National Audit Office

Report
by the Comptroller
and Auditor General

Ministry of Defence

Managing infrastructure projects on nuclear-regulated sites

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Managing infrastructure projects on nuclear-regulated sites

Report by the Comptroller and Auditor General

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Comptroller and Auditor General
National Audit Office

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This report examines the Ministry of Defence's (the Department's) management of its large and complex infrastructure projects at nuclear-regulated sites.

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Contents

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Key facts

£2.5bn

current forecast cost of the Ministry of Defence's three infrastructure projects under construction at its nuclear-regulated sites, October 2019[1]

£1.35bn

total increase (115%) in project costs between initial and latest position for the three projects reviewed

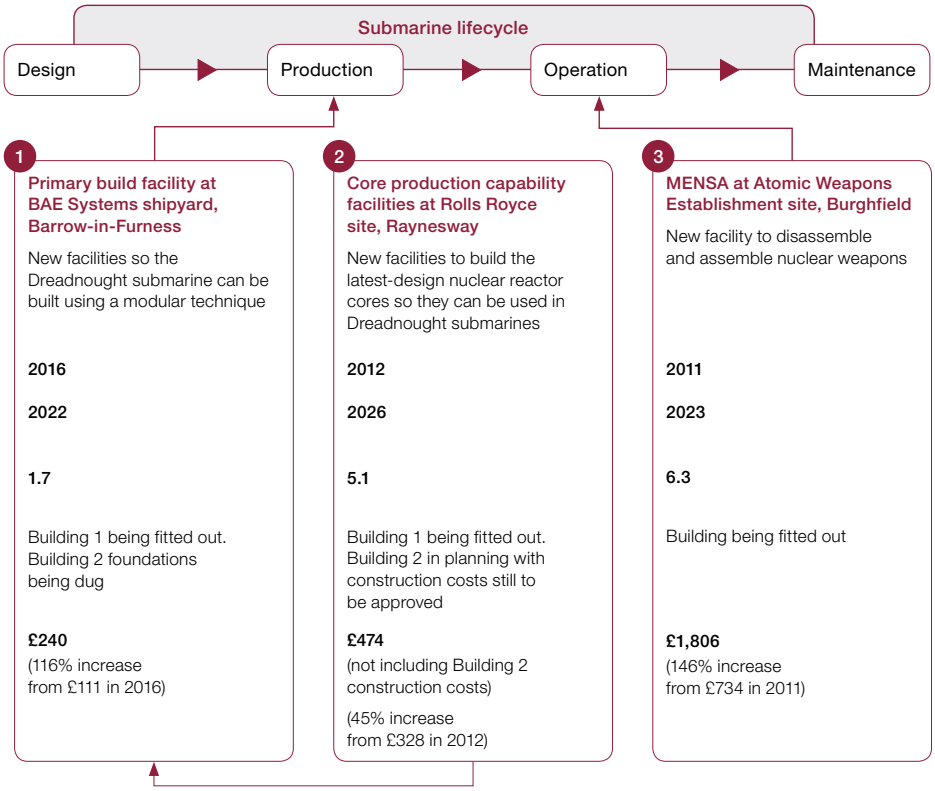
£647m

estimate of the total cost increase across the three projects arising from the Ministry of Defence starting construction too early

24%

percentage attributed to three projects, by their initial value, of the Ministry of Defence's 52 current Nuclear Enterprise infrastructure projects, initially valued at £4.9 billion

The Ministry of Defence's (the Department's) three infrastructure projects currently in construction at nuclear-regulated sites



	1 Primary build facility at BAE Systems shipyard, Barrow-in-Furness	2 Core production capability facilities at Rolls Royce site, Raynesway	3 MENSA at Atomic Weapons Establishment site, Burghfield
	New facilities so the Dreadnought submarine can be built using a modular technique	New facilities to build the latest-design nuclear reactor cores so they can be used in Dreadnought submarines	New facility to disassemble and assemble nuclear weapons
Project start	**2016**	**2012**	**2011**
Latest forecast completion date	**2022**	**2026**	**2023**
Estimated delay to in-service date (years)	**1.7**	**5.1**	**6.3**
Current stage	Building 1 being fitted out. Building 2 foundations being dug	Building 1 being fitted out. Building 2 in planning with construction costs still to be approved	Building being fitted out
Current forecast cost (£m)	**£240** (116% increase from £111 in 2016)	**£474** (not including Building 2 construction costs) (45% increase from £328 in 2012)	**£1,806** (146% increase from £734 in 2011)

Note

1 Figures cover the Ministry of Defence's three infrastructure projects at nuclear-regulated sites that are currently in the construction phase. It does not cover other projects, such as at Devonport, HM Naval Base Clyde and the Atomic Weapons Establishment Pegasus project which are in their earlier stages.

Source: National Audit Office analysis of Ministry of Defence data

Summary

Introduction

1 The Ministry of Defence (the Department) maintains a submarine-based continuous at sea nuclear deterrent to support the government's national security policy. To do so it relies on a network of equipment, people and infrastructure, often referred to as the Defence Nuclear Enterprise (the Enterprise).[1] The infrastructure includes sites critical to producing, installing, operating, maintaining and disposing of nuclear reactor cores and weapons. These are known as nuclear-regulated sites (sites). Some, but not all, sites are owned by the government, with several of the most significant ones owned or operated by contractors. For these sites to operate, independent regulators must provide assurance that they, and the facilities within them, can safely handle nuclear materials. This includes by having sufficiently thick walls to contain any nuclear material, and deep enough foundations to withstand an earthquake.

2 Site regulators include the Office for Nuclear Regulation (ONR), which regulates Departmental sites licensed under the Nuclear Installations Act 1965, and the Defence Nuclear Safety Regulator (DNSR), which approves the safety of non-licenced Department-operated sites. For the construction of new facilities, the regulators carry out additional reviews, as well as providing any required legal permissions.

3 The Department currently has a number of large and complex construction projects for facilities at nuclear-regulated sites. These include three projects, currently valued at £2.5 billion, where construction has already started. The Department is undertaking these projects for different reasons. These include replacing ageing facilities built as early as the 1950s when the UK first invested in a nuclear submarine capability. The projects we examined (see Appendix Three) are:

- **MENSA:** The Department is building a new nuclear warhead assembly and disassembly facility at the Department-owned and Atomic Weapons Establishment (AWE)-operated site in Burghfield (Reading).[2]
- **Core production capability (CPC) facilities:** The Department is replacing facilities at the Rolls Royce-owned and operated site in Raynesway (Derby) so it can produce the latest nuclear reactor core designs.

1 Comptroller and Auditor General, *The Defence Nuclear Enterprise: a landscape review*, Session 2017–2019, HC 1003, National Audit Office, May 2018.
2 AWE refers to both AWE Management Limited, the commercial entity with whom the Department contracts, and AWE Plc, who operate sites on their behalf.

- **Primary build facility**: The Department is building new facilities at the BAE Systems-owned and operated shipyard in Barrow-in-Furness (Cumbria), which will allow a modular-build approach for the Dreadnought-class submarines.

The Department is also considering further projects at nuclear-regulated sites, which include the docks in Devonport and at HM Naval Base Clyde. A further project, to build a replacement facility for storing and manufacturing enriched uranium components at the AWE-operated Aldermaston site, has been paused.

4 For nuclear-licenced sites, statutory arrangements mean that the Department does not itself have a formal regulatory role.[3] Under statute, the regulator ensures site operators reduce nuclear and other safety risks to levels that are as low as reasonably practicable. This involves the construction and maintenance of facilities meeting modern regulatory standards. Although the regulator and site operator recognise the need for value for money, they are not formally required to focus on this factor under statute. As the Department pays for the facilities, it is responsible for securing value for money from its contractors. These arrangements differ from those for civil nuclear projects, where the site operator, also regulated by the ONR, pays for the infrastructure, with costs then reimbursed by government and value-for-money incentives more easily created.[4] For the projects we examine, the nuclear regulators have continued to assess sites as safe to operate.

5 To ensure value for money during the early project stages, the Department must overcome both the inherent risks affecting all complex infrastructure projects, as well as the unique nuclear regulatory challenges. This report examines if the Department's management of these projects to date represents value for money. It assesses whether the Department works with site operators and regulators to produce cost-effective designs; if commercial arrangements transfer risks; and how these projects are managed. In doing so, it aims to set out lessons for the Department to consider when completing these projects and planning its next cycle of such projects, as well as for others managing similarly complex work.

6 Against this background, this report examines:

- progress to date with infrastructure projects on nuclear-regulated sites (Part One);
- the Department's approach to the nuclear regulatory environment (Part Two); and
- whether the Department's project management aligns with accepted programme and commercial management standards (Part Three).

Appendix One outlines our audit approach. We focus on the three projects listed in paragraph 3. We do not conclude on whether the Department's decisions to undertake these projects represent value for money.

3 For Departmental-owned and operated sites, the DNSR reports directly to the Secretary of State for Defence.
4 For the purposes of this report, reference to 'civil nuclear' relates to sites under the responsibility of the Nuclear Decommissioning Authority.

Key findings

Performance to date

7 **None of the three projects in our review will be delivered to their original timeframe, with delays of between 1.7 to 6.3 years, and a combined £1.35 billion cost increase.** The projects all experienced cost increases and delays in their early stages, with projects for CPC facilities and MENSA being re-scoped. Given the complex nature of these programmes, a range of factors – similar to those identified across civil nuclear and earlier defence projects – contributed to the cost increases and delays. As described in paragraphs 16 to 19, the Department has since changed its project and commercial approach and has progressed each project (paragraphs 1.15 to 1.18, Figures 4 to 6).

8 **Delays and cost increases have impacted more broadly across the Enterprise.** The Department needs the facilities covered by these three projects to provide critical aspects of the Enterprise, such as the nuclear propulsion systems for submarines to operate and nuclear warheads to arm them. Delays with these projects affect the existing infrastructure, which must continue in service for longer, and the wider Enterprise. For example, following delays to MENSA, the Department and its contractor AWE had to continue using existing infrastructure. In 2016, the ONR stated AWE could do this for a further three years. The Department expects to spend £21 million between 2016-17 and 2019-20 on site upgrades to maintain regulatory approval to use the site. For the primary build facility project, the Department continues to consider how to mitigate the impact of potential delays to the project on the Dreadnought-class submarine production programme (paragraphs 1.14, 1.16 and 1.17, Figure 3).

9 **The Department has not learned all it could from the early stages of similar projects concluded in the UK and elsewhere**. The Department has experienced similar challenges to those identified during its last cycle of nuclear-regulated site investment in the 1980s and 1990s. These include starting to build before requirements or designs were sufficiently mature, increasing risks through inappropriate contracts, and failing to engage with regulators to understand requirements. Some of these challenges were also identified in UK civil projects and American defence projects. Many – including Department-wide projects – were subject to extensive reviews, but we did not identify examples of the Department formally capturing and sharing lessons learned (paragraph 3.19 and Figure 11).

Understanding the reasons for past performance

Working with regulators and site operators

10 The Department did not manage the value-for-money risks arising from its lack of a formal regulatory role. The Department, regulators and contractors all raised concerns with us that without further controls and a lack of consistent, three-way engagement, there is a risk of designs being over-specified and therefore more costly than necessary. Regulators do not specify the design, which is developed by the site operator based on publicly available regulatory standards. Without an in-depth technical review comparing designs to requirements, the extent of over-specification is difficult to establish. However, indications these risks have not been managed include the Department not having routine three-way discussions with the regulator and site operator around cost-effective designs, and an independent review identifying over-specified designs for the primary build facility (paragraphs 2.4 to 2.7).

Commercial management

11 The Department did not set up contractual arrangements to share financial risks, meaning it bore the full impact of cost increases itself. The primary supplier contracts for the three projects we examined did not incentivise suppliers to control cost growth. In addition, the contract terms meant AWE earned additional fees when work got deferred, which partly resulted from the Department needing to achieve in-year savings. The Department's exposure to cost increases grew as its primary suppliers generally contracted with their supply chain on a cost-plus basis. This meant subsequent cost increases transferred to the Department. For example, for the primary build facility contract, the Department has to date paid £65 million for cost increases incurred by the supply chain (paragraphs 3.5 and 3.6).

12 In two of three cases we looked at, the Department had limited contractual levers and insufficient oversight to reduce its risk exposure. For project MENSA, both the Department and AWE failed to effectively oversee contracts. The Department told us that, as a result, it took them some time to identify emerging problems such as a lack of design maturity and poor sub-contractor performance, contributing to cost increases and delays. A lack of commercial expertise within the Department and its primary contractors contributed to this insufficient oversight. Also, for the CPC facilities contract, the Department has limited means to respond to poor performance. The overarching contract does not include performance measures and has limited termination opportunities should performance deteriorate. Like other infrastructure-related contracts, the Department will not be able to exit the contract without decommissioning the facilities (paragraphs 3.7 to 3.9).

Project management

13 By progressing projects too quickly early on, the Department increased its risk exposure. A reliance on monopoly site operators (AWE, BAE Systems and Rolls Royce) weakens the Department's commercial negotiating position and means it is more likely to hold more of the contractual risks. Furthermore, the inherent uncertainties of early designs do not incentivise site operators, or their sub-contractors, to negotiate and share risks, increasing risks for the Department. Departmental risks further increased, when it started building before both the requirements and design were mature. For the three projects in our review, this contributed 48% of the total £1.35 billion cost increase. For example, for the primary build facility contract, construction costs increased by £108 million following changes in requirements (paragraphs 1.17, 3.2, 3.9, 3.16 and 3.17, and Figure 6).

14 The Department did not always manage interdependencies across Enterprise projects, contributing to projects starting too early. The three infrastructure projects in our review have interdependencies, both with each other and across the Enterprise. The Department did not always build into projects the flexibility to allow for changes. For example, the Department undertook a wider project to determine what the future nuclear reactor core would look like. However, it started building the new CPC facilities without a clear specification of the core design and a full understanding of how the facility would be used. The initial facility subsequently turned out to be too small, contributing to the £146 million total project cost increase. Unforeseen events, such as the Department's decision to refuel *HMS Vanguard*, also had time and cost implications for the project (paragraphs 3.16 and 3.17)**.**

15 The Department and its contractors struggled to secure the knowledge needed to design and build cost-efficient infrastructure. Regulators require site operators to provide detailed documentary evidence to show that proposed site changes meet regulatory standards. This includes evidence of design specifications, testing and the source of all parts used in the build. Preparing such documents requires specialist knowledge and skills but, as we have previously reported, there remain nuclear-related skills gaps across the Enterprise. Given the specialist nature of the projects we reviewed, and the small pool of contractors able to design and construct them, the three site operators were using many of the same contractor firms. In addition, project MENSA had specific staff shortages (paragraphs 1.9, 2.6, 3.3, 3.15 and 3.16).

Addressing the challenges affecting past performance

16 After earlier challenges, the Department has made progress during the later stages of these infrastructure projects. After developing greater certainty across project MENSA and the first phase of the CPC facilities project, by October 2019 the Department had built the facilities. It is now focused on fitting them out and seeking regulatory approval for the sites to be used. In 2018, the Infrastructure and Projects Authority assessed MENSA as 'Amber' in terms of delivery confidence, publishing the same assessment for the broader CPC project, which covers the new facilities and site operation, in July 2019. For the primary build facility, one building has now largely been constructed, and is being fitted out, with the construction of the foundations having started for the other building (paragraph 1.19).

17 By introducing organisational changes, the Department aims to improve its oversight of infrastructure projects. By establishing in 2016 the Defence Nuclear Organisation (DNO), which has a dedicated nuclear warhead team directly overseeing AWE-site projects, the Department aims to improve its project oversight and ability to identify and manage interdependencies. Also, in 2017, AWE sub-contracted the management of project MENSA to improve oversight and the handling of interdependencies. It is too early to assess the impact of these changes. The Department continues to consider the MENSA project as challenging, with successful completion dependent on managing significant delivery risks (paragraphs 3.13 to 3.15 and Figure 10).

18 Since 2016, the Department, site operators and regulators have established more constructive relationships to better manage value-for-money risks. Each party told us that after developing a clearer understanding of the previous project challenges, relationships and interactions had improved. Since the DNO's creation in 2016, the Department has been more directly involved in regulatory discussions. For example, at both AWE and in Devonport, a senior-engagement forum of all parties was created to discuss requirements and progress, with the Department looking to establish a similar group for the primary build facility project. Through these groups, the Department aims to develop more efficient approaches to designing infrastructure. From our work on the Nuclear Decommissioning Authority, we know how such forums can contribute to the better management of nuclear projects (paragraphs 2.8 and 2.9).

19 The Department re-negotiated its contract covering the largest project, MENSA, but must still manage some commercial risks. In 2016, the Department renegotiated its contract with AWE, which covered MENSA. This change ensured the contract complied with the Single Source Contract Regulations 2014, which are designed to give the Department greater visibility over costs. AWE also renegotiated contracts with its supply chain, with 85% now having a fixed price, either through a fixed or target cost contract. However, the Department was not able to renegotiate the contract covering its CPC facilities project with Rolls Royce. It did seek to mitigate the risk of contracting for uncertain designs by separating out the design and construction for the second phase of the project (paragraphs 3.4, 3.6 and 3.18).

Conclusion on value for money

20 To maintain the continuous at sea deterrent, the Department must complete three critical infrastructure projects, valued at £2.5 billion, on its nuclear-regulated sites. It has made some progress, with the MENSA facility to assemble and disassemble nuclear weapons and the CPC facilities now taking shape. However, these three projects experienced problems in their earlier and riskier stages, with a cumulative £1.35 billion cost increase and delays of between 1.7 and 6.3 years. Given the interdependencies across different elements of the Nuclear Enterprise, such delays have broader implications which the Department must manage.

21 The challenges with these projects were not unique. It is therefore disappointing to see that in their early days the Department made the same mistakes, also experienced by others, as were made more than 30 years ago. To secure value for money, the Department should have managed the inherent challenges of these projects, such as not starting construction too soon and allowing some flexibility, as well as addressing the risk of not having a statutory role to agree cost-effective designs. In not doing so, the Department's early management of these projects has not delivered value for money. More recently, the Department has started to get to grips with the challenges through revised commercial, regulatory and governance arrangements, although it is too early to tell whether these will be effective.

Recommendations

22 Over the past three years, the Department has introduced revised governance arrangements and developed its relationship with regulators. As well as embedding these changes, the Department should, for these and future projects:

a **undertake work to better understand, quantify and manage the inherent risks presented by the regulatory arrangements.** Although not having a statutory regulatory role, the Department should work with regulators and site operators so that all parties understand value-for-money risks with designs and consider these risks through formal discussions;

b **more explicitly recognise and manage the inherent uncertainties associated with the early stages of these projects.** For each project, the Department should consider the appropriate milestones needed to reassess progress alongside the remaining uncertainties and flexibility needed. This should be balanced against allowing teams to press forward with projects;

c **agree commercial arrangements with site operators that better balance risks and ensure they share some risks, particularly as projects progress.** The Department should fully consider using all available levers to reduce its risk exposure, including the Single Source Contract Regulations or by splitting commercial arrangements into stages with agreed milestones for defined work;

d **put the structures in place to understand and manage interdependencies between projects.** The Department may need to take some risks by starting projects early given interdependencies across the Enterprise, and the uncertainties associated with future requirements. When it does so, the Department should ensure it recognises and manages the potential impact of these decisions;

e **introduce ways to identify and apply lessons learned from other projects, both within the Department and from other sectors**. Infrastructure projects at civil, military and overseas nuclear-regulated sites have experienced similar problems over the years, which have been the subject of multiple reviews. The Department should work across government to share lessons learned on how to challenge, interpret and apply regulations to achieve value for money; and

f **continue efforts to develop nuclear capacity and skills within the Department and its contractors**. As well as investing in graduate programmes and apprenticeship schemes, and working with civil nuclear colleagues, the Department should think more broadly as to how it can sequence its major projects to develop a smoother work profile and more stable job market. It should think innovatively about how to increase staff capacity, such as requiring contractual partners to maintain a minimum number of experienced specialist staff.

Part One

Nuclear-regulated site infrastructure projects

1.1 To maintain the Nuclear Enterprise (the Enterprise) the Ministry of Defence (the Department) requires nuclear-regulated facilities in which to produce, install, maintain and dispose of nuclear reactors and weapons.[5] The Department currently has several large and complex projects under way to enhance or replace this infrastructure. Collectively, these projects affect all parts of the Enterprise and are critical to maintaining the continuous at sea deterrent. This Part describes the nuclear-regulatory environment and progress with these projects.

Nuclear-regulated sites

1.2 The government regulates all defence and civil sites handling nuclear materials to ensure their ongoing safety and to fulfil the UK's commitment to act as a responsible nuclear power. These sites are known as nuclear-regulated sites (sites). To operate, site operators must show they meet specified nuclear safety standards such as providing necessary training and undertaking regular safety inspections. For example, they must demonstrate that submarine docks can withstand earthquakes or that explosions within nuclear manufacturