Cost overruns of major government projects

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Key findings

- In an analysis of 10 recent and in-progress UK major government projects, overruns have grown to a total of 32.7 years and £17.2 billion, or £624 per UK household.[1]
- The £17.2 billion accumulated overrun could have paid for seven of the 10 projects at their initial cost estimates, with £4 billion leftover.
- Out of the 10 projects, the modernisation of the Great Western railway, Carrier Strike, and the Emergency Services Network programme incurred the most significant cost overruns at a combined £10.8 billion.
- Both internationally and in the UK, major project forecasts have been shown to be consistently optimistic in terms of both cost and time to completion and almost always take longer and cost more than expected.
- Multiple studies have suggested costs are intentionally underestimated to secure project approval, which means the potential for costs to overrun dramatically are greatly increased.

Introduction

The whole life cost of ongoing major government projects is currently £442 billion.[2] £210 billion of this will go towards infrastructure and construction, £138 billion towards military capabilities, £84 billion towards transformation and service delivery, and £10 billion on ICT infrastructure.[3] Yet when it comes to major projects, government has a troubling record: between 2013 and 2019 the number of major projects deemed at least "probable of a successful delivery" by the Infrastructure and Projects Authority, has fallen steeply from 48 per cent in 2013 to just 17 per cent in 2019.[4]

Nor does government have a pre-existing positive reputation when it comes to major projects. In 2009, the TaxPayers' Alliance discovered that 240 UK capital projects had seen costs overrun by a total of £19 billion.[5] Meanwhile, high profile projects like HS2 face bitter opposition amongst both the public and in parliament, whilst Crossrail has been delayed by up to 27 months, and has seen costs run £3 billion over its 2010 budget.

This paper makes it clear that overruns remain a major problem for government and for taxpayers. Projects have frequently gained approval based on flawed estimates that sometimes fall billions of pounds short of the final cost. Furthermore they have taken years longer to complete. When projects are not finished on time, it is not just a matter of paying for labourers and equipment for a longer period, but often one of opportunity cost. Every month that Crossrail is delayed is another month that taxpayers are not benefiting from it, and Transport for London is not collecting anticipated revenue. As the Astute submarine programme has gradually slipped back ever further, the risk has increased that the Dreadnought submarine programme will be delayed due to shortages of shipyard space. This means current submarines must be kept at sea for longer, and the Royal Navy's ability to conduct operations is put at risk.

This report first explores why major government projects so frequently go over-budget. It then examines 10 ongoing or recently completed projects that have experienced overruns in order to illustrate the significant costs that result from flawed forecasting.

[1] Calculation based on ONS Families and households data.
ONS, *Families and households*, Office for National Statistics, 7 August 2019, table 5: Households by size.
[2] Infrastructure and Projects Authority, *Annual Report on Major Projects 2018-19*, 18 July 2019, p.5.
[3] Ibid
[4] Ibid, p.19.
[5] O'Connell, J., *Out of Control: How the Government overspends on capital project*, TaxPayers' Alliance, 20 November 2009.

The scale of overruns

Frequency of cost overruns is not a phenomenon isolated to Britain, and is a puzzle that has left practitioners and academics scratching their heads for decades. The oft-repeated mantra when it comes to sizable capital projects (often called megaprojects) is that they will invariably be "over budget, over time, over and over again".[6]

Although there have been several pieces of research in past decades examining how much costs on major projects typically overrun, there is low consistency in the precise focus of these projects. There have been numerous projects focused exclusively upon transport and infrastructure, and others focused more broadly on all major government projects. This paper will begin by assessing a selection of these studies relevant to the UK. Additionally, while there is much research available on overruns in the developing world, these have not been analysed due to significantly divergent circumstances.

One of the 21st century's most substantial studies so far has been a 2003 analysis of over 250 transport infrastructure projects. This research, by Flyvbjerg et al, analysed a range of transport infrastructure 'megaprojects' mainly in Europe and North America with values in excess of US$1 billion.

Flyvjberg's analysis found that on average final costs exceeded initial estimates by 28 per cent (see table 1). This was, however, subject to significant deviations, depending on what form of transport the project concerned was. Rail projects for example were found to exceed their initial estimates by 45 per cent. Road projects meanwhile (which made up 65 per cent of the samples) on average exceeded budgets by just 20 per cent. Bridge and tunnel projects typically exceeded forecasts by 34 per cent. Additionally, it was found that overruns occurred in as many as 90 per cent of projects.[7]

Table 1: cost overruns of major transport infrastructure projects[8]

Type of project	Average cost escalation (%)
Rail	45
Bridges and tunnels	34
Road	20
All projects	28

However, a similar Australian study by Love et al, found that overruns were less severe. According to this analysis, road projects exceeded budgets by an average of 14 per cent, bridges by 3 per cent, and tunnels and subways by 1.5 per cent.[9] The key difference between these projects however was the average budget. All of Flyvbjerg et al's projects had average contract values in excess of US$ 1 billion, whilst Love et al's had an average cost of AUS$33 million. This would suggest that larger projects are associated with higher overruns. In contrast, a 2010 study looking at Australian highway projects found smaller projects typically experienced the highest overruns at 36 per cent, whilst those with budgets of between AUS$5 and 50 million typically experienced a 22-25 per cent overrun.[10]

A 2009 study by the TaxPayers' Alliance meanwhile looked at 240 major government projects which overall suffered from a 38 per cent cost overrun.[11] A significant proportion of these were road infrastructure projects, which had an average overrun of 13 per cent, comparable to Love et al's 14 per cent average.

[6] Flyvbjerg, B., *Megaprojects: over budget, over time, over and over*, Cato Institute, January 2017, available at: https://www.cato.org/policy-report/januaryfebruary-2017
[7] Flyvbjerg, B et al., *How common and how large are cost overruns in transport infrastructure projects?*, Aalborg University, 2003, p.85
[8] Ibid, p.80.
[9] Love et al., *Moving beyond optimism bias and strategic misrepresentation: an explanation for social infrastructure project cost overruns*, IEEE Transactions On Engineering Management, vol. 59, no.4, November 2012, p.560.
[10] Creedy, G et al., *Evaluation of risk factors leading to cost overrun in delivery of highway construction projects*, journal of construction engineering and management, volume 136, no.5, p.39.
[11] O'Connell, J., *Out of Control: How the Government overspends on capital project,*. TaxPayers' Alliance, 20 November 2009, p.1.

Finally, a 2002 study commissioned by HM Treasury examined the effect of optimism bias on British major government projects. The study looked in detail at 50 major projects with a value in excess of £40 million (2001 prices). As table 2 shows in detail, engineering and construction projects on average went 17 per cent over schedule and 46 per cent over budget. However, non-standard projects typically experienced cost overruns of 72 per cent, significantly higher than standard projects, and in the case of buildings, much higher time overruns.[12]

Table 2: optimism bias of British major government projects[13]

Project type	Works duration (%)	Capital expenditure (%)
Non-standard buildings	39	51
Standard buildings	4	24
Non-standard civil engineering	15	66
Standard civil engineering	34	44
Equipment/Development	54	214

This final study provided what still remains the 'generic optimism bias adjustment percentages' as contained within the Treasury green book (though with slight adjustments). This ensures that project managers are aware of the potential for cost underestimation in their forecasts, and that optimism bias is suitably applied. If this is being consistently applied, UK government projects should display a reduced level of overruns because this should have been taken into account sooner in a project's lifecycle, or at the very least already possess sufficient contingency funds to account for any overrun.

