practice for managing major programmes. It has not fully informed the board about progress with delivery and has made it difficult to monitor risks. Network Rail has told us that it is developing earned value management measures, but it has not yet put these into practice (paragraph 2.16).

18 Network Rail has a challenging task to deliver the main benefits from the infrastructure programme, within the current schedule and budget. The schedule for electrification contains some ambitious assumptions, for example that piling and mast construction rates will increase significantly between August and November 2016. The budget for the electrification programme between London and Cardiff currently has less funding available to manage risk than Network Rail believes it needs (paragraphs 3.15 to 3.17).

19 Some passengers will have to wait longer to see the full benefits of modernisation because of budget constraints. The Department has decided to further delay electrification on some stretches of the route as the costs cannot be met within the current funding package. The Department currently intends to electrify these sections but not until the next rail investment period, which runs from April 2019 to March 2024 (paragraphs 1.7 and 2.18).

Conclusion on value for money

20 The Department's failure to plan and manage all the projects which now make up the Great Western Route Modernisation industry programme in a sufficiently joined up way, combined with weaknesses in Network Rail's management of the infrastructure programme, has led to additional costs for the taxpayer. The way in which the programme was delivered before 2015 cannot be said to have best protected value for money.

21 The modernisation of the route has potential to deliver significant benefits for passengers, but the Department's assessment of value for money does not reflect recent developments, particularly changes to the train specification, and needs to be revisited. The Department and Network Rail have begun to improve the management of the programme. They have more to do to protect value for money in the future.

Recommendations

22 To continue to improve delivery of the Great Western Route Modernisation industry programme:

- a** The Department should assess whether the full extent of electrification, as currently planned, is still value for money. We understand the Department is updating its March 2015 business case to support this assessment. It should complete this process as soon as possible, and use the business case to inform other important decisions such as the start of the competition for the Great Western franchise in 2018.
- b** The Department for Transport and Network Rail together should improve the quality of programme management information presented to the programme board, drawing on best practice on other major programmes such as Crossrail. To support this, Network Rail should accelerate its plans to introduce an earned value management approach across the business, and use this to monitor the infrastructure programme.

23 To improve the delivery of future major programmes:

- c** The Department should be clear about the benefits it wants to provide for passengers before beginning any future major modernisation projects.
- d** Network Rail should capture all of the learning from its experience of introducing both new technology and new ways of working on the Great Western infrastructure programme. It should use this to create more realistic plans for future projects, including the Midland Main Line and Trans Pennine Express electrification schemes.

Part One

Introduction

1.1 The Great Western Route Modernisation industry programme is sponsored by the Department for Transport (the Department). It aims to provide faster, greener trains, improved services and more seats for passengers throughout the Great Western rail network. The network extends from London to the south-west and Wales and covers London suburbs, Oxford, the Cotswolds and the south coast. **Figure 1** overleaf shows the type of infrastructure works required for the programme, on different routes within the network.

1.2 **Figure 2** on page 13 sets out the main components of what is now known as the Great Western Route Modernisation. The Department is responsible for procuring the new Intercity Express trains, setting high-level requirements for rail infrastructure, funding the work and awarding the franchise to operate services on the route. These elements are together known as the ‘industry programme’. Network Rail is responsible for delivering the ‘infrastructure programme’, that is, the works on the railway infrastructure.

1.3 Since the first parts of the programme began, the relationship between the Department and Network Rail has changed. The Department funds Network Rail in five-year cycles to deliver its requirements for the railway. Before 2014, Network Rail was a private company, able to borrow from the financial markets to cover increases in the costs of its work. In 2014, Network Rail was reclassified as a public sector body and since then it has only been able to borrow from government, with a loan cap of £30.3 billion. The *Report of the Bowe Review into the planning of Network Rail’s Enhancements Programme 2014–2019* also found that before reclassification Network Rail had only a weak incentive to get initial forecast costs right.¹ Part Three of this report discusses how this has affected the management of cost increases on the Great Western Route Modernisation infrastructure programme.

¹ *Report of the Bowe Review into the planning of Network Rail’s Enhancements Programme 2014–2019*, Department for Transport, Cm 9147, November 2015, available at: www.gov.uk/government/uploads/system/uploads/attachment_data/file/479560/bowe-review.pdf

Figure 1
The Great Western Route Modernisation



- +— Electrification, capacity and capability works
- Other capacity and capability works
- Station works
- Stations

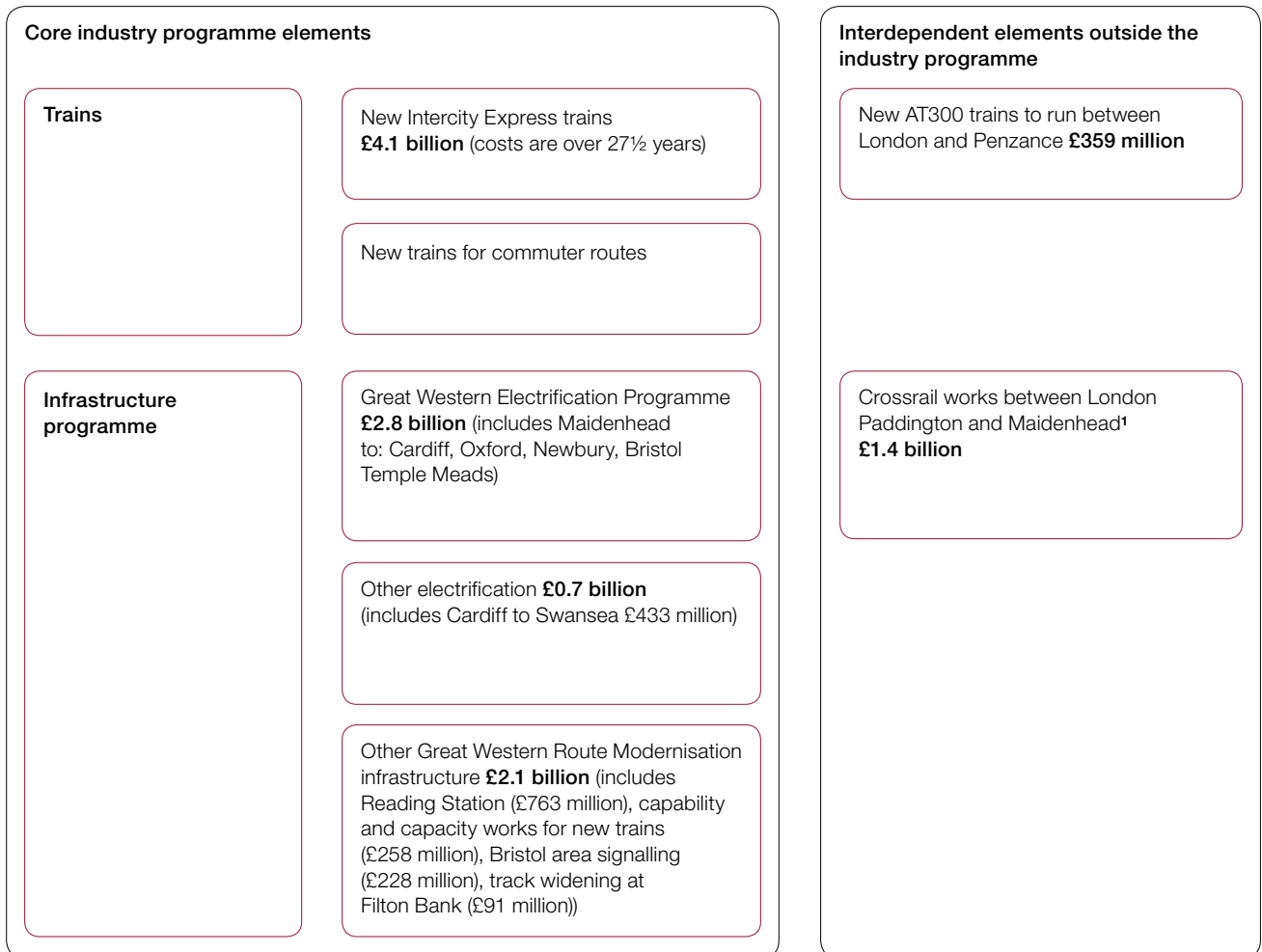
Note

1 Capacity and capability works include work to bridges, tunnels, cuttings etc, to ensure that the new trains can run safely and efficiently.

Source: Network Rail's Enhancements Delivery Plan update (March 2016), available at: www.networkrail.co.uk/Enhancements-Delivery-Plan-March-2016.pdf

Figure 2

Key elements of the Great Western Route Modernisation industry programme



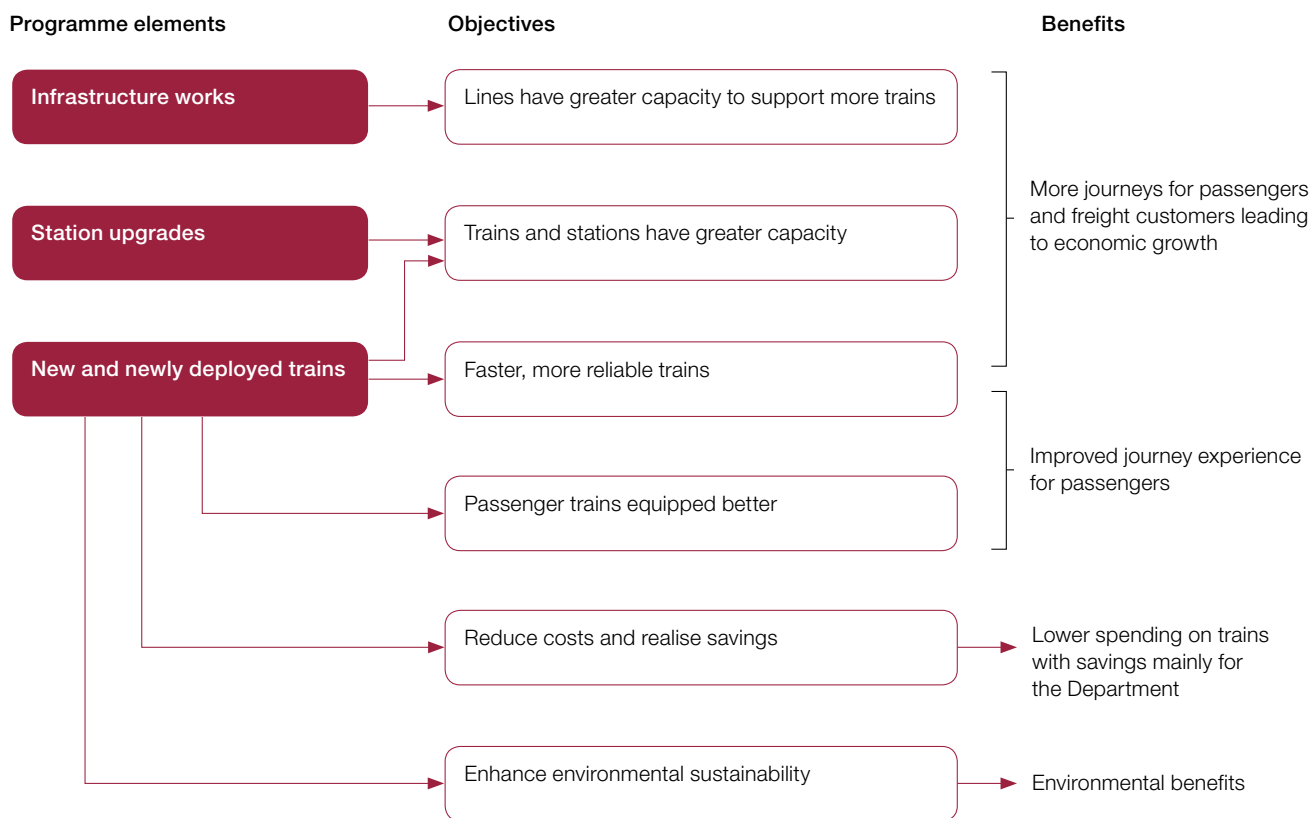
Notes

- 1 Work on part of the Great Western route, between London Paddington and Maidenhead is funded separately by the Crossrail programme. Network Rail is carrying out works on this route section in support of the Crossrail programme.
- 2 Infrastructure costs are in 2012-13 prices. The cost of the Intercity Express Programme trains is the net present cost, in 2014 prices. The cost of the AT300 trains is in 2015-16 prices. The size of rectangles is not proportionate to spend.

Source: National Audit Office collation of Department for Transport and Network Rail figures

1.4 The Department anticipates that the projects making up the Great Western Route Modernisation industry programme will provide a range of benefits for passengers, including faster, more frequent services (**Figure 3**). Achieving these benefits relies on all the elements of the programme being implemented.

Figure 3
Expected benefits of the industry programme



Source: National Audit Office summary of the Department for Transport's Great Western Route Modernisation business case (March 2015)

1.5 The Department brought together the projects making up the Great Western Route Modernisation industry programme in 2015, several years after it began the first projects to modernise the route. By then, it had become clear that elements of the programme were costing more and taking longer than expected. This meant that the electrification work had to be replanned, with significant effects on the Department's plans to introduce new trains onto the network, and on the operation of franchised services on the route.

1.6 The replan of the Great Western work was part of the government's response to wider concerns about Network Rail's 2014–2019 spending programme. In June 2015, the Secretary of State for Transport announced that other planned electrification schemes, on the Midland Main Line and TransPennine routes, would be paused. The government commissioned three reviews, to look at lessons to be learned from the planning of the investment programme, Network Rail's delivery of the investment programme, and the future shape and financing of Network Rail.

1.7 In publications in November 2015² and January 2016,³ Sir Peter Hendy, chair of Network Rail, proposed a revised timetable to deliver the Great Western electrification at a cost of £2.8 billion.⁴ This was £1.2 billion more than Network Rail's 2014 estimate. Network Rail now expects electrification of the route from London to Cardiff to be completed in December 2018, 18 months later than it expected in September 2014. Under the January 2016 version of the revised timetable, other sections of the route were to be electrified up to 36 months later than planned in September 2014. In October 2016, the Department decided to further delay electrification on some sections of the route, although it and Network Rail have not yet set precise target dates to complete this work (**Figure 4** overleaf; see also paragraph 2.18).

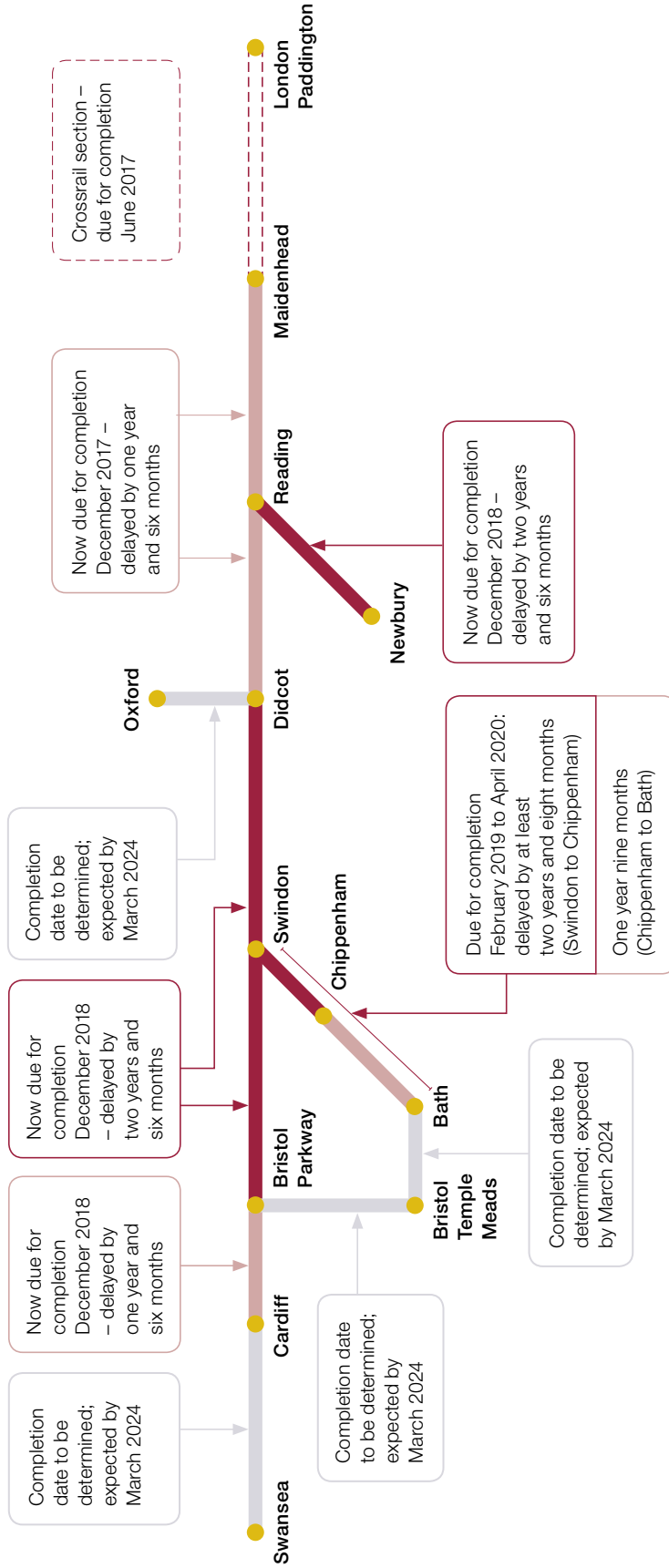
2 Network Rail, *Report from Sir Peter Hendy to the Secretary of State for Transport on the replanning of Network Rail's Investment Programme*, November 2015, available at: www.networkrail.co.uk/Hendy-review/

3 Network Rail, *Report from Sir Peter Hendy to the Secretary of State for Transport on the replanning of Network Rail's Investment Programme: Enhancements Delivery Plan Update*, January 2016, available at: www.networkrail.co.uk/enhancements-delivery-plan-update.pdf

4 In 2012-13 prices, as measured by the Retail Prices Index.

Figure 4 Current timetable for electrification between London and Swansea, and delays compared with plans in September 2014

Network Rail expects to electrify the section of the main line between Cardiff and London by December 2018; the branch to Oxford has been delayed by at least three years



■ Delays of one to two years ■ Delays of two+ years ■ Completion date not yet decided

Notes

- 1 Darker shading shows longer delays.
- 2 Grey indicates that an exact date for completion is not yet decided. In the cases of the route sections between Didcot and Oxford and between Bath and Bristol Parkway, this is because, in October 2016, the Department for Transport instructed Network Rail to delay some route sections, for affordability reasons (see paragraph 2.18). Before this decision, Network Rail's January 2016 plan anticipated a three-year delay to the section between Didcot and Oxford, compared to its September 2014 plans.
- 3 The section between Reading and Didcot has been open for testing of new Intercity Express trains since September 2016, and the Department plans for electric trains carrying passengers to run from December 2017 as shown above.

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

1.8 The remainder of this report examines:

- the Department for Transport's role in initiating the Great Western Route Modernisation industry programme (Part Two);
- the reasons for the increases in the cost of the electrification programme and Network Rail's plans to improve delivery of the wider infrastructure programme (Part Three); and
- the impact on passengers and taxpayers of the failure to manage the modernisation work as an integrated programme from the beginning (Part Four).

Part Two

The Department for Transport's management of Great Western improvements

2.1 The Department for Transport is responsible for the 'industry programme' on the Great Western Route Modernisation – the integration of the trains, the infrastructure programme and the operator franchise – to provide benefits for passengers. This part examines the Department's role in improving trains and infrastructure on the Great Western route and how this has affected Network Rail's delivery of the infrastructure work. We assess:

- how, what is now known, the Great Western Route Modernisation industry programme was developed;
- the Department's business case for the modernisation programme; and
- the programme management arrangements that the Department put in place in early 2015.

The Department's strategy for the route

2.2 The Department's aims changed several times between 2007 and 2014. In 2007, the Department required Network Rail to deliver the infrastructure improvements needed for the new trains that it had decided to commission for the Great Western route. In 2009 the Department announced that the route would be electrified, significantly increasing the scope of Network Rail's work. Network Rail did some preparatory work, but the Department changed the extent of electrification on the route several times between 2009 and 2012:

- In 2009, the Department announced its plan to electrify the line between London and Swansea, which meant that the planned new diesel trains would be a mixture of electric trains and 'bi-modes' (capable of either diesel or electric operation). Earlier in 2009, the Department had appointed Agility Trains as the preferred bidder for the Intercity Express Programme procurement.

- Following the November 2010 Comprehensive Spending Review, the Department confirmed that electrification would be carried out between London and Didcot, Newbury and Oxford.
- In March 2011, the Department confirmed electrification between Didcot and Cardiff, at the same time as it confirmed that it would continue with Agility Trains as the preferred bidder to supply the Intercity Express trains for the route.
- In July 2012, the Department reinstated the original plan to electrify the route from London to Swansea. It also added electrification of the Thames Valley lines⁵ and local lines in the south wales valleys.

2.3 The industry programme relies on successfully delivering new trains, operated by the train operator holding the franchise, and completing infrastructure works, including track electrification (**Figure 5** overleaf). This has made it crucial that the Department works with Network Rail and other stakeholders, such as the train operator, to sequence improvements carefully, and to manage interdependencies between different parts of the programme.

2.4 The Department's approach to managing such interdependencies has varied between different rail investment programmes. For the Thameslink rail programme, infrastructure improvements also needed to be coordinated with the introduction of new trains and with changes to the franchise. In that case, the Department agreed governance arrangements from the outset which were intended to help it and other interested organisations to manage the dependencies between infrastructure, trains and franchising.⁶ However, in the case of the Great Western Route Modernisation industry programme, there was no integrated governance until early 2015.

2.5 The Department used reviews by the regulator, the Office of Rail and Road, to inform its view of Network Rail's work, but this work was not sufficient to ensure a complex programme could be managed efficiently. The Office of Rail and Road determined the 'efficient cost' of the Great Western Electrification Programme,⁷ but the Committee of Public Accounts found in 2015 that its approach was unconvincing and it was not robust enough in scrutinising Network Rail's plans.⁸

5 Acton – Willesden; Slough – Windsor; Maidenhead – Marlow; Twyford – Henley-on-Thames.

6 Comptroller and Auditor General, *Progress in the Thameslink Programme*, Session 2013-14, HC 227, National Audit Office, June 2013. Available at: www.nao.org.uk/report/progress-in-delivering-the-thameslink-programme/

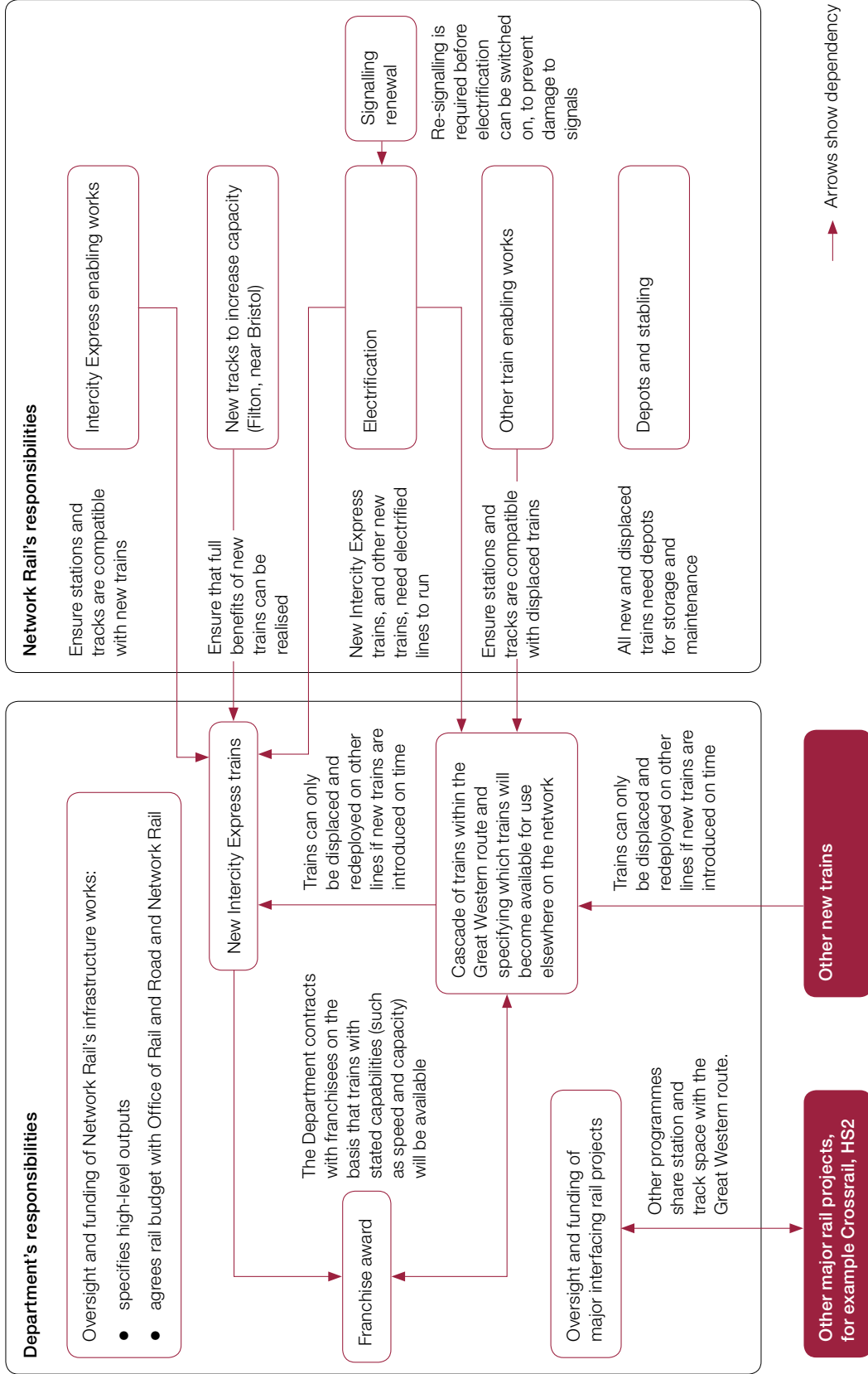
7 National Audit Office, *Planning and delivery of the 2014–2019 rail investment programme*, September 2015, Memorandum to the Committee of Public Accounts, available at: www.nao.org.uk/time/pac-memorandum-planning-and-delivery-of-the-2014-2019-rail-investment-programme/

8 HC Committee of Public Accounts, Network Rail's 2014–2019 investment programme, Ninth Report of Session 2015-16, HC 473, November 2015.

Figure 5

The Department's, and Network Rail's, responsibilities relating to the modernisation programme

The Department's priorities – such as successfully running new trains, and fulfilling its contract with the franchise holder – rely on programme outputs



2.6 When the Department entered into a contract to buy the Intercity Express trains in July 2012, creating fixed deadlines for electrification, Network Rail had only just identified that it would need to develop a new type of electrification equipment (**Figure 6** on pages 22 and 23). It is unlikely that either Network Rail or the Department had a good enough understanding of the work involved in developing and installing this new design, to be confident in the time it would take when the Department let the contract for the new trains. Under the Department's contract with Agility Trains the Department would pay a penalty to Agility if these deadlines were missed. Between 2009 and 2012, there was a dialogue between the Department and Network Rail around the electrification specification, delivery arrangements and the timescales needed to meet these deadlines. In April 2012 Network Rail started design work on a new type of electrification, which was needed to meet European Union regulations, and because of performance concerns about equipment used on other routes. In its January 2013 Strategic Business Plan, Network Rail confirmed that it expected to complete electrification as the Department required. Paragraphs 3.5 to 3.10 of this report discuss the main reasons for subsequent cost increases and changes to the electrification schedule.

2.7 The Department and Network Rail did not agree a clear set of requirements for Network Rail until nearly two years after the Department had formally instructed Network Rail to electrify the route. This made it more difficult to deliver the programme to the planned timetable (**Figure 7** on page 24). In December 2012, the Department issued an early outline of its requirements for the works on the Great Western Main Line, and in Wales. However, it was August 2014 before the Department and Network Rail agreed more detailed requirements for the infrastructure on the main line.

The creation of the Great Western Route Modernisation industry programme

2.8 From late 2013, the Department began to realise, from discussions with Network Rail and reports from the regulator (the Office of Rail and Road) that there were risks to Network Rail's schedule for the electrification work and that costs were rising. This had implications for the rest of the industry programme.⁹ In early 2015, the Department introduced changes aimed at strengthening control over the wider industry programme and providing greater assurance on its schedule and costs. The Department developed a combined business case for the entire programme and put integrated governance structures in place.

A business case for the programme

2.9 In March 2015, the Department produced the first business case for the industry programme,¹⁰ more than two years after ordering the trains and over a year after Network Rail began work to electrify the route. This summarised and communicated what the electrification and new trains should achieve. It was also intended to inform the terms of the franchise agreement let to FirstGroup to continue to operate services on the route, from September 2015.

⁹ National Audit Office, *Planning and delivery of the 2014–2019 rail investment programme*, September 2015, Memorandum to the Committee of Public Accounts, available at www.nao.org.uk/time/pac-memorandum-planning-and-delivery-of-the-2014-2019-rail-investment-programme/

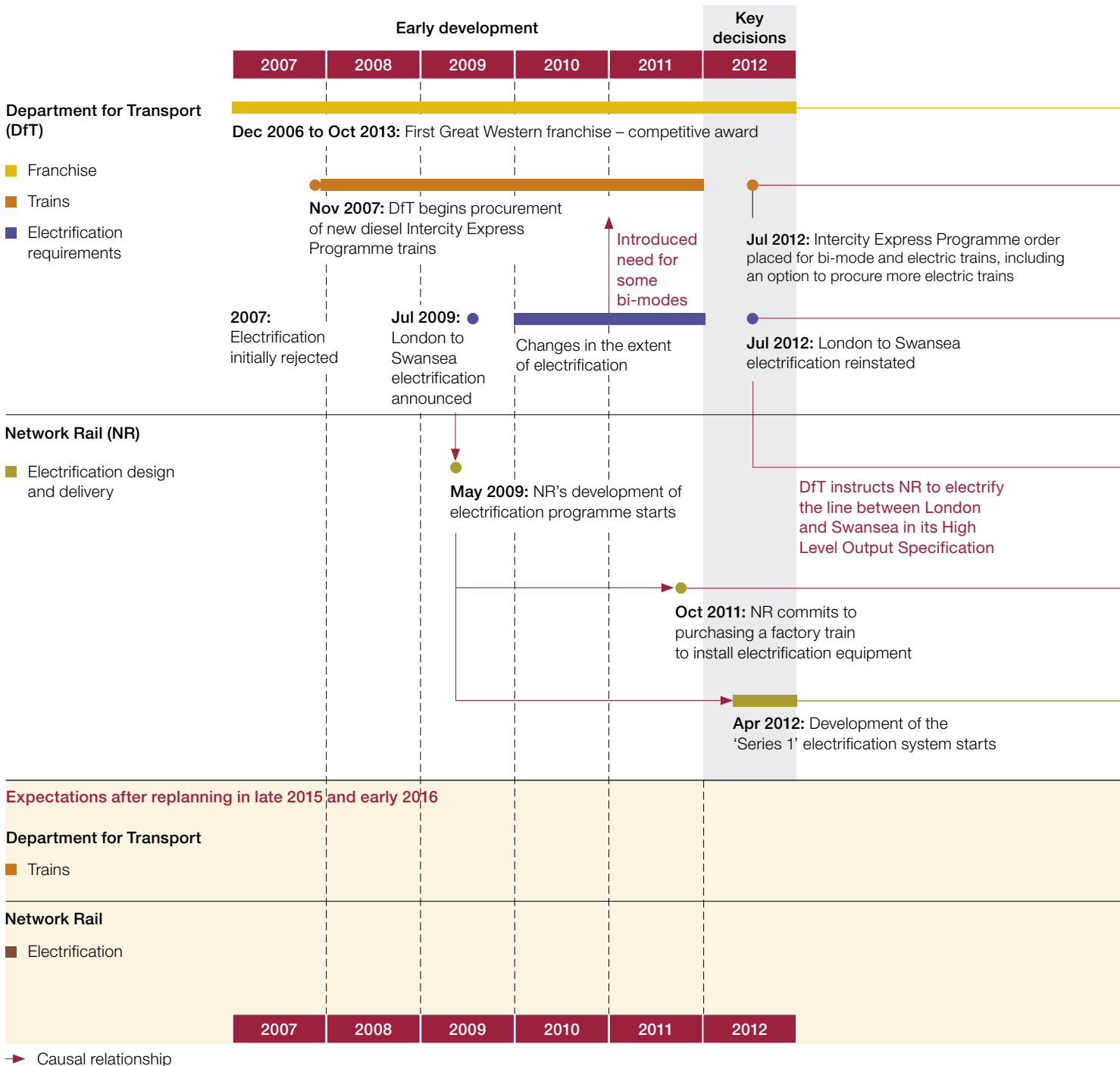
¹⁰ There had been earlier business cases for aspects of the programme. Network Rail produced a business case in 2009 examining electrification on many major rail routes in the British network. The Department produced a business case for the Intercity Express Programme in 2009, and updated it in 2012, which made reference to the associated electrification and infrastructure modifications.

Figure 6

The Department’s requirements for electrification, and Network Rail’s delivery

The Department’s requirements imposed a challenging deadline for electrifying the route, which Network Rail accepted. The Department changed its requirements while Network Rail was developing electrification designs

Early requirements and Network Rail’s delivery



Source: National Audit Office

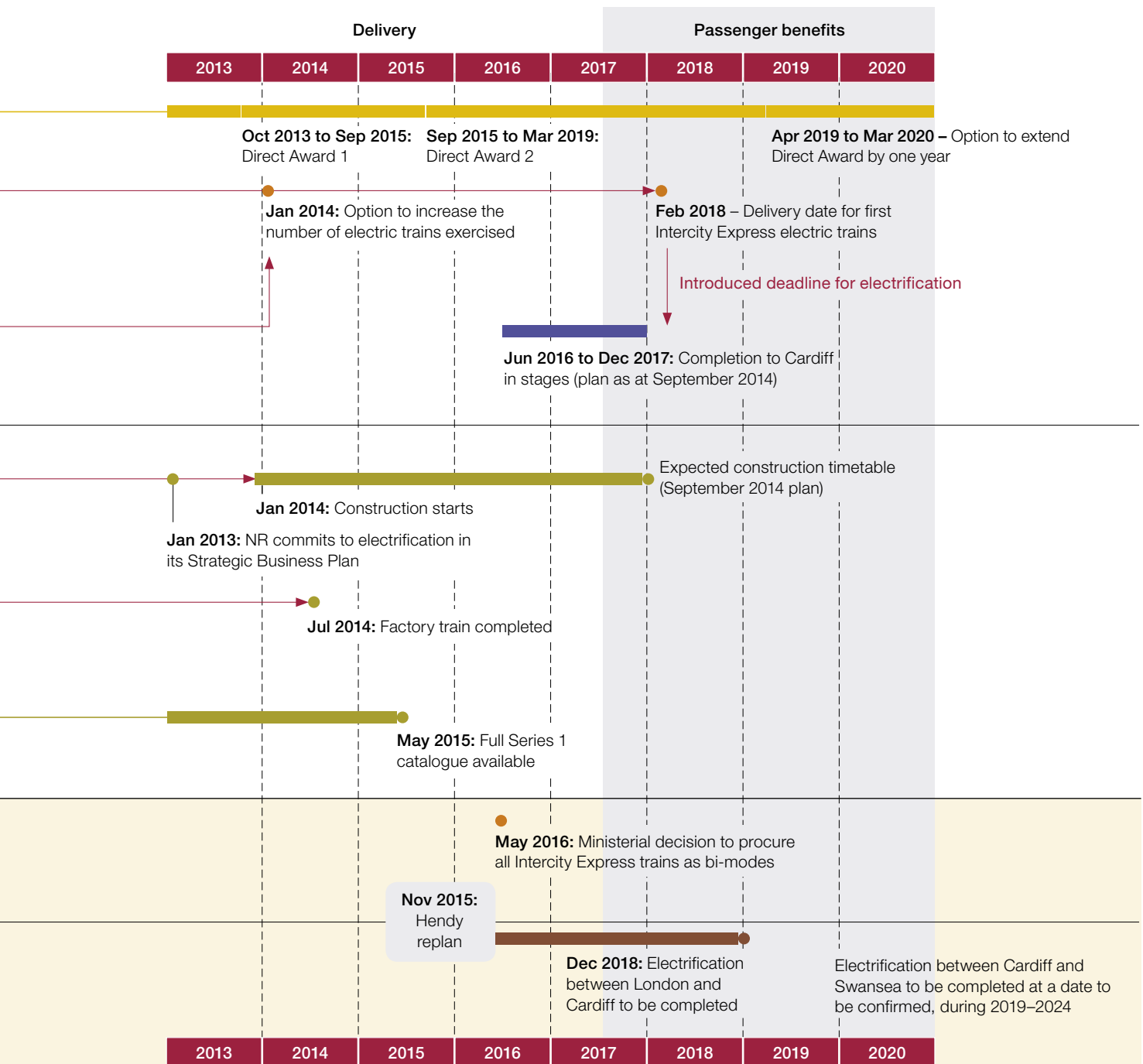


Figure 7

Examples of the implications of unclear specifications

The Department's original plans did not include 'stabling' (storage for trains when they are not being used, for example overnight) for the Class 387 electric trains coming into the Thames Valley section of the route and significant depot shortages were expected, particularly around May 2017. Since the problems arose, the Department has worked intensively with Network Rail to resolve the shortages, largely through changes to the deployment of trains. The Department now has a plan in place that it believes will resolve the shortages, although as at November 2016 there was still a small storage shortfall of 17 cars. In January 2016, Network Rail and the Department established a long-term strategy for providing depots and stabling.

Network Rail did not initially understand whether the Department wanted trains to run at a maximum speed of 125 or 140 miles per hour. This has implications for the strength of the steelwork supporting the electric wires. In January 2014 the Department instructed Network Rail that the maximum speed should be 125 miles per hour. By this point, design work was well underway and Network Rail expected to complete it in March 2014. In September 2014, the main design contractor was still working to a specification of 140 miles per hour.

Source: National Audit Office analysis of Great Western Route Modernisation programme documentation

2.10 There is a clear strategic argument for investing in the route:

- There is a need for greater capacity on the route. The Department forecasts that passenger demand on the route will grow by 81% between 2013-14 and 2018-19. This means an extra 21,200 passengers arriving at London Paddington during the peak period, each day. The modernisation programme will allow two additional peak-time services per hour between Bristol and London, from December 2018.
- The franchise had a history of unreliable service. For example, in 2013-14 and 2014-15, the proportion of trains arriving on time was below the target for the funding period.
- Passengers' experiences have been poor. In autumn 2013, three of the 10 most overcrowded train services in England and Wales were Great Western services into Paddington. National Rail Passenger Survey results for Great Western Railway, quoted in the business case, indicated that passenger satisfaction has been generally below the average for train operators.¹¹
- The works were needed to provide the full benefits of investments that the Department had already made on the Great Western route, such as the Intercity Express Programme and the redevelopment of the Reading station area. The works also complement other investments such as upgrades to signalling (the European Rail Traffic Management System) and Crossrail.

¹¹ Since late 2014, the National Rail Passenger Survey has found that Great Western Railway passenger satisfaction has improved, and is now slightly above average compared to other train operators.

2.11 The Department's May 2016 decision to procure all the new Intercity Express trains for Great Western as bi-modes, rather than a combination of bi-modes and electric trains, affects the assumptions underpinning the March 2015 business case. This recent change calls into question whether the full extent of electrification under the programme is still justified, as the new trains will now all be able to run on non-electrified route sections.

2.12 The business case assessed the value-for-money case for investing in the route through the infrastructure programme and new trains, in the context of changes to the franchise. The Department assessed the programme as 'high value for money' with a benefit–cost ratio of 2.4:1 (**Figure 8**).

Figure 8

The March 2015 economic case for the Great Western Route Modernisation industry programme

Type of benefit/cost	Value (£m, 2010 prices)
Faster journey times	3,416
Reduced crowding	510
Enhanced journey quality	149
Non-user benefits (reduced carbon emissions and road decongestion)	2,003
Indirect tax	-942
Present value of benefits	5,136
Operating costs	-4,221
Capital costs (1)	-2,636
Revenue	4,684
Present value of costs	-2,173
Benefit/cost ratio	2.4:1

Notes

- 1 This business case was produced in March 2015. Capital costs do not include the subsequent £1.2 billion increase in the estimated cost.
- 2 These costs and benefits do not include the full costs of maintaining the infrastructure.
- 3 All costs and benefits are discounted to a 2010 base, and are in 2010 prices (as measured by the Gross Domestic Product deflator).

Source: 2015 business case for the Great Western Route Modernisation programme

2.13 We estimate that the benefit–cost ratio for the programme is likely to be around 1.6:1, due to changes that the Department and Network Rail have confirmed since March 2015. This represents ‘medium’ value for money in the Department’s appraisal methodology. This reflects a number of changes, including an increase in the cost of improving infrastructure (paragraph 3.5), the added costs and performance differences of the bi-mode Intercity Express trains, and a reduction in the income that the Department receives from the train operator (paragraph 4.9). We have not been able to assess the impact of changing the scope of electrification, as a result of the decision that all the Intercity Express trains will be bi-modes, on the benefit–cost ratio. Neither the Department’s nor our estimate of the benefit–cost ratio takes into account the full cost of routine maintenance on the route. When more trains are running on the route, Network Rail will need to carry out maintenance within shorter timescales; the Department and Network Rail are developing maintenance plans. Our estimate also does not take into account the impact of delays on passenger benefits.

2.14 If costs increased by a further 3–4% we estimate that the benefit–cost ratio would fall below 1.5:1. The Department defines this as ‘low’ value for money. However, there are some factors which would be likely to increase the estimated benefits of electrification, such as a higher value now placed on reducing air pollution. These sensitivities highlight the importance of the Department using a revised business case to inform decisions about which elements of the programme’s scope are likely to achieve greatest value for money.

Improved programme governance

2.15 In February 2015, the Department established integrated governance structures for the Great Western Route Modernisation industry programme. These arrangements are similar to those it had in place from the start of a similar programme, Thameslink.¹² Compared with prior arrangements for the Great Western Route Modernisation industry programme, they provide a better platform for managing the interdependent elements of the programme. They also provide a forum for assurance about the programme’s progress. The major features of the new arrangements are as follows:

- A programme board, which includes representatives from the Department and Network Rail; the passenger and freight train operators; key contractors; and representatives of other rail programmes which interface with Great Western, such as Crossrail and High Speed 2. Representatives from the Department include the teams responsible for the Intercity Express Programme trains, oversight of Network Rail and the franchise. The board is supported by a programme delivery group which works out detailed issues and submits them to the board for decisions.

¹² Comptroller and Auditor General, *Progress in delivering the Thameslink programme*, Session 2013–14, HC 227, National Audit Office, June 2013. Available at: www.nao.org.uk/report/progress-in-delivering-the-thameslink-programme/

- A senior responsible owner for the programme, a Department official, was formally appointed in January 2016 and chairs the programme board.
- The Department and Network Rail have recently introduced new arrangements to work together when they need to make trade-offs between different enhancement programmes, including the Great Western Route Modernisation.¹³ The new Rail Portfolio Board first met in February 2016.

Remaining risks for managing the industry programme

2.16 The programme board's ability to manage the programme is limited by the quality of the information it receives (**Figure 9** overleaf). As the Department did not manage what it now calls the Great Western Route Modernisation as an integrated industry programme from the start, it did not set up management information systems of the type we have seen on other major programmes. The Department has improved the management information during 2014 and 2015 and there is an established system of reporting. But the board still does not have:

- a 'critical path' for the industry or infrastructure programme showing the minimum feasible schedule and how different projects within the programme interact with each other and affect the final delivery dates;
- clear high-level indicators of cost and schedule performance, based on an earned value management approach in line with best practice for major programme management.¹⁴ Network Rail told us that it is developing better schedule performance indicators, but it has not yet put them into practice; and
- independent challenge to Network Rail, through a mechanism such as a 'project representative'. The 'P-Rep' is an engineering expert who reviews and interrogates the progress of work on behalf of the programme sponsors. This approach is used on Crossrail and on High Speed 2. In August 2016, the Department was given funding to appoint such experts to scrutinise Network Rail's progress.

2.17 The governance arrangements rely on effective joint working between the different teams in the Department that are responsible for the various elements of the industry programme. There are many interfaces between the Great Western Route Modernisation programme and other rail programmes including Crossrail and High Speed 2 (**Figure 10** on page 29). This requires close working across all of the teams in the Department's rail and high speed rail groups. The programme board must manage these complex interfaces.

¹³ Department for Transport and Network Rail, *Memorandum of Understanding between the Department for Transport and Network Rail on rail enhancements*. Available at: www.gov.uk/government/uploads/system/uploads/attachment_data/file/509545/mou-dft-network-rail-rail-enhancements.pdf

¹⁴ Earned value management is a technique for measuring project performance and progress, based at its simplest on quantified measures of work planned (planned value) and work completed (earned value) (National Audit Office definition from project management sources).

Figure 9

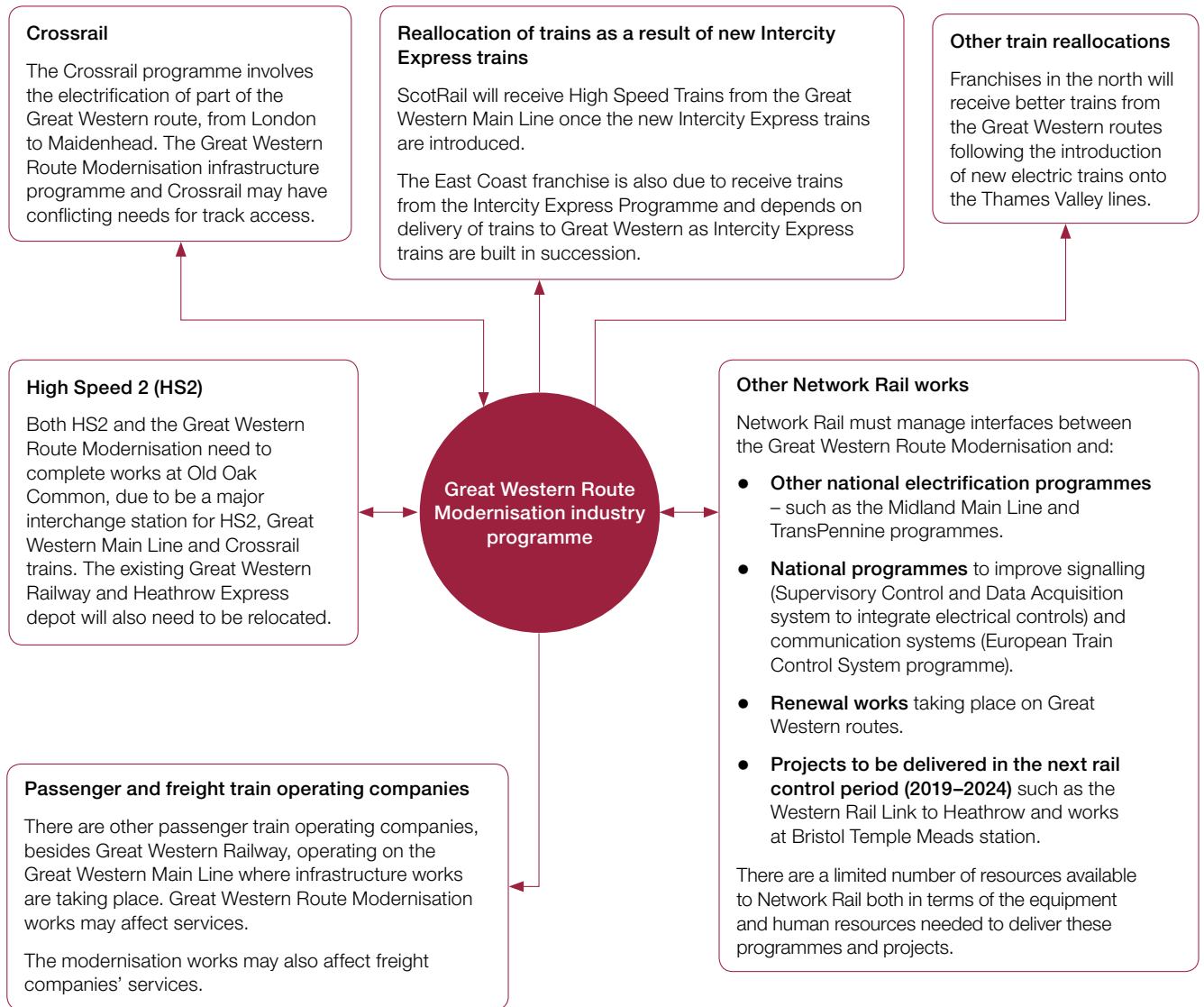
Our assessment of performance information currently provided to the programme board

Programme-level performance measures fall short of our good practice criteria, limiting board scrutiny

Reporting area	Best practice	Great Western Route Modernisation industry programme
Overall progress reporting	<p>Progress reporting is aligned with overall programme objectives, as set out for example in the business case.</p> <p>Systematic reporting that reduces reliance on individual judgement.</p>	<p>There is reporting on significant risks to the service changes that underpin some benefits in the business case. However, these benefits are not systematically tracked and updated.</p> <p>Performance information does not explicitly link to the business case. Some expected benefits set out in the business case (such as environmental benefits) are not tracked by the programme board at all, despite changes in plans – such as the reintroduction of diesel capacity for the Intercity Express trains – that will affect these. Regular progress reporting focuses on infrastructure works.</p> <p>A consistent set of information is reported, but it does not provide a complete overview of progress. The programme board relies in large part on the judgement of senior Network Rail staff about whether progress is on track.</p>
Cost and delivery indicators	<p>Cost and delivery indicators are integrated, or at least aligned, to provide an overall value measure. For example, progress reporting reflects the difficulty of work done (earned value management).</p>	<p>Cost and delivery measures are reported separately. Network Rail provides updates at the programme board's monthly meetings on progress with electrification on individual sections of the route. In the information provided to the board on these occasions, Network Rail reported on how the number of items to be built compared with the number of items actually constructed. This does not reflect the cost and difficulty of remaining work. Cost is reported as 'cost of work done' which does not provide a check against the expected costs incurred to date.</p>
Monitoring of forthcoming risks	<p>Horizon scanning (a systematic approach to anticipating risks) is carried out.</p> <p>There is an overall measure of confidence in delivery to cost and schedule.</p> <p>Systematic criteria for escalation.</p>	<p>The programme uses a RAG (red/amber/green) rating system to highlight forthcoming risks identified and rated by senior managers.</p> <p>There is no overall measure of confidence, although RAG ratings refer to delivery to schedule and cost.</p> <p>There are varying criteria for selecting risks at different programme board meetings; often the top three risks are selected for consideration by the board.</p>

Source: National Audit Office assessment of programme management information

Figure 10
Interfaces with other programmes



Source: National Audit Office adaptation of a Great Western Route Modernisation industry systems integration office diagram

2.18 Although the Department and Network Rail have made progress in defining the scope of the programme, there is still some uncertainty because of affordability. The Department has instructed Network Rail to defer electrification on some stretches of the route for longer, reflecting between £146 million and £165 million of spending, because it cannot meet the costs within the current funding package. It still intends to electrify these sections, during the next rail investment period, which runs from April 2019 to March 2024. As a result, passengers in affected areas may have to wait longer to see the full benefits of modernisation. These deferrals are intended to fund projects that are considered critical, but were not allocated funding in the 2015 replan. Such critical projects account for £72 million of the funding shortfall. The largest of these are:

- A new depot in Exeter (£36 million). The Department agreed to make funding available for this in March 2015, as part of the second franchise extension, known as a 'direct award'.
- Work at Bristol East Junction (£15 million). Network Rail now expect that it will need to spend more on this project in the current rail investment period in order to complete it before this section of line is electrified.
- Platform extensions on the Cotswold Line, which are needed to allow the new Intercity Express Programme trains to stop at smaller stations (£13 million). The Department instructed Network Rail to carry out this work in August 2014.

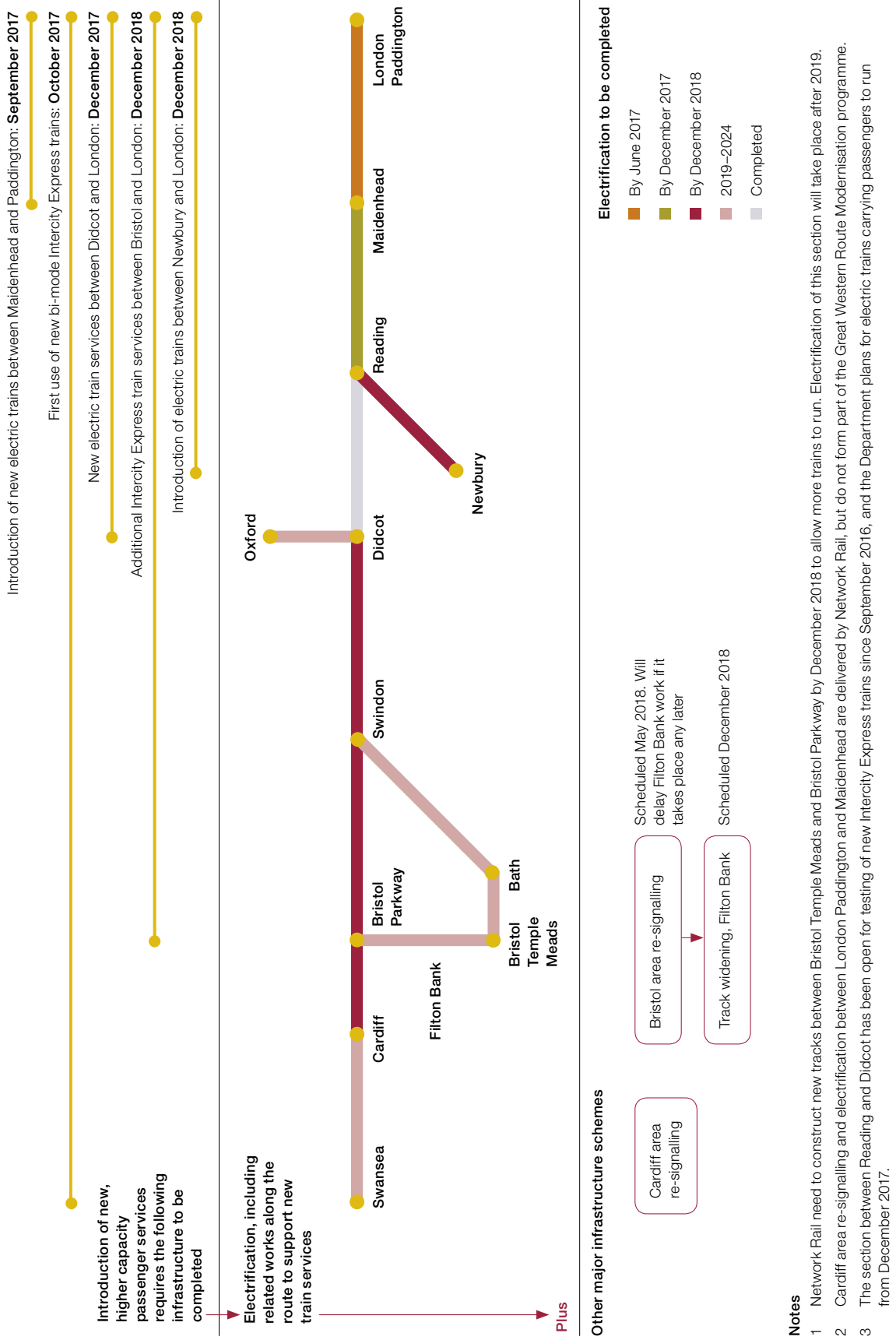
Part Three

Network Rail's management of infrastructure works

3.1 The infrastructure elements of the Great Western Route Modernisation programme form a programme of works in their own right, with complicated interdependencies between them (**Figure 11** overleaf). These projects are all essential because:

- electrified overhead lines provide the power for electric trains;
- signal systems must be upgraded before the electrified lines can be used, to prevent interference between the high-voltage power cables and sensitive signal cables;
- 'enabling works' such as lengthening platforms, are needed to make use of new, larger trains, and bridges need to be raised to make space for overhead lines;
- the train operator needs places to store trains overnight and carry out maintenance work. Adequate depot and stabling facilities must be available before trains can be introduced; and
- two extra tracks between Bristol Parkway and Bristol Temple Meads stations ('Filton Bank') need to be built to allow more trains to run between Bristol and London from December 2018.

Figure 11
Network Rail must complete several complicated projects by 2018



3.2 In 2015, The Committee of Public Accounts found that Network Rail's 2014–2019 nationwide rail investment programme was not deliverable. In large part this was because over half of planned spending was on projects where cost and scope were highly uncertain at the start of the period. Prior to July 2014, Network Rail was able to finance cost increases through increasing the amount it borrowed from the financial markets, and so did not have strong incentives to get initial cost forecasts right. As noted in Part One of this report, in 2014 Network Rail was reclassified as a public sector body by the Office for National Statistics, and lost this flexibility.

3.3 Since 2013, the cost of the Great Western infrastructure programme has risen by £2.1 billion (**Figure 12**). The largest project, to electrify the line between Maidenhead and Cardiff, accounts for £1.7 billion (79%) of the increase. The estimated cost of other projects that were in the programme's scope in 2013 increased by £446 million to £2.0 billion, a 28% increase. The increased cost of the electrification programme is partly the consequence of Network Rail improving its understanding of costs and scope. However, £1.2 billion of the cost increase came after Network Rail believed that it could reliably estimate the cost. We explore the reasons for the increased cost of electrification in the rest of this part.

Figure 12

Costs have increased since 2013 on most Great Western Route Modernisation infrastructure projects

Scheme	October 2013	November 2015 (Hendy Replan)	August 2016	Increase since October 2013	
	(£m)	(£m)	(£m)	(£m)	(%)
Great Western electrification programme	1,130	2,810	2,808	1,678	148
Electrification between Cardiff and Swansea ¹	295	381	433	138	47
Reading Station ²	766	775	763	-3	0
Other planned enhancements	389	597	609	220	57
Bristol area signalling renewal	137	230	228	91	67
Subtotal-works planned in 2013	2,716	4,792	4,840	2,124	78
Enhancements planned since 2013	–	448	553 ³	–	–
Other renewals	–	166	183	–	–
Total	2,716	5,406	5,576	–	–

Notes

- 1 Network Rail did not have a comparable cost estimate for Cardiff-Swansea electrification in October 2013. The cost was estimated at £295 million in March 2014.
- 2 The Reading Station project was at a lower risk of cost increases, as most of the work had already been carried out in 2013. For the other projects, almost all of the spending was forecast.
- 3 The overall cost of these schemes has not increased since December 2015. The Hendy Review excluded two projects from its analysis which account for the difference in costs, since these were not expected to affect the funding Network Rail required between 2014 and 2019.
- 4 All costs are in 2012-13 prices (as measured by the Retail Prices Index). Numbers may not sum due to rounding.

Source: National Audit Office analysis of Network Rail data

3.4 This part examines:

- why the Great Western electrification programme increased in cost;
- how Network Rail is improving programme and project management to help control costs; and
- the remaining risks to the infrastructure programme.

Cost increases in the Great Western electrification programme

3.5 Network Rail's plans were not well developed in October 2013 as it was still determining the most appropriate way of meeting the Department for Transport's (the Department's) requirements. Since the plan was at an early stage of development, the expected cost of the work was highly uncertain. It rose over the next year from £1.1 billion to £1.8 billion. Network Rail believed the plan was more mature in September 2014, when it presented its £1.8 billion estimate for review by the Office of Rail and Road. The Office of Rail and Road concluded that if the planned works were carried out as efficiently as possible, they would cost £1.6 billion (**Figure 13**). Network Rail accepted that it would be able to achieve around £100 million of the £185 million savings the regulator identified, but it felt the remaining £85 million was 'at risk'. However by June 2015, nine months later, Network Rail had identified that it needed to fundamentally replan the programme. It subsequently revised its cost estimate to £2.8 billion (Figure 13).

3.6 Network Rail's failure to install electrification equipment as quickly as planned was the main reason why the programme had to be replanned. However, even if electrification equipment had been installed as efficiently as planned, Network Rail would not have been able to complete the programme in time to deliver the expected passenger benefits. This was because of delays to other elements of the infrastructure work that had already occurred by June 2015, when the programme was replanned:

- The planned date for essential re-signalling work between Swindon and Bristol Parkway had slipped to February 2017, two months after electric trains were supposed to run to Bristol. This was caused by another signalling project on the route taking longer than planned, combined with a nationwide shortage of people with the skills to design and commission signal systems.
- Network Rail had not obtained planning permission in time to start major construction work at Oxford Station and on several historic bridges in Oxfordshire. This delay meant that electric trains would not be able to operate between Oxford and London from December 2016 as planned.

Figure 13

Cost increases on the Great Western electrification programme

Element	Estimated cost in 2014 ¹ (£m)	Estimated cost in 2016 (£m)	Increase since 2014 (£m)	Percentage Increase (%)
Installation of electrification equipment	736	1,165	429	58
Route clearance ²	239	385	146	61
Programme management	186	311	125	67
Signals and communications equipment	106	142	36	34
Lead design organisation ³	69	110	41	59
Risk and opportunity	196	442	246	126
Other	117	248	131	112
Total	1,649	2,803	1,154	70

Notes

- 1 These are the costs that the Office of Rail and Road determined were the 'efficient' costs of electrification in its September 2014 review. Network Rail's original estimate before this review was £1.8 billion. All costs are in 2012-13 prices (as measured by the Retail Prices Index).
- 2 Route clearance covers projects needed to enable electrification equipment to be installed, such as raising bridges or lowering track where there is not enough clearance for overhead lines to be installed.
- 3 The lead design organisation does most, but not all, of the design work along the route.

Source: National Audit Office analysis of Network Rail information

3.7 The costs increased partly because Network Rail's 2014 estimate for the cost and schedule was still too optimistic. The plan included some key assumptions that proved to be unrealistic as the programme progressed, including:

- The original plan relied on a new 'factory train', carrying out much more work each night than could be accomplished using traditional construction techniques, at lower cost. **Figure 14** overleaf describes the construction process. The original plan assumed that the train would complete 18 piles (for foundations) per shift and complete 80% of the work. While Network Rail has demonstrated that the train is capable of installing up to 24 piles per shift, it has not been able to do this routinely, and Network Rail now plans for it to complete eight piles per shift on average. On average, the train completed five piles per shift between April and September 2016 (35% of the work completed during this time). It installed seven piles or fewer on 68% of nights it was used.
- Between 2014 and 2015, Network Rail continued to identify additional work that needed to be done on bridges to allow the electric lines to be fitted, increasing the cost of this part of the work.

Figure 14

The construction of overhead line electrification equipment

Electrification work generally takes place overnight to avoid disrupting passenger services, since some or all of the tracks must be closed to do the work. The factory train was designed to greatly increase the amount of work that could be done each night, reducing the cost of electrification and the time it would take.

When the train is operating as intended, a section of it moves along the track, carrying the equipment and materials needed to carry out one of the stages of electrification at several adjacent locations. Another train section follows on a subsequent night to carry out the next stage. If the factory train cannot be used, trackside crews carry out the work using conventional equipment such as cranes.

Work stage

Foundations (piles) are either dug or driven ('piled') into the ground alongside the track, at regular intervals.

A steel mast is lifted onto each foundation and secured in place.

Horizontal booms are installed spanning the tracks, supported by either one or two masts. Smaller steel parts are then suspended from the booms, over each track.

Wires are strung between the booms.

Once construction has finished on a section of track, Network Rail carries out tests and then 'commissions' the section. Trains can then use the newly electrified line.

Tunnels are typically electrified by fitting an overhead bar to carry electricity. This work is particularly challenging, and is carried out by closing the line entirely. Work on the Severn Tunnel took six weeks, in autumn 2016.

Source: National Audit Office

3.8 Failings in Network Rail's approach to planning and delivering the infrastructure programme are likely to have contributed to increased costs. It is not possible to determine how much of the £1.2 billion increase since 2014 could have been avoided, and how much was the result of unrealistic assumptions being corrected. There are signs that Network Rail consistently prioritised completing electrification works as soon as possible over completing them in the most efficient way:

- **Figure 15** on page 38 shows that critical activities overlapped to a greater extent than Network Rail planned, preventing some key activities from being carried out in a logical sequence. For example, designers started deciding what type of masts should be installed at each location two years before the complete list of components was available, which resulted in many designs having to be revised. The factory train was purchased before it became clear that the new electrification system would require deeper foundations and had to be modified. If Network Rail had adhered to the original plan, these activities would have followed each other in a sensible sequence. However the electrification system took much longer to design than expected, while Network Rail continued to try to complete the programme by the date it had originally planned, resulting in these overlaps.

- Network Rail responded to the low output of the factory train by increasing the amount of work done using more expensive conventional techniques, such as trackside crews constructing individual mast foundations at different locations. This reduced the gap between the amount of work planned and the amount completed, but also made it harder to achieve consistently high productivity from the factory train. The factory train is most productive when it is used to install similar equipment at a number of adjacent sites, and using 'conventional' construction techniques has reduced the number of opportunities for this.
- Network Rail's failure to put in place an adequate plan to obtain all the consents it needed from local authorities in good time has led to higher costs. It needed to obtain more than 1,800 separate consents, such as permission for works that could affect protected species or listed buildings. Network Rail now believes that it might have been more efficient to ask the Secretary of State for Transport to grant planning permission for the whole scheme. This would have required Network Rail to fully develop the scheme before starting construction works and may have resulted in a longer schedule for the programme.

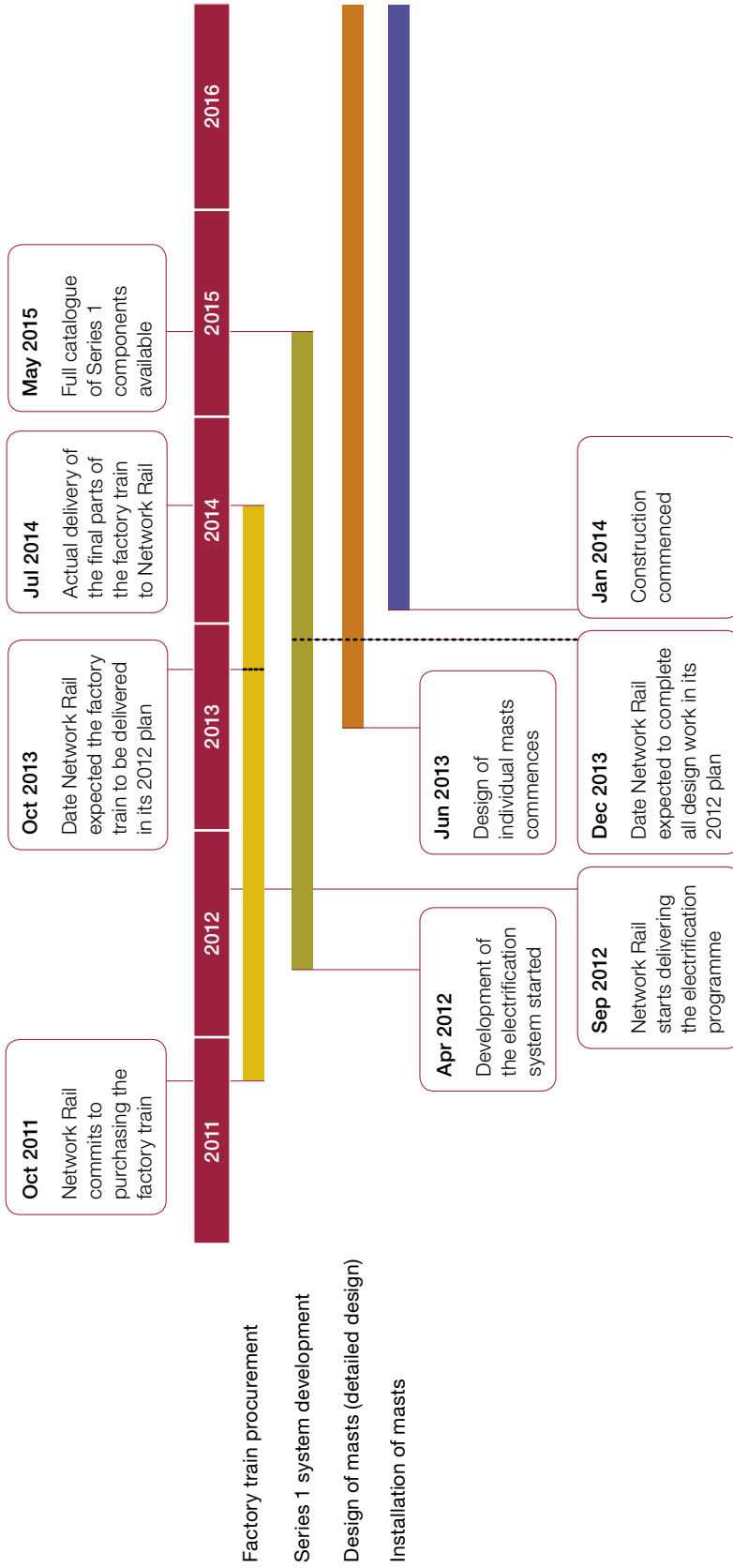
3.9 Network Rail did not recognise that making best use of the new technology required significant changes in its management systems and culture, including its relationships with suppliers and contractors. To operate efficiently and be as productive as expected, the factory train needed to be treated as part of a broader construction system from the beginning. This meant Network Rail had to align the capabilities of the factory train, the equipment installed and the way the factory train was used, with its management of other contractors (such as those producing site designs) and of the component supply chain. For example, delays in completing designs (see Figure 15) prevent Network Rail from using the factory train effectively, since the cost of filling in gaps in a sequence of masts is high. An integrated 'design and build' contract might have helped, since this would have eliminated the interface between the contractor carrying out the design and the contractor responsible for construction.

3.10 Over the last year, Network Rail has made a number of changes in how it delivers the electrification programme which it hopes will improve efficiency. Some of the cost increases could have been avoided if these changes had been implemented earlier. These changes include:

- Locating design managers alongside the teams planning works to ease the bottleneck caused by delays in completing designs.
- Reducing the number of different electrification components used. This makes it easier to ensure that the right components are available when needed.
- Establishing a new 'Collaboration Board', to share knowledge between suppliers and Network Rail and identify improvements.

Network Rail is considering introducing contractual mechanisms to reward suppliers if the electrification programme as a whole is delivered to the revised schedule and budget. However, the need to keep making progress in order to hit programme milestones and the rigidity of contracts already entered into, limit Network Rail's ability to make this improvement.

Figure 15
Sequence of system development and programme delivery



Network Rail's earliest cost estimates assumed that it would be able to use the 'Mark 3' electrification system, which is used on the West Coast Main Line. In 2011, Network Rail realised that new European regulations meant that it would not be able to use the existing system for trains that travel at 125 miles per hour. It decided to develop a new system, 'Series 1'. Although developing new technology introduced a significant new risk to the electrification work, the deadline for completing construction did not change.

Procurement of the factory train should have taken place after the Series 1 electrification system was well developed. Series 1 masts frequently require much deeper foundations, which the factory train was not designed for. There are also two different widths of pile and the factory train is less efficient when it needs to switch between types.

Network Rail was simultaneously delivering the programme and designing the electrification system. Detailed design, the process of determining exactly which equipment should be installed where, started two years before the catalogue of components, specifying all the individual parts which are assembled into the electrification system, was complete. Construction started 16 months before the catalogue was finished in May 2015.

Network Rail did not carry out sufficiently detailed surveys of the route before the 'detailed design' took place. This is critical, since if ground conditions at one site are not as expected, designs for a number of nearby locations could need to be changed. This delays piling and installation of masts. In November 2015, Network Rail estimated that 78% of designs completed so far had needed to be revised. The failure to properly survey the route meant that contractors accidentally cut through two signal cables in October 2014 causing significant passenger disruption. Network Rail now requires trial holes to be dug before piles can be driven.

Network Rail's improvement plans

3.11 Since 2014, Network Rail has begun to take a more integrated approach to delivering the Great Western infrastructure programme. Between 2013 and 2015, Network Rail identified a number of weaknesses in its coordination and management of the Great Western infrastructure programme. For example, there was no 'controlling mind' with the information and authority needed to make critical decisions. This made it difficult to manage the interdependencies between the projects effectively. These weaknesses are likely to have contributed to the cost increases across the programme. **Figure 16** sets out the weaknesses identified and Network Rail's response.

Figure 16

Weaknesses in the management of the infrastructure programme and Network Rail's responses

Identified weakness	Network Rail's response
Unclear responsibility for the programme with no single programme sponsor.	Single sponsor and programme director from early 2014.
No integrated schedule with a 'critical path' (a plan showing the minimum possible delivery schedule and interdependencies within the programme) for works and no overall budget.	Since April 2014, Network Rail has had a programme office, largely staffed by a contractor, which is responsible for maintaining an integrated management plan and programme schedule.
Lack of independent challenge of delivery team.	Extension, in January 2016, of internal programme sponsors' responsibilities, making them accountable for programme delivery throughout the programme life cycle. Plans, since early 2016, for 'peer reviews' by Network Rail staff without direct programme involvement. In 2015, Network Rail carried out a peer review of the Great Western infrastructure programme.
No consolidated view of the track access that Network Rail needed to do the work which is likely to have led to delays due to equipment and construction vehicles not being able to access the track when expected.	Establishment of working groups to coordinate Network Rail's requirements for access to the track, with train operators.

Source: National Audit Office assessment, drawing on Network Rail internal reviews

3.12 In 2015 Network Rail, in conjunction with the regulator, identified a number of systemic failings in the planning, delivery and governance of enhancement projects. These failings were contributing to rising costs and inefficient delivery. Network Rail has since put in place a major, organisation-wide change programme known as the Enhancements Improvement Plan to improve its capabilities in areas including:

- **Cost estimation** – good quality information about the likely cost of a project ensures that investment decisions are well informed and programme management is effective. Network Rail plans to increase its internal capacity for estimating costs, make better use of information from previous projects and produce more consistent estimates.
- **Project delivery** – organisational and workforce development changes aimed at developing the skills of Network Rail staff.
- **Project and portfolio monitoring** – Network Rail is introducing earned value management techniques. These link spending with an assessment of the value of work completed, to provide useful information on whether a project is likely to be finished on time and budget. Some projects and programmes within Network Rail use these techniques, but this has not yet been rolled out to all projects that would benefit.
- **Project governance** – Network Rail has introduced a new system of ‘peer reviews’, to provide assurance that projects are on course to deliver their requirements on time and within budget.

3.13 This change programme has the potential to improve Network Rail’s control of the Great Western infrastructure programme as well as its planning and delivery of future enhancement programmes. In July 2016, the regulator reported that Network Rail was making ‘good progress’ in delivering these improvements.

Remaining risks on the infrastructure work

3.14 Network Rail has made progress in delivering the electrification work, in recent months:

- the Office of Rail and Road (ORR) has reduced its rating of the electrification programme from ‘5’, which is the highest level of concern on the ORR’s five-point scale, to ‘2’ between June and October 2016. The ORR had rated the programme at ‘5’ since March 2015, and had regarded Network Rail’s performance as concerning since August 2013; and
- Network Rail has delivered the section of track near Didcot which is used for testing the Intercity Express Programme trains, on schedule by September 2016. This is the first major milestone under the 2015 replan of the programme.

3.15 There are risks to the current schedule for delivering the infrastructure programme:

- Electrifying the line from Maidenhead to Cardiff by December 2018 relies on the assumption that Network Rail can significantly increase mast installation and piling rates, compared with the rates it has achieved so far. Network Rail's current target is to increase the number of piles installed each week from 62 in August 2016 to 195 piles by November 2016. The rate of mast installation is expected to increase from 55 per week to 191 per week over the same period. However, Network Rail is currently developing a new plan which it expects will mean it will install around 150 piles per week between November 2016 and March 2017, without delaying the completion of electrification any further. In early September 2016 Network Rail had completed 6,804 foundations, 44% of the total required. It had installed 3,438 masts (23% of the total) and 1,352 booms (15%).
- Network Rail has not yet completed a quantified schedule risk analysis on the current schedule for the electrification programme. Without this, neither Network Rail nor the programme board can have confidence that the schedule is achievable. Network Rail has completed its risk assessment of individual sections of the route. For each of these sections, it is at least 80% confident that it can complete work on time, assuming that delays on the other sections do not have a knock-on effect. This is encouraging, but does not necessarily indicate confidence in the schedule for the electrification programme as a whole. This would require a route-wide analysis, taking into account the fact that delays on one section of the route can affect other sections and that Network Rail may be able to take steps to reduce the impact of risks.
- It is not clear whether there is sufficient float (time contingency) in the electrification schedule to allow Network Rail to complete work before the deadlines agreed with the Department if it misses its 'stretch' targets. For example, Network Rail did not meet its 'stretch' delivery date of June 2016 for opening the test track for the Intercity Express trains. It used up all of its float, but it did complete work by the date it committed to as part of the 2015 replan.

3.16 There are also risks related to other aspects of the infrastructure work:

- Further delays in the Bristol area re-signalling programme would affect the rest of the infrastructure programme, as there is no remaining float in the schedule. Network Rail needs to finish installing new signals in the Bristol area in a short window over Easter 2018, so that more trains can run between Bristol and London from the end of that year. This work has already been rescheduled once in 2015, due partly to the limited capacity of its suppliers. There is a continuing shortage of skilled signalling engineers.
- The programme team is showing signs of the pressure it is under – stress and depression caused on average 2.2 days of absence per member of staff last year. This is much higher than the national average of 0.5 days for people in professional occupations.

3.17 The project for electrification between London and Cardiff currently has £109 million less contingency than the amount Network Rail believes it needs to be prudent. This puts the project at greater risk of further cost increases. There is currently a £256 million provision for risks, 19.2% of the estimated cost of remaining work. This is less than when Network Rail's board re-approved the project in April 2016 (when there was 26.3% contingency available). This is because some issues that were identified as risks have now occurred and more risks have been identified since then.

Part Four

Impact of works and delays to electrification

4.1 The delay to electrification has had a knock-on effect on other elements of the programme including those crucial to realising the programme's objectives. Passengers will have to wait longer to see the benefits of the programme, such as increased capacity, and the taxpayer will face additional costs. These costs are still uncertain, but the Department's current estimate is that they are likely to be between £280 million and £330 million. This includes the cost of changing the order for Intercity Express trains so they can operate using diesel power and the Department's best estimate of the impact of delays on the income it will receive from the franchisee, Great Western Railway.

4.2 In this part of the report we assess how the Department for Transport (the Department) and Network Rail have managed:

- the impact of the infrastructure works on passengers travelling on the route;
- the impact of delays to electrification on other parts of the programme, specifically;
 - the introduction of new electric high-speed trains on the route, under the Intercity Express Programme (IEP); and
 - plans to introduce new trains onto the Great Western network, allowing existing trains to be reallocated to other routes within the franchise and across the wider network.

Disruption to passengers

4.3 Considering the scale of the infrastructure works that Network Rail must complete to deliver benefits to passengers, a certain amount of disruption to services is inevitable. To date passengers have faced disruption in the form of delays and the reorganisation of services.

4.4 Overall Network Rail has kept unplanned disruption to passengers relatively low, considering the complexity of the works. On average long-distance trains on Great Western routes have been delayed by five to six minutes between 2011 and 2016.¹⁵ This is a considerable improvement on delays to trains during the modernisation of the West Coast Main Line, another long-distance route, which we reported on in 2006.¹⁶ In 2004, Virgin West Coast trains were delayed by 17 minutes on average, and nine and a half minutes on average when things had improved in 2006.

¹⁵ Total delays (Network Rail and train operating company) per planned train.

¹⁶ Comptroller and Auditor General, *The Modernisation of the West Coast Mainline*, Session 2006-07, HC 22, National Audit Office, November 2006. Available at: www.nao.org.uk/report/the-modernisation-of-the-west-coast-main-line/

4.5 Network Rail has made efforts to improve the planning of infrastructure works, with a focus on the impact on passengers. In March 2016, Network Rail and Great Western Railway signed an alliance agreement detailing closer working practices aimed at reducing disruption to passengers. They collaboratively plan when and where track closures will take place, a practice that may further reduce the impact on passengers.

Delays in introducing more modern trains

4.6 To increase capacity and improve services on Great Western routes and across the rail network, the Department had identified a complex series of train reallocations known as a 'cascade'. Its original expectation involved introducing electric trains on newly electrified routes (see Figure 1, page 12), displacing older diesel trains (**Figure 17** on pages 46 and 47). This therefore depended on electrification being completed on time. The Department expected that:

- electric trains from Thameslink would replace diesel trains in the Thames Valley providing more capacity to reduce overcrowding;
- Thames Valley could then release Class 165 and Class 166 diesel trains to the west, providing more capacity for passengers on the Bristol, Exeter and Cornish networks; and
- West Devon and Cornwall routes would then release Class 153 and 150 diesel trains to support service improvements on Northern franchise routes allowing further onward cascades.

Additionally:

- new Super Express Trains from the Department's Intercity Express Programme would replace ageing diesel High Speed Trains (also known as IC125 trains) on the London to Swansea line cutting journey times from London to Cardiff; and
- the London to Swansea route could then release the diesel High Speed Trains to address capacity issues on intercity routes in Scotland.

Finally:

- An additional fleet of diesel and electric capable trains recently ordered by the train company, Great Western Railway, (AT300 bi-modes) would be introduced in the south-west, providing more capacity and faster journey times on London to Plymouth and Penzance routes.

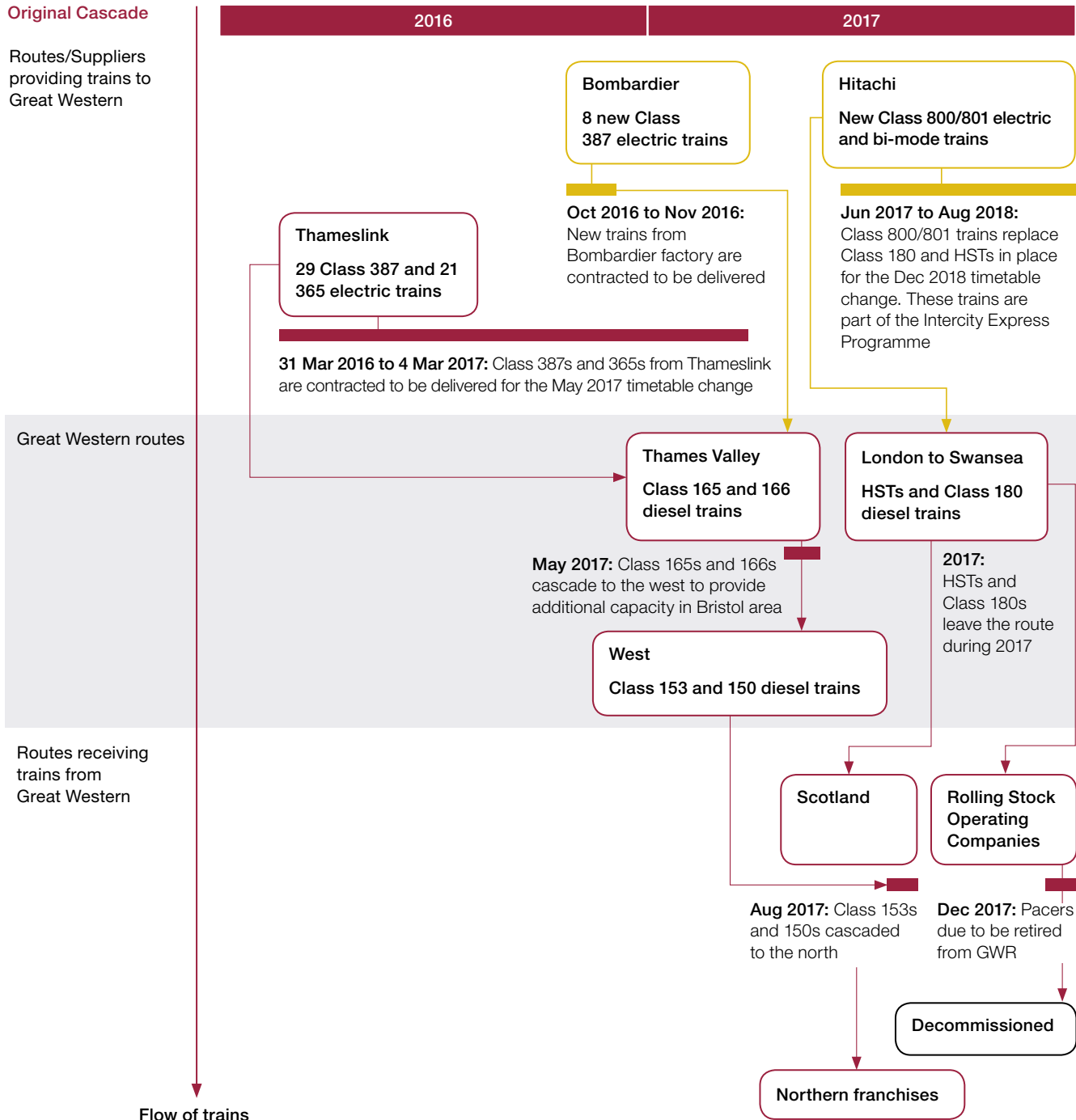
4.7 In April 2016, the Department began reviewing its original cascade expectations to protect existing services. Delays in electrification mean that trains cannot be introduced into the Thames Valley from the dates originally envisaged. To avoid cancelling services for passengers in the Thames Valley, diesel trains due to go to the west in 2017 will be retained until 2019 as electrification is completed and new electric trains are phased in. Revising the cascade expectations (**Figure 18** on pages 48 and 49) was a complex exercise. It involved input from the operator, Great Western Railway, and was a significant achievement for the industry. As a result of Great Western Railway and the Department's intervention, passengers will not see a reduction in services and the programme will still provide benefits, although these will be delayed in some areas. Passengers in the west (Bristol, Exeter and Cornwall routes) will now have to wait almost two years later than scheduled to see benefits such as more capacity.¹⁷ In the wider rail network, passengers on Northern franchise routes may have to wait an additional nine months as trains are retained in the west to protect services. At the time of the revision the Department was aware of potential delays to infrastructure works in the north which would have meant that Northern would not have required the trains as early as planned. Great Western Railway has also had to make additional orders of new bi-mode trains to prevent the cancellation of services on busy Oxford to London routes.

4.8 Because of the delays to electrification, the train operating company, Great Western Railway, will have to incur additional costs to cover:

- Converting old trains that need to be used for longer, to comply with stricter regulations about access for persons of reduced mobility.
- Renting five more bi-mode trains to operate services between Oxford and London, since it will not be able to use electric trains from May 2017 as planned. Without these trains, it would only be possible to operate one direct train service between London and Oxford per hour. These trains are in addition to the trains procured by the Department under the Intercity Express Programme, which are discussed in paragraphs 4.11 and 4.12.
- Higher running costs, as fuel and maintenance costs for diesel trains are more expensive.
- Lower passenger revenue, since higher capacity trains will be introduced later than planned.

¹⁷ Trains were originally due to be released to the west in May 2017 but under revised plans will remain in Thames Valley until the end of March 2019.

Figure 17
Train reallocations (cascades) – original plan



Notes

- 1 London to Swansea includes the Great Western branches via Hereford and Cheltenham (see Figure 1 of this report) as well as the main line route to Bristol and Swansea.
- 2 HST stands for High Speed Trains.



Hitachi
New AT300 bi-mode
(diesel/electric) trains

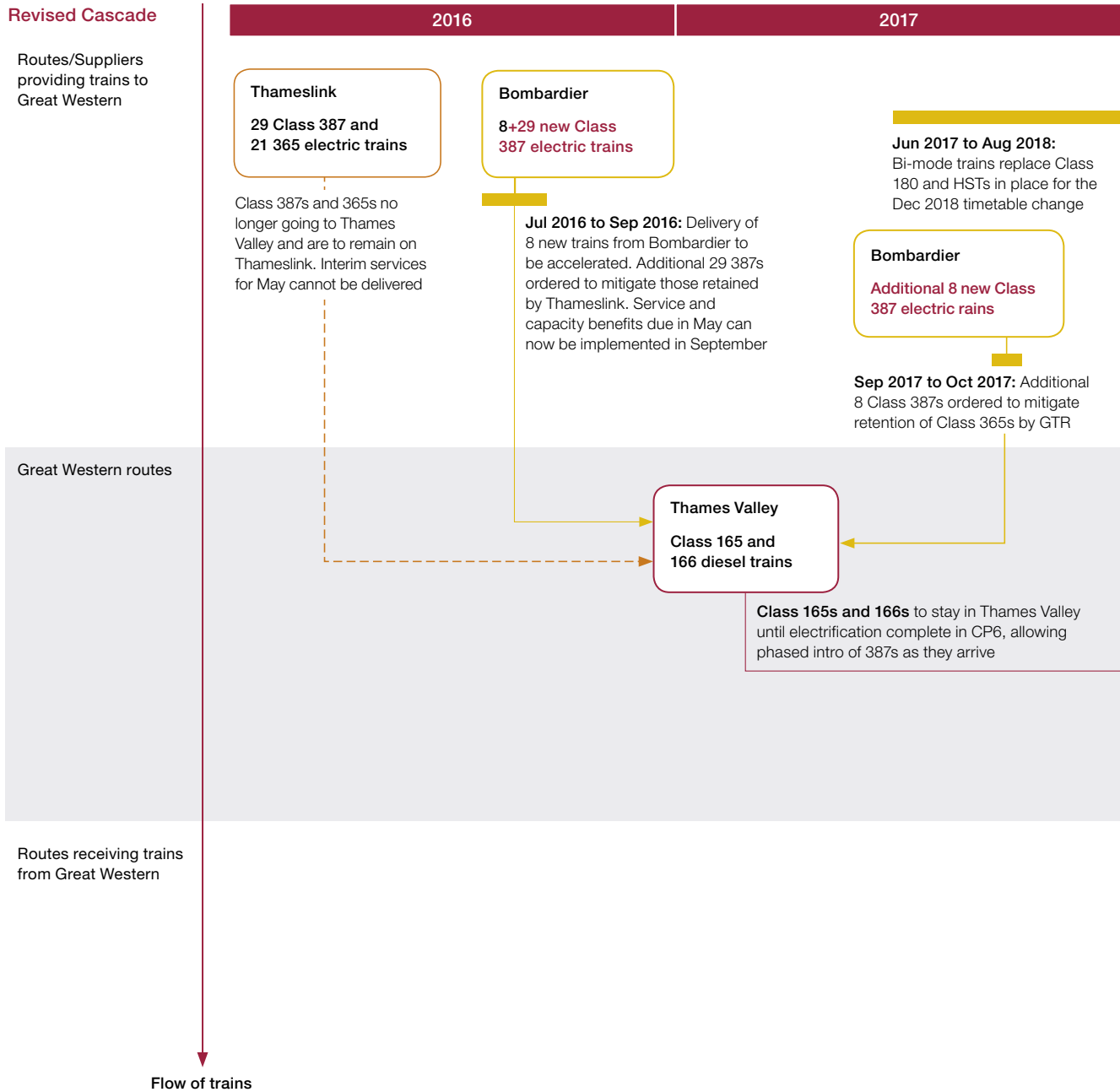
May 2018: Bi-mode trains to provide additional capacity and reduce journey times in the south west

South west

Exeter
Class 143 Pacers

- Existing trains
- New trains

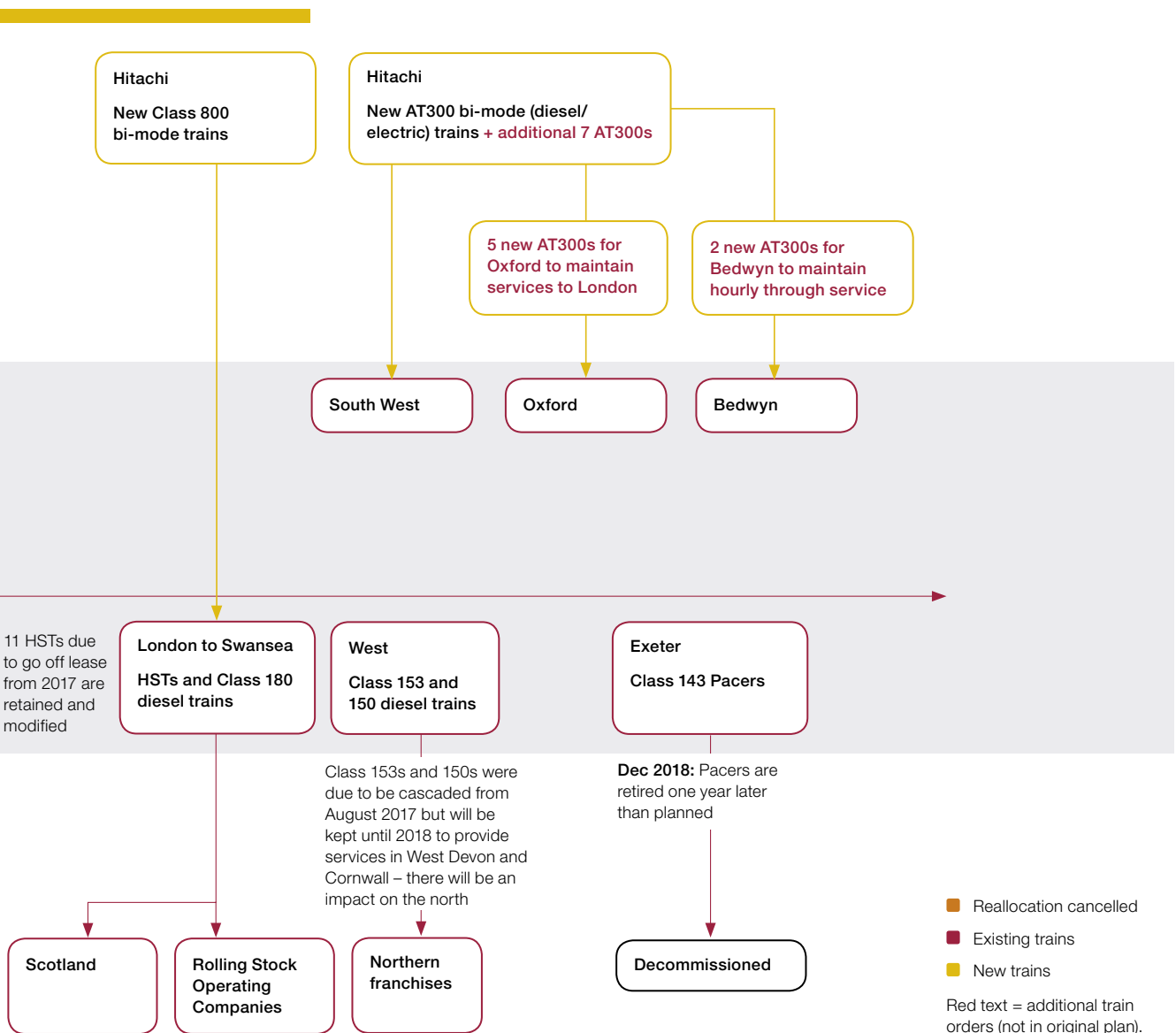
Figure 18
Train reallocations (cascades) – revised plan



Notes

- 1 London to Swansea includes the Great Western branches via Hereford and Cheltenham (see Figure 1 of this report) as well as the main line route to Bristol and Swansea.
- 2 HST stands for High Speed Trains.

Source: National Audit Office analysis of the Department’s documents



4.9 Under the terms of its contract with the train operating company, Great Western Railway, the Department is responsible for any costs caused by delays to electrification. These costs will be reflected in the 'premia' payments that Great Western Railway pays to the Department. This is because the Department agreed, in its March 2015 franchise award to Great Western Railway, that electrification and new trains would result in electrification being ready in December 2016 (London to Newbury), June 2017 (London to Bristol Parkway) and May 2018 (London to Cardiff). Network Rail will now not meet these dates (Figure 4).

4.10 Any further delays to the cascade will affect the wider rail network and have an adverse impact on the Department's rail franchising programme. As part of the franchise competition process, the Department requires bidders to demonstrate how they will meet set objectives for improving passenger experience. This requires bidders to specify the train fleet they propose to use and how trains will be configured to meet demand.¹⁸

Impact on the Intercity Express Programme

4.11 As a result of delays to electrification, the Department has negotiated a variation to its contract with Agility Trains for the new Intercity Express Programme trains, so that all the trains are capable of running on either diesel or electric power (bi-modes). Under the original contract Agility was due to deliver 36 bi-modes and 21 electric trains. In May 2016, HM Treasury approved the Department's request for the 21 trains previously specified as electric to now be procured as bi-modes. If it had not done this, old trains would have continued to operate services. The Department would have had to pay £400,000 per day to Agility Trains to lease new trains that could not be used until the overhead electrification was complete. We estimate that this would have cost the Department about £400 million over the three years that it took to complete electrification. The Department has not yet decided whether to pay the costs of converting the trains up front or ask the owner of the trains to pay the costs in exchange for higher lease payments. The second approach would save money in the short term, but would cost more overall since the Department would have to pay the train owner's finance costs.

¹⁸ Comptroller and Auditor General, *Reform of the rail franchising programme*, Session 2015-16, HC 604, National Audit Office, November 2015. Available at: www.nao.org.uk/report/reform-of-the-rail-franchising-programme/

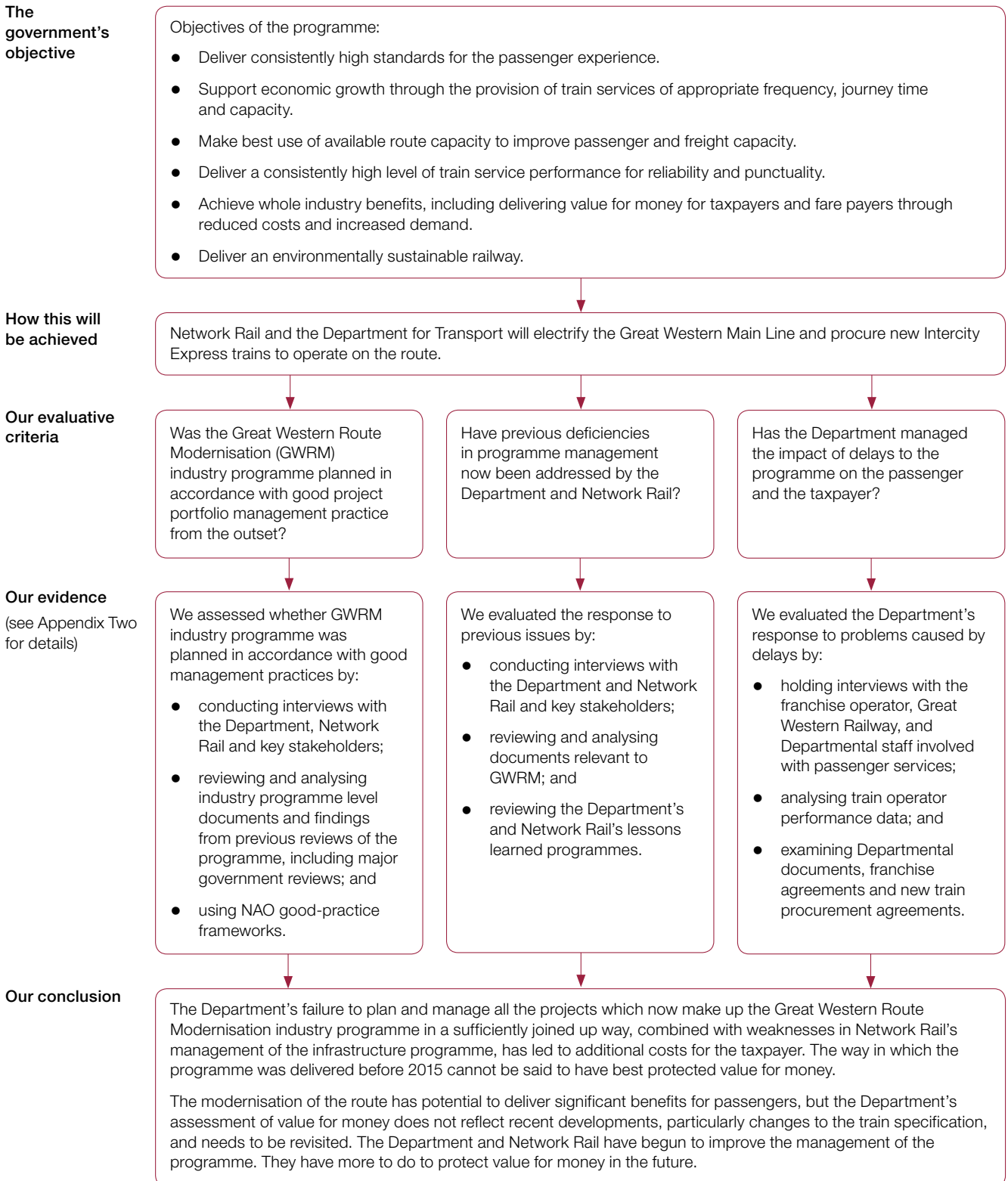
4.12 The decision to procure all the trains as bi-modes means that the Great Western Route Modernisation industry programme will not achieve all the benefits that the Department expected in the short term. Bi-modes allow greater flexibility in service patterns since they can run on electrified and non-electrified routes, but when using electric power, bi-modes cause more damage to the track and incur higher energy costs than electric trains as they weigh more. The top speeds of the new bi-modes when operating under diesel power are probably lower than the existing high-speed diesel trains and the Department is exploring the overall effect of using these trains on journey times. There is a risk that it will not be possible to introduce the services the Department expects from December 2017, since the trains will only be able to use electric power on the route between London and Didcot. The trains will run under diesel power on the main line between Didcot and Cardiff until December 2018. Bi-modes used in diesel mode are also noisier and emit more pollution than electric trains. For the Department to deliver the benefits originally expected from electrification, some of the bi-mode trains would need to be modified to remove diesel engines once the line has been electrified.

Appendix One

Our audit approach

- 1 This study examined planning and programme management of the Great Western Route Modernisation industry programme as a result of significant issues arising on delivery of the programme.
- 2 Our key areas for review were:
 - whether the Department for Transport (the Department) and Network Rail managed the programme in accordance with good project and programme management principles;
 - whether the Department and Network Rail have responded to the previous issues in the programme; and
 - the extent to which the Department has managed the impact of delays to the programme on the passenger and the taxpayer.
- 3 Our audit approach is summarised in **Figure 19**. Our evidence base is described in Appendix Two.

Figure 19
Our audit approach



Appendix Two

Our evidence base

1 Our conclusion as to whether the programme has been effectively managed by the Department for Transport (the Department) and Network Rail, and whether the programme will achieve value for money, has been reached following our analysis of evidence collected between April and August 2016.

2 Our audit approach is outlined in Appendix One.

3 We examined whether the programme was planned in accordance with good project and programme management:

- We assessed key programme documents against our programme management assessment framework.
- We reviewed strategic documents and the Department's March 2015 business case to understand the basis for the Department's decisions on electrification and the train specifications for the Intercity Express Programme.
- We conducted interviews with key staff from the infrastructure projects team in Network Rail to obtain further information about how Network Rail manages related infrastructure works, and how it worked with the Department.
- We reviewed programme-level documents and the process and timing of key decisions made on the programme.
- We analysed external and internal reviews of the programme.
- We drew on our past work on similar large infrastructure projects, such as Crossrail and High Speed 2.

4 We examined how the Department and Network Rail have responded to the issues in the programme:

- We held interviews with key staff at the Department to obtain further information about how governance and risk management of the programme is evolving.
- We reviewed minutes from, and submissions to, the programme board. We reviewed the management information provided to the board and also observed board meetings.
- We reviewed the Department's and Network Rail's risk assessment documents to assess what challenges remain for the programme.
- We reviewed ministerial correspondence to understand how the Department responded to the financial impact of the delays to electrification, and the impact on the planned cascading of trains.
- We reviewed cost estimates provided by Network Rail.

5 We examined how the Department managed the impact of delays to the programme on the taxpayer and the passenger:

- We reviewed the Department's revised train cascade expectations to assess how the Department is minimising the impact on passengers.
- We reviewed agreements with the train operator and spoke with the Department to understand the Department's rationale behind amending the Intercity Express Programme trains contract with Agility Trains.
- We reviewed franchise arrangements between the Department and the franchise operator, Great Western Railway.
- We analysed data on train delays.

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