As these studies are not uniform in the form of project included, it is difficult to combine them to produce any form of consistent estimate. Yet viewed together they do suggest some possible conclusions.

- Road infrastructure projects have consistently been shown to overrun by between 13 and 36 per cent.
- On average, it should be anticipated that major government projects will take and cost longer than initially forecast.
- More expensive and more complex projects seem to be more likely to overrun than standard and/or lower budget projects.

In the next section, this paper will attempt to understand what the key factors are leading to cost overruns.

[12] Mott MacDonald, *Review of large public procurement in the UK*, July 2002, p.14.
[13] Table transmuted from Mott MacDonald report page 14. Excludes PFI/PPP projects and outsourcing projects.

The causes of overruns

Although it is no secret that major projects frequently experience significant cost and time overruns, there remains less consensus as to.

However, of the studies mentioned thus far, all examined optimism bias as a key factor leading to overruns.

The aforementioned UK-focused Mott MacDonald study commissioned by the Treasury came to a number of startling conclusions regarding some of the reasons for cost overruns. Firstly, the study observed that an inadequate business case was accountable in 58 per cent of cost overruns.[14] In these cases, the risk typically arises from an inadequate definition of requirements and implementation method, and inadequate attention to mitigating risk.

More concerning still was that optimism bias was found to be even more prevalent in "politically important" projects:

> *"..if it is believed that once given the go-ahead a project cannot be allowed to fail, then there remains a strong incentive for optimism bias..."* [15]

In addition, it was concluded that there had been multiple occasions whereby costs had possibly been intentionally aimed at the politically acceptable figure rather than a more likely estimate.[16] This allows the project to gain political momentum and continue despite those promoting the project knowingly underestimating costs and times.

The Mott MacDonald study repeatedly alludes to possible project costs being intentionally misrepresented to decision makers to secure funding or project approval. However, the report does not delve into the specific reasons why.

A 2013 National Audit Office (NAO) report, however, did examine this. It was stated that "endemic over-optimism" was frequently to blame for overruns. In an examination of what contributes to over optimism,[17] the NAO found that the following factors were largely to blame:

- **Behaviour and incentives**
  Individuals may be optimistic in their estimates in order to secure project investment. This has been particularly prevalent when projects are subject to tight deadlines or short budgetary cycles. There has also been a cultural reluctance to challenge senior views and a10dency to mask bad news in government organisations.

- **Complexity**
  The NAO found that optimism is prevalent amongst particularly complicated projects. Because government has often failed to get to grips with the complexity, government's ability to deal with potential challenges in the delivery pipeline are over-estimated.

- **Evidence base**
  The NAO reported numerous examples wherein estimates were modelled on poor quality data. This masks potential risks and allows optimism to go unchallenged.

[14] Mott MacDonald, *Review of large public procurement in the UK*, July 2002, p.16.
[15] Ibid, p. 22
[16] Ibid, p. 24
[17] National Audit Office, *over-optimism in government projects*, December 2013, p.4.

- **Independent challenge and accountability**
  The decision making process effectively encourages optimism. The rewards for being over-optimistic are strong, whilst scepticism carries few rewards. High staff turnover further incentivises short-term rewards because staff may not be around by the time the problems emerge. Additionally, it is rarely the case that any one person has overall responsibility for a project, meaning accountability is diffused.

- **Stakeholders**
  In the past, government departments have made attempts to impose major projects upon other public sector elements without sufficient consultation. This increases the opposition these groups (rightly or wrong) pose to the project. An optimistic approach attitude may disregard concerns these groups have.

To summarise, high staff turnover coupled with optimism-encouraging incentives means that those ultimately responsible for underestimates have often moved on before problems begin to emerge, and are rewarded for it. Furthermore, high diffusion of responsibility may encourage 'buck-passing' as the blame is passed on ever further down the line.

If anything, the other factors behind such optimism are enabled by this structural flaw. Were it not for high staff turnover, those same staff would be better enabled to getting to grips with the complexity of any one project.

Although the NAO report does acknowledge that project managers may on occasion intentionally produce misleading estimates, it stops far from attributing this as a leading cause for overruns.

Having examined a range of oft-produced explanations for why overruns occur (in the forms of technical, economic, psychological and political), Flyvbjerg et al conclude that the only feasible reason that overruns can happen so often and to such a degree is that project promoters and forecasters intentionally produce skewed estimates.

According to Flyvbjerg et al, the majority of studies comparing actual costs and estimates of infrastructure projects too freely attribute blame to "forecasting errors".[18] These errors may come from "imperfect techniques, inadequate data, [and] honest mistakes…" Similar to the position taken in the NAO report, however, they do not seek to address the common explanation for this range of problems.

Flyvbjerg et al report that these forms of 'technical' explanations may have some validity (so would be fair excuses if used in isolated and relevant cases). Yet they reject them because, if this were the case, the frequency of overruns would have been reduced over time rather than largely remained constant. This might suggest that technical issues are effectively used as a scapegoat to obscure the true cause of overruns.

Following a similar vein, 'appraisal optimism' is also rejected.[19] Appraisal optimism is when forecasters are overly optimistic about outcomes early on and so subconsciously embrace optimistic estimates. Yet Flyvbjerg et al reject this explanation, because as a viable excuse it relies on the naivety of generations of forecasters at every level, a consistent trend that is near unfathomable. However, in light of the 2013 NAO report, this could be attributed to high staff turnover preventing specialisation and excusing accountability.

[18] Flyvbjerg, b, et al., U*nderestimating costs in public works projects: error or lie?* Journal of the American Planning Association, 2002, volume 68, no. 3, p.286.
[19] Ibid, p.288-289.

The final explanation Flyvbjerg et al discusses is the political,[20] by which it is meant that favourable estimates are intentionally presented as reliable to better attract investment and to get the project moving. A prime example used in this instance is of the Channel Tunnel which experienced an 80 per cent cost overrun. The cause for such an extreme overrun against a favourable initial estimate was that investors were convinced of the projects viability under the 'Everything-Goes-According-to-Plan' (EGAP) principle. When adhering to EGAP, promoters will omit any cost escalations from the business case that might arise from delays, accidents or changes to the project otherwise.

Supporting this, in 58 per cent of cases of cost overruns, the aforementioned Mott MacDonald study found this was, like the Channel Tunnel, due to 'inadequacy of the business case'.

Like the Mott MacDonald study, Flyvbjerg et al found that major projects in receipt of government funding are easily perceived as being 'too big to fail'. If taking advantage of this, promoters will ensure that certain costs and add-ons are hidden until the project reaches a point of no return. At this point it becomes too big to fail because the sunk costs are so great. One example of this was the Transbay Terminal in San Francisco. Discussing the cost overruns after the project was completed, former mayor Willie Brown said:

> *"We always knew the initial estimate was way under the real cost…If people knew the real cost from the start, nothing would ever be approved. The idea is to get going. Start digging a hole and make it so big,* [that] *there's no alternative to coming up with the money to fill it in."*[21]

Although the Mott MacDonald study did not assert that misrepresentation was a *leading* cause for cost overruns, it did highlight that forecasted costs being tailored to what was politically acceptable was a recurring problem in major projects (see page 6).

However, acceptance that optimism bias is most often to blame for overruns is not completely universal. Love et al for example dispute this line of argument and instead blame a number of 'pathogens' that accumulate to effectively leave no miracle cure to the overruns puzzle.[22] To some degree this is reinforced by the Mott MacDonald study, which found that optimism could be influenced by several factors other than incompetency and misrepresentation, such as underestimation of the environmental impact, economic, and legislative factors to name a few (though these were in the minority).

Although Love et al do not deny that optimism bias and misrepresentation may cause some overruns, they remark that many projects experience problems without these causes being to blame.

Whilst individual projects may incur overruns for a variety of reasons, optimism bias is the reason most frequently held to blame as this collection of studies has shown. The reasons for the prevalence of this however is disputed. UK government studies have generally refrained from casting blame on any one reason for the causes of optimism bias, a position reinforced by Love et al. In contrast to this, the work of Flyvbjerg et al confidently presents the possibility that project managers and promoters intentionally skew forecasts (in some cases) in order to see favoured projects approved. Both government-related studies looked at allude to this as a possibility though do not join Flyvbjerg et al in considering it a leading cause for overruns.

[20] Flyvbjerg, b, et al., U*nderestimating costs in public works projects: error or lie?* Journal of the American Planning Association, 2002, volume 68, no. 3, p.289-290.
[21] Flyvbjerg, B., *What you should know about megaprojects and why: an overview*, project management journal, volume 45, no. 2, 2014, p.13.
[22] Love et al., *Moving beyond optimism bias and strategic misrepresentation: an explanation for social infrastructure project cost overruns*, IEEE transactions on engineering management, vol. 59, no.4 November 2012, p.570-571.

In summary, although optimism bias may not always be the reason for cost overruns, it is certainly a leading cause. Furthermore, that forecasts are intentionally skewed to secure project approval is a possibility that must be taken very seriously. In order to ensure initial estimates are as accurate as possible, budgeters must be held to account and forecasts scrutinised with the utmost vigilance.

Major overruns of major projects - case studies

This section examines 10 ongoing and recently completed major projects undertaken by various government organisations. Eight of these are currently in progress. Of the two completed, one effectively accomplished nothing in six years, the final costs of the other meanwhile may yet rise significantly as the result of a legal dispute.

As shown in table 3 below, across the 10 projects they have accumulated a total time overrun of 33.5 years, and a total cost overrun of £17.2 billion. Using the original cost estimates of the projects, £17.2 billion would have been enough to pay for 7 of the 10 projects at initial estimates, with £4 billion leftover.

In each instance the earliest cost estimate has been used that can be sourced, and the predicted completion date at that point. In some cases this may be different to the date of the agreed funding package or main investment decision. The reason for using the earliest estimate is to illustrate the price government had expected to pay at the time of project approval. Similarly, start dates have been selected based on the form of project and information available. Major infrastructure projects have used the works start as beginning date (i.e. when construction began proper) whilst other projects, such as IT projects, will have used a project start date because the 'works start' is less easily defined.

Additionally, the cost overruns are only illustrative of cash prices as published by government. This is because government sources used do not always make clear if their own forecasts are adjusted for inflation.

Table 3: Time and cost overruns of each project

Project	Time overrun (%)	Cost overrun (%)
Thameslink	65	9
Great Western railway modernisation	67	458
Electronic monitoring programme	258	36
Carrier Strike	100	86
Crossrail	24	12
Priority school building programme phase 2	26	50
Aberdeen Western Peripheral Route	25	116
Astute class submarine	11	24
Emergency Services Network	37	49
Core Production Capability	40	42
Accumulated overrun	**32.7 years**	**£17.2 billion**
Cost per household		**£624**

1. The Thameslink programme – Department for Transport (DfT) and Network Rail

Works start: 2009	
Original planned completion: 2015	Initial budget: £5 billion
Revised completion: December 2019	Latest forecast: £5.5 billion[23]
Time overrun: 47 months (65 per cent)	Cost overrun: £474 million (9 per cent)[24]

First proposed in 1989, Thameslink 2000 (as it was originally called), was intended to dramatically increase the Thameslink network and its passenger capacity. After repeated delays, the project was allowed to proceed in 2007 with work starting in 2009. Phase 1 of the Thameslink Programme was completed on time in late 2011. However, prior to beginning phase 2, the completion timeline was revised back from 2015 to late 2018.[25] Then in 2017, it was again revised to late 2019.[26]

Although phase 1 came in under budget and on schedule, phase 2 is 18 per cent over budget and running 20 per cent behind even the revised schedule adopted in 2010, let alone the original schedule given the green light in 2007.

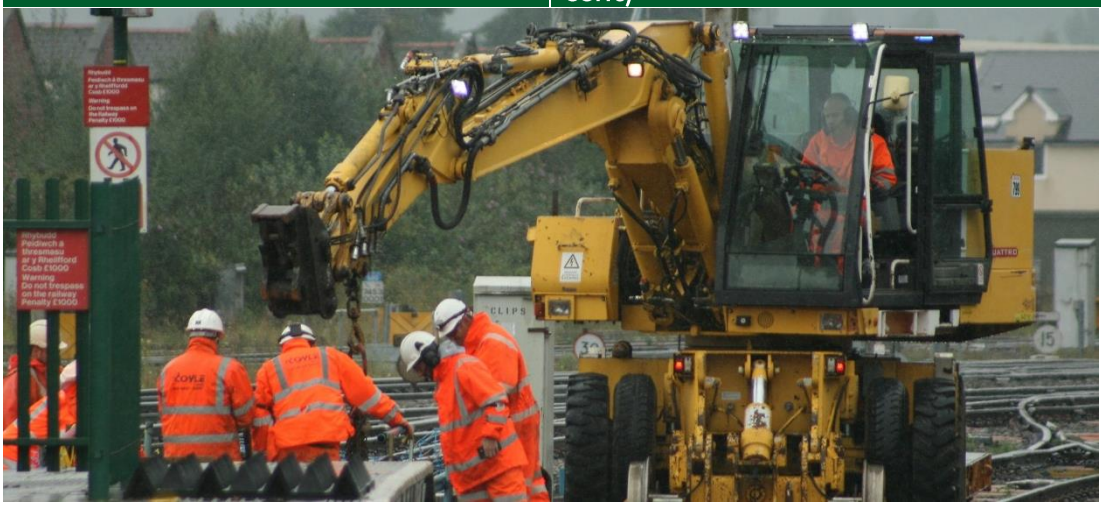
The phase 2 timeline was first revised to 2018 when Network Rail realised in 2009 that the complexity of the works required would make meeting the original project timeframe significantly challenging. At this point it was predicted that overspend for phase 2 might rise as high as £527 million with 2020 considered a likely end date.[27]

These predictions have largely been vindicated, with current estimates very close to this worst case scenario. According to Network Rail, the cost overruns occurred thanks to site-inappropriate designs at London Bridge station which required extra construction work, this created further delays down the line, delaying the detailed design phase by 18 months. It also meant other parts of the programme had to be accelerated to make up for those delays, and meant Thameslink was unable to take advantage of a new network-wide traffic management programme and so had to fund its own.[28]

[23] National Audit Office, *Update on the Thameslink programme*, 2017, p.4.
[24] Ibid
[25] National Audit Office, *Progress in the Thameslink programme*, 2013, p.4.
[26] National Audit Office, 2017, p.8.
[27] National Audit Office, 2013, p.25.
[28] National Audit Office, 2017, p.16.

2. Great Western railway modernisation – Department for Transport (DfT) and Network Rail

Works start: January 2014	
Original planned completion: 2017	Initial estimate: £1 billion
Revised completion: 2019 (in progress)	Latest forecast: £5.58 billion
Time overrun: 24 months (67 per cent)	Cost overrun: £4.58 billion (458 per cent)



The electrification of the Great Western main line was first mooted by a Labour government in 2009. It was estimated to cost 'around' £1 billion,[29] proceed as far as Swansea, and would be completed by the end of 2017.[30] However, in March 2011 the coalition government decided to proceed only as far as Bristol. Then in 2012, the government again decided to include Swansea before deciding in mid-2017 that no electrification would take place beyond Cardiff.[31] By this point total costs had risen to at least £5.58 billion.[32]

In a 2016 NAO report scrutinising the causes of the overruns, it found that the project had been fragmented prior to 2015. Projects were not planned and managed in a joined up way, nor was there any central business case until years into the project.[33] This meant that the project proceeded haphazardly, with planning permission often not gained on time and with insufficient consideration of related projects overrunning.

Furthermore, the estimates of the work required were both unrealistic and optimistic. A new factory train, for example, was forecast to complete 18 overhead line foundations per shift. Yet in reality seven or less were installed in almost 70 per cent of shifts.[34]

The accumulated delays and cost increases have also severely impacted the value-for-money measurement of the project. Although it had been considered 'high' at the beginning with a benefit-cost ratio of 2.4:1, it had by 2016 declined to just 1.6:1, or 'medium' value for money.[35] Prior to the latest decision to scrap the electrification as far as Swansea, the ratio had sunk as low as 1.07:1, after which it meekly recovered to 1.13:1, or 'poor' value for money.[36]

[29] Department for Transport, *Britain's Transport Infrastructure: Rail Electrification*, 2009, p.25.
[30] Ibid, p.11.
[31] Haylen et al., House of Commons Library, *Great Western rail delays and performance across the network, 2019, p.5-7.*
[32] National Audit Office, *Modernising the Great Western railway*, 2016, p.4
[33] Ibid, p.6-7.
[34] Ibid, p.35.
[35] Ibid, p.25-26.
[36] Welsh Affairs Select Committee, *The cancellation of rail electrification in South Wales*, 2018, p.7.

3. New generation electronic monitoring programme – Ministry of Justice (MoJ)

Project start: 2011	
Original planned completion: 2013	Initial estimate: £426 million[37]
Revised completion: 2019	Latest forecast: £580million[38]
Time overrun: 62 months (258 per cent)	Cost overrun: £154 million (36 per cent)

When the Ministry of Justice decided to replace G4S and Serco electronic monitors (popularly known as ankle tags) in 2011, they anticipated that it could be deployed in late 2013. It was hoped that the Ministry would be able to procure bespoke GPS-enabled monitors that would show wherever an offender was at any time, unlike regular tags that only transmit location information in relation to the offender's home.

Yet, the Ministry's procurement plan suffered from significant optimism bias. An especially ambitious timeframe for procuring the bespoke tags allowed just 15 months for them to be deployed. Furthermore, the Ministry had neither established that there was demand amongst sentencing authorities for GPS-enabled tags, nor whether they were technologically viable. The Ministry desired tags able to provide far more location data than existing models, which would meet increased data security standards, and crucially would be reliable, robust, comfortable and with minimal recharging requirements.[39]

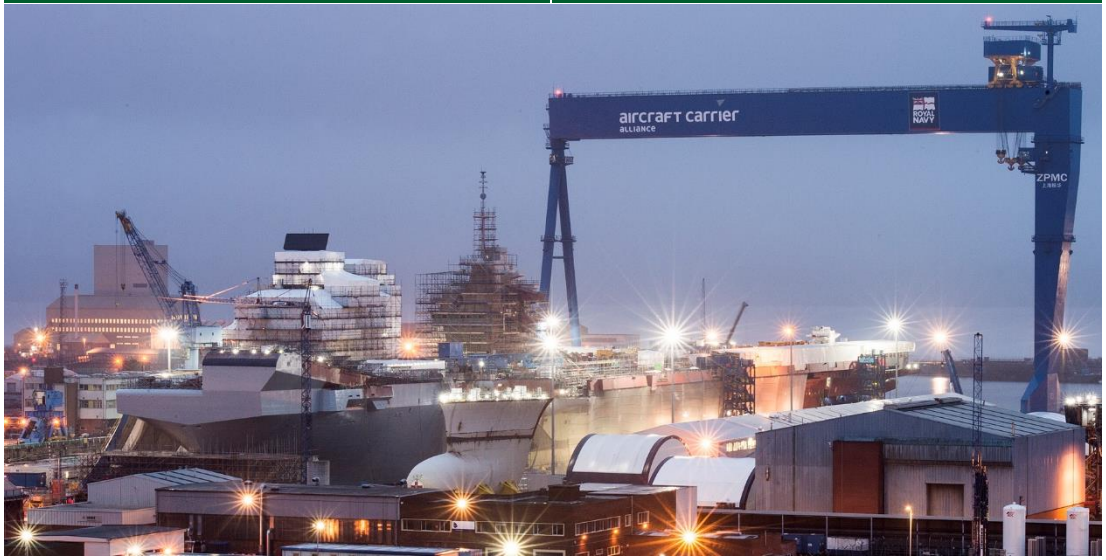
As events transpired, contracts were signed much later than planned. The first chosen supplier was dropped from the project in March 2014 over 'disagreements' about data security. A secondary supplier was dropped in 2015 over delays. This was followed by disputes with another supplier, Capita, which would not be resolved until June 2016.[40]

Finally, after six years wasted and £60 million spent developing the new tags, the ministry awarded a contract again to G4S for new tags already available on the market and the bespoke tag programme was dropped.[41] The rollout of the 'new' tags began in February 2019[42], more than 5 years after their due date of November 2013.

[37] Ministry of Justice, *MOJ Government Major Projects Portfolio data*, 2015.
[38] Ministry of Justice, *MOJ Government Major Projects Portfolio data*, 2019.
[39] National Audit Office, *The new generation electronic monitoring programme*, 2017, p.7-8.
[40] Ibid, p.9
[41] Ibid, p.7.
[42] Ministry of Justice, *Justice Secretary unveils GPS tag rollout to better protect victims*, 16 February 2019, available at: https://www.gov.uk/government/news/justice-secretary-unveils-gps-tag-rollout-to-better-protect-victims, accessed 31 July 2019.

4. Carrier Strike – Ministry of Defence (MoD)

Works start: July 2009	
Original planned completion: 2016	Initial estimate: £3.65 billion
Revised completion: 2023	Latest forecast: £6.8 billion[43]
Time overrun: 84 months (100 per cent)	Cost overrun: £3.15 billion (86 per cent)



The replacement of Britain's three Invincible-class 'light' aircraft carriers by two larger 'super' carriers (each Queen Elizabeth-class carrier is almost equal in tonnage to all three Invincible-class carriers combined) was initially committed to in 1998, with a final commitment following in 2007.

From almost the beginning, the procurement processes of these aircraft carriers was flawed. Initially expected to cost £3.65 billion[44] and with both ships expected to enter service by 2016, it was not long before overruns began to appear. By 2009, the forecast costs had already increased to £5.133 billion and in-service dates had shifted 10 months into the future.[45] The 2010 major projects report revised the increase by a further £767 million.[46] This early overrun increase was attributed to a decision to slow the production to ease the annual burden on the MoD budget, yet this had the adverse effect of increasing overall programme costs by £1.56 billion.[47]

Following the 2010 security and defence spending review (SDSR), the role and design of the carriers was again changed substantially. It was decided that only one carrier would be kept operable, with the second retained at 'extended readiness.' The one carrier to go into service would be converted to include catapult and arrestor gear to increase interoperability with allies, a decision which would delay the initial service date to 2020.[48]

The decision to convert one carrier to include catapults however was reversed just two years later in 2012. As it transpired, the 2010 decision had been based on "immature data and flawed assumptions" which underestimated the delivery estimate by three years for the first carrier.[49] Additionally, the value of allied interoperability had been overstated.

[43] Ministry of Defence, *MOD Government Major Projects Portfolio data, 2019*, 18 July 2018.
[44] National Audit Office, *Carrier Strike*, 6 July 2011, p.4.
[45] This figure (and the 2010 figure) included the £123m costs of extending the service life of the Invincible-class, though two of the three were later decommissioned following the 2010 SDSR. National Audit Office, *The Major Projects Report 2009*, 15 December 2009, p.10.
[46] National Audit Office, *The Major Projects Report 2010*, 15 October 2010, p.11.
[47] Ibid, p.15.
[48] HM Government, *Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review*, October 2010, p.22-23.
[49] National Audit Office, *Carrier Strike: The 2012 reversion decision*, 10 May 2013, p.11.

That the interoperability potential had been overstated was not, however, the main reason for the reversion. Relatively soon into the conversion development phase, the MoD's cost estimate for the conversion was found to be a 150 per cent underestimate. In 2010 it had been predicted that the conversion would cost either £500 or £800 million depending on the form of catapult. With the preference being for the more expensive electromagnetic system, the latter figure was the more accurate. It was not until the MoD was privy to US technological information that the true cost of an electromagnetic system became clear, at around £2 billion for a single carrier conversion. As a result of the U-turn, the MoD was estimated to have written off £62 million.[50]

In the investigation into how such an important decision was made without sufficient due diligence, the NAO noted several key reasons, such as overestimate of savings from a scaling down in the electromagnetic technology, design changes costs and the impact on industry. Ultimately, the catapults venture led to initial operating capability being moved back to 2020 for the first carrier, and to 2023 for both, as well as further unquantified costs arising from the period of uncertainty.[51]

Finally, in 2014, the fate of both carriers was secured when then prime minister David Cameron announced both would be made fully operational. Since then the costs of the programme have largely stabilised, with no further overruns reported since 2012-13.[52]

[50] Hammond, P, *Minister's statement on Aircraft Carriers and UK Shipbuilding*, 6 November 2013, Hansard, column 251. Available at: https://publications.parliament.uk/pa/cm201314/cmhansrd/cm131106/debtext/131106-0001.htm#13110656000003 (accessed 16 July 2019).
[51] National Audit Office, *Carrier Strike: The 2012 reversion decision*, 10 May 2013, p.7.
[52] According to analysis of government major projects data published annually from 2013-2018. Available at: https://www.gov.uk/government/collections/major-projects-data#2017-data (accessed 16 July 2019).

5. Crossrail – Department for Transport (DfT)

Works start: May 2009[53]	
Original planned completion: December 2019	Initial estimate: £15.9 billion Late estimate: £14.8 billion
Revised completion: April 2022	Latest forecast: £17.8 billion[54]
Time overrun: 27 months (24 per cent)	Cost overrun: £1.9 billion (12 per cent)

Crossrail is a long-anticipated infrastructure project in London that aims to run direct services from Reading and Heathrow in the west, to Shenfield and Abbey Wood in the east. The new line will be 73 miles long, stopping at 40 stations. This will include 10 new stations and 26 miles of new tunnels.

Excluding HS2, Crossrail is the biggest government project currently ongoing. The initial funding package was set at £15.9 billion in 2007, but reduced to £14.8 billion following savings made in 2010.[55] As late as 2017-18, Crossrail remained in budget, but what was not publicly known then, however, was that the project had already used all of Crossrail Ltd's £600 million contingency and was rapidly getting through the £2 billion contingency provided by Transport for London.[56]

In early 2018, as far as the public and parliament were aware, Crossrail was on track to arrive on time, with the full service due to open in late 2019 and the main line expected to open in late 2018. Throughout 2018, the scale of the work remaining gradually became apparent until, finally, Crossrail admitted in August 2018 (just four months before the main line was scheduled to begin running) that the programme was undeliverable with the main line not opening until late in 2019. This was later revised back as far as March 2021, with full project completion not likely until 2022.[57]

[53] Crossrail, *Construction of crossrail begins as foundations laid for new canary wharf station,* 15 May 2009. Available at: http://www.crossrail.co.uk/news/articles/construction-crossrail-begins-as-foundations-laid-for-new-canary-wharf-station (accessed 24 July 2019).
[54] It was announced on 23 July that Network Rail had been allotted an additional £200 million for its part of the Crossrail project against an original budget of £2.3 billion, and a revised budget of £2.6 billion. The total now stands at £2.8 billion. Grayling, C, *Minister's written statement on Crossrail,* Hansard, 23 July 2019, Volume 663. Available at: https://hansard.parliament.uk/Commons/2019-07-23/debates/19072367000022/Crossrail?highlight=department%20transport#contribution-497E2B15-2561-40A2-939E-99F1C468FE59 (accessed 24 July 2019).
[55] National Audit Office, *Completing Crossrail,* 3 May 2019, p.19.
[56] Public Accounts Committee, *Oral evidence: Crossrail, HC 2127.* Q. 56.
[57] Public Accounts Committee, *Completing Crossrail,* 10 July 2019, p.11.

Table 4: Crossrail cost forecasts over time[58]

Date of forecast	Cost forecast (£ billions)
October 2007	15.9
October 2010	14.8
July 2018	15.4
December 2018	17.6
July 2019	17.8

As the second largest government project in the pipeline, Crossrail has naturally attracted a lot of attention since the delay was announced. Both the National Audit Office and the Public Accounts Committee have published reports examining the delays. Both identified a range of reasons for the overruns.

Critical to the delays has, ironically, been a long held determination to see the main line complete by December 2018. This date was fixed in 2010 by the sponsors, chiefly the Department for Transport and Transport for London. Yet the sponsors had allowed Crossrail Ltd such a level of autonomy that there was little they could do to influence the progression of the project.[59] When DfT suspected the project was slipping in spring 2018, they had little recourse but to effectively rely on Crossrail Ltd's guarantees.[60]

The fixed date of 2018 also meant that multiple parts of the project had to run in parallel, such as boring new tunnels at the same time as completing new stations. This effectively created a chokepoint whereby one activity could be impacted by problems within another.

This optimistic approach was enabled by the perception that Crossrail had "an exceptional team capable of delivering exceptional results".[61]

This cavalier sense of optimism was endemic right to the top of Crossrail. When Andrew Wolstenholme, the former chief executive of Crossrail from 2011 to 2018, was questioned about the overruns he admitted that when he resigned from his position in March 2018 he believed that successful programme delivery was only 50 per cent likely. When asked why Crossrail Ltd did not request permission to deliver the programme late, Wolstenholme stated that the cheapest option was always to overcome the challenges.[62] Yet however admirable this determination to deliver on cost was, it also proved woefully optimistic and exacerbated the overall delays when the "exceptional team" did not deliver "exceptional results".

Though Crossrail Ltd must bear a significant proportion of the blame, it was also the 'long leash' that the company was allowed by Transport for London and the Department for Transport which prevented them from providing necessary oversight of the programme as far back as 2010.

[58] 2007, 2010 and 2019 figures are all referenced on the first page of this case study. 2018 figures are sourced from: Public Accounts Committee, *Completing Crossrail, 10 July 2019, p.8.*
[59] National Audit Office, *Completing Crossrail*, 3 May 2019, p.6.
[60] Public Accounts Committee, *Completing Crossrail, 10 July 2019, p.8-9.*
[61] NAO, p.22.
[62] Public Accounts Committee, *Oral evidence: Crossrail, HC 2127*, 2019, Q. 55.

6. Priority school building programme phase 2 – Department for Education (DfE)

Project start: 2014	
Original planned completion: March 2021	Initial estimate: £1.6 billion
Revised completion: December 2022	Latest forecast: £2.4 billion
Time overrun: 21 months (26 per cent)	Cost overrun: £900 million (50 per cent)

The Priority School Building Programme (PSBP) is a £4.4 billion project to rebuild and refurbish school buildings at 537 schools across the country.[63] The programme was split into two phases, the first of which was largely completed by the end of 2017. The second phase however (PSBP 2) did not begin until 2014 and was originally forecast for completion by March 2021.[64]

PSBP 2 aimed to rebuild the most deteriorated school buildings, or blocks of buildings, in England at 278 schools with a total whole life cost of £1.6 billion.[65] Yet almost from the start of the project the Infrastructure and Projects Authority branded successful project delivery to be in doubt and in possession of major risks, receiving an 'amber-red' rating.

When just £27 million of its annual budget of £77 million was spent in 2016-17, it became clear that some of the initial forecasts made had been overambitious, and that the roll-out was not proceeding as intended. This led to a 'major realignment' in 2017.[66] However, it also saw the lifetime project costs rise to £2 billion and the end date revised back 21 months to end of year 2022.[67]

2018 again saw the project rise even higher to £2.4 billion.[68] According to the Department for Education this rise was to avoid ever greater costs in the future due to a "deteriorating estate".[69] This suggests that the costs have come about as a result of the time delays the project has suffered.

Although this project has received only minimal public and parliamentary attention, it is experiencing significant time and cost overruns and continues to be branded 'amber-red' by the Infrastructure and Projects Authority.

[63] Education & Skills Funding Agency, *Priority School Building Programme: overview*, 6 December 2016, available at: https://www.gov.uk/government/publications/psbp-overview/priority-school-building-programme-overview (accessed 25 July 2019).
[64] Department for Education, *DfE Government Major Project Portfolio data, September 2015*, 7 July 2016.
[65] Ibid
[66] Department for Education, *DfE Government Major Project Portfolio data, September 2017*, 4 July 2017.
[67] Ibid
[68] Department for Education, *DfE Government Major Project Portfolio data, September 2018*, 18 July 2019.
[69] Ibid

7. Aberdeen Western Peripheral Route – Transport Scotland

Works start: December 2014[70]	
Original Planned completion: March 2018[71]	Initial estimate: £345 million[72]
Revised completion: February 2019[73]	Latest forecast: £745 million[74]
Time overrun: 11 months (25 per cent)	Cost overrun: £400 million (116 per cent)

The Aberdeen Western Peripheral Route (AWPR) project was first mooted in the 1950s, before eventually being announced in 2003.[75] The idea was to build a bypass around Aberdeen that would ease congestion and decrease north-south travel times.

From the very beginning, however, the project proved divisive. Though welcomed by business and council leaders, it was fiercely opposed by those who feared the environmental impact and sceptical of the potential cost of the project.[76] Following a public enquiry that was slated as "window dressing", and a failed legal challenge, work began in 2014.[77]

During construction, the project encountered numerous problems which contributed to the overruns. These included pipe diversions and re-cabling falling behind schedule, the region's worst ever recorded flooding and the collapse of Carillion, a key project partner.[78]

The other two project partners, Balfour Beatty and Galliford Try, absorbed the costs of the Carillion collapse and employed almost all the Carillion employees working on the AWPR. Yet in doing so they incurred costs that ran into the hundreds of millions.[79] Because the project was agreed on a fixed-price contract, the Scottish Government has not automatically had to cover these costs. This has led both companies undertaking settlement negotiations with Transport Scotland for liability for extra costs incurred. They claim that the true cost of the AWPR has risen to over £1 billion.[80]

[70] Scottish Government, *Major capital projects progress update 2016*, September 2016, p.5.
[71] Transport Scotland, *Infrastructure investment plan 2015: major capital projects progress update (March 2018)*, 17 April 2019, p.3.
[72] The early estimates of the project were £295-395 million, as such a midpoint has been used.
Swinney, J., *Plenary, 13 Jan 2010 : 13 January 2010 Business Motion*, Scottish Parliament, available at: http://www.parliament.scot/parliamentarybusiness/report.aspx?r=5130&i=44821&c=999901&s=Aberdeen%2520Western%2520Peripheral%2520Route (accessed 12 August 2019).
[73] Transport Scotland, *Infrastructure investment plan 2015: major capital projects progress update (March 2019)*, 17 April 2019, p.3.
[74] Ibid
[75] Banks, K., *Aberdeen bypass: The long and winding road*, BBC Scotland, 19 February 2019, available at: https://www.bbc.co.uk/news/uk-scotland-north-east-orkney-shetland-46586029 (accessed 12 August 2019).
[76] Ibid
[77] Ibid
[78] Rural economy and connectivity committee, *Statement by Balfour Beatty and Galliford Try for appearance on Wednesday 5 December 2018*, Scottish Parliament, 5 December 2018.
[79] Tarr, S., *Official Report of Meeting 5 December 2018*, Rural economy and connectivity committee, 5 December 2018, p.15-16.
[80] Ibid

8. Astute class submarine – Ministry of Defence (MoD)

Works start: 2001	
Original planned completion: 2022[81]	Initial estimate: £8.2 billion[82]
Revised completion: April 2025[83]	Latest forecast: £10.2 billion[84]
Time overrun: 28 months (11 per cent)	Cost overrun: £2 billion (24 per cent)

The replacement of Britain's Trafalgar class submarines began in 1997, with the first of the Astute-class submarines laid down in 2001. The replacement of the Trafalgar class submarines was done in two batches. The first three boats were ordered together and delivered individually between 2010 and 2016. The following four were ordered one by one, to be commissioned between 2019 and 2024.

From the beginning, the complexity of the project turned out to be greatly underestimated. What was expected to be a modest upgrade to the Trafalgar class swiftly became more challenging than expected. A wider reactor, and necessary lower radiation signatures meant the Astute-class would become a far more complicated design than the Trafalgar class.[85]

Problems were exacerbated by lack of expertise of those working on the project: too many skilled people had already retired or moved on.[86] This caused problems at several levels of the programme, including in design. Due to a lack of skilled designers, the use of 3D Computer Aided Design software actually increased design time and costs.[87] Eventually US designers had to be brought in to assist.[88]

It had also been assumed that parts from previous classes of submarine would be suitable for Astute, yet this optimism was misplaced as much of this equipment was no longer procurable.[89]

The first boat, HMS Astute, had been expected to enter service in 2005, though after delays would not be commissioned into the Royal Navy until 2010. This initial delay seemingly created a butterfly effect throughout the programme as the fourth boat, HMS Audacious, has yet to put to sea having been laid down 12 years ago.[90]

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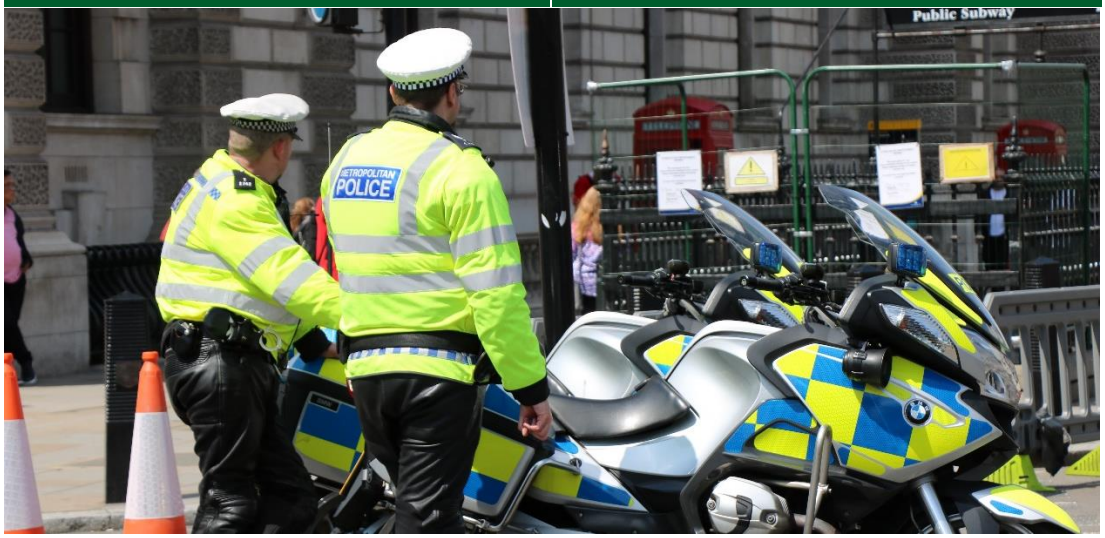
[81] Ainsworth, B., *written question: attack submarines*, 3 March 2008, available at: https://hansard.parliament.uk/Commons/2008-03-03/debates/08030334000004/AttackSubmarines?highlight=astute%20submarine#contribution-08030334000042 (accessed 26 July 2019)
[82] National Audit Office, *Major Projects Report 2015 and the Equipment Plan 2015 to 2025*, 22 October 2015, p.42
[83] Ministry of Defence, MoD *Government Major Project Portfolio data, September 2018*, 18 July 2016.
[84] This figure is a combination of the cost of boats 1-3 contained within the Major Projects Report 2015 (see footnote 82) and the figures cited within the below article. The source has been verified through contact with the article writer.
Jones, H, *Astute boats 4-7 now more than £800m over budget.* UK Defence Journal, 11 September 2018, available at: https://ukdefencejournal.org.uk/astute-boats-4-7-now-more-than-800m-over-budget/ (accessed 26 July 2019)
[85] Schank, J et al., *Learning from experience. Lessons from the United Kingdom's Astute Submarine* Program. RAND National Defense Research Institute, 2011, p.39.
[86] Ibid, p.40.
[87] Ibid, p.43.
[88] Ibid, p.44.
[89] Ibid, p.41.
[90] Save The Royal Navy, *HMS Audacious yet to begin sea trials, risking further decline in Royal Navy submarine numbers*, 22 June 2019, available at: https://www.savetheroyalnavy.org/hms-audacious-yet-to-begin-sea-trials-risking-further-decline-in-royal-navy-submarine-numbers/ (accessed 26 July 2019).

9. Emergency Services Network – Home Office

Project start: 2015	
Original planned completion: 2019	Initial estimate: £6.2 billion
Revised completion: 2022	Latest forecast: £9.3 billion
Time overrun: 3 years (37 per cent)	Cost overrun: £3.1 billion (49 per cent)



The Emergency Services Network (ESN) project plans to replace the current Airwave system with a new system capable of using 4G networks. When working, it will be one of the most advanced emergency services networks in the world, an ambition that has greatly extended the implementation timeline and seen the costs soar.[91]

When the business case was made in 2015, it was anticipated that the project would be fully implemented by December 2019, and would have a lifetime cost of £6.2 billion – saving £3.6 billion over 17 years when compared with the costs of Airwave.[92] Relatively soon, however, the project began to encounter problems. By September 2016, it was already five months behind schedule,[93] a delay that was considered recoverable. By early 2017, this attitude had shifted significantly, when the timeline was extended a further nine months, and even more to three years in 2018.[94]

The National Audit Office had expressed concern that the project was undeliverable in 2016, believing the project's goals were overambitious. With the Airwave system, although expensive, it already provided a superior system than most G20 countries, and it was unclear if attempting to replace it with a significantly more advanced system was worth the risk.[95] Unlike Airwave, which was an independent network, ESN would use a commercial network but one which, at the time, had only 70 per cent UK coverage.[96]

Apart from £1.7 billion additional programme and contingency costs, delaying the programme meant that the use of Airwave had to be extended at a cost of £1.4 billion.[97] This resulted in a decline in quantified benefits of £1.5 billion. As things stand, it remains unclear if the forecast costs and completion dates will rise further.

[91] National Audit Office, *Upgrading emergency service communications: the Emergency Services Network Summary,* 15 September 2016, p. 7.
[92] National Audit Office, *Progress delivering the Emergency Services Network Summary,* 10 May 2019, p.9.
[93] National Audit Office, 2016, p.4.
[94] Public Accounts Committee, *Oral evidence: Emergency Services Network: progress review, HC 1755,* 22 May 2019, p.7-9
[95] National Audit Office, 2016, p.7.
[96] Ibid, p.4.
[97] National Audit Office, 2019, p.4.

10. Core Production Capability – Ministry of Defence (MoD)

Project start: 2012[98]	
Original planned completion: 2023[99]	Initial estimate: £1.2 billion[100]
Revised completion: 2028[101]	Latest forecast: £1.7 billion[102]
Time overrun: 52 months (40 per cent)	Cost overrun: £500 million (42 per cent)

The Core Production Capability project is a MoD programme that aims to regenerate nuclear core production facilities on a Rolls-Royce site in Derby. The purpose is to sustain core production capabilities, so that nuclear reactor cores can be produced and developed for the ballistic missile submarines carrying the Trident nuclear deterrent at present and in the future.

The programme encountered troubles in 2012 when concerns emerged over the integrity of the reactor cores within Vanguard-class nuclear submarines. As a precaution, it was announced in 2014 that HMS Vanguard would be refueled, with HMS Victorious possibly refueled in the future.[103] Nuclear refueling is an extremely complex matter that can take years and cost10s of millions of pounds or more. Usually it is done just once during the lifetime of a submarine.

In 2018, however, the government announced no further refueling would be necessary after a series of technical assessments established the problem was resolved. The precautionary refit had however meant the programme spent around £270 million from its contingency funds and led to project completion being delayed to 2028.[104]

All four Vanguard-class submarines underwent extensive refits between 2002 and 2012 in HMNB Devonport during which all were retrofitted with new pressurised water reactors. The cost of refitting the final submarine alone, HMS Vengeance, was £350 million.[105] The refit of HMS Vanguard completed in 2004 had at the time expected to be the final refit during the ship's lifespan.

[98] Infrastructure and Projects Authority, *MoD Government Major Project Portfolio Data, 2014.* 23 May 2014.
[99] Ibid
[100] Ibid
[101] Infrastructure and Projects Authority, *MoD Government Major Projects Portfolio Data, 2019.* 18 July 2019.
[102] Ibid
[103] Save the Royal Navy, *A relief for the submarine service – HMS Victorious does not need nuclear refuelling.* November 7 2018. Available at: https://www.savetheroyalnavy.org/a-relief-for-the-submarine-service-hms-victorious-does-not-need-nuclear-refuelling/. Accessed 30 July 2019.
[104] Ibid
[105] Ministry of Defence, *British jobs secured through upgrade to nuclear deterrent,* 4 December 2015. Available at: https://www.gov.uk/government/news/british-jobs-secured-through-upgrade-to-nuclear-deterrent (accessed 30 July 2019).

Conclusion

The first two sections of this report examined how common overruns were, and why they might have happened by examining a range of studies on the topic. From this analysis it is clear that overruns have in the past occurred far too frequently and proven a persistent problem for policymakers at home and abroad. Furthermore, past analyses have generally blamed optimism bias for the overruns.

Ten recently concluded or ongoing projects that were experiencing overruns in the UK were examined, including some of the UK's biggest projects such as Crossrail and Carrier Strike. Between those and the remaining eight projects, they have accrued a total time overrun of 33.5 years and a total cost overrun of £17.2 billion.

The causes for the overruns examined in this study are broad. In the case of Thameslink, the Electronic Monitoring Programme, and the Emergency Services Network, the overruns can generally be attributed to high ambitions and complexity. The modernisation of the Great Western Railway and procurement of Carrier Strike meanwhile chiefly encountered troubles due to poor project management early on in their lifecycles. Crossrail suffered from a leadership team imbued with a cavalier sense of optimism, coupled with a fixed completion date at the beginning of the project that may never have been achievable. In contrast, the problems encountered by the Aberdeen Western Peripheral Route and the Core Production Capability programmes were largely beyond the control of project managers.

As such, in the cases examined, overruns (at least to the significant extent identified) are not always avoidable and projects are susceptible to factors beyond the reasonable control of project managers. However, in most cases the scale of the overruns was such because of factors that should have been identified at the very beginning of a project's lifecycle, before funding was approved. Had ministers been aware, for example, that the Great Western railway modernisation cost-benefit ratio would fall so far, it is questionable whether the project would have been approved in the first place.

Recommendations

Though there is likely no miracle cure to solving the cost overruns puzzle, there are some steps government could take to reduce the frequency of overruns:

- Those responsible for long-term problems within major projects must be held sufficiently accountable later. Civil servants often move across multiple departments over their careers and can enjoy lucrative private sector careers off the back of this. Regardless of where their career takes them, they must expect to be held accountable for their own failures whenever they occur.

- The senior decision makers and managers within major projects should receive any bonus remuneration in a way that better reflects the pace of the project. This could mean for example, that bonuses are paid out over time, contingent on the successful implementation of the project.

Methodology

This report has been conducted by collating research into major projects overruns in the UK and internationally.

The case studies in the report were selected to represent a range of departments and government organisations. The Ministry of Defence and Department for Transport have provided the majority of the projects analysed. This is because they make up the majority of projects listed by the government as major projects by the infrastructure and projects authority, and have high levels of capital expenditure relative to their departments.

When possible, the cost estimate cited by government has been used (where available) at the time of project approval. This is often different to when funding is agreed to illustrate that projects are often promoted and gain support based on those early optimistic cost-benefit forecasts.

Project start dates are often not comparable with cost forecasts and are invariably decided later. Where possible, a works start date has been used to illustrate the real length of project delivery. However, in cases where this is less easily defined, such as in PSBP2 and in IT projects a more general project start date has been used.

Additionally, prices have not been redefined to account for inflation and often represent cash prices. This is because varying government sources do not consistently make clear if this has been done already, to do so would risk adding inflation to a figure that has already accounted for this.

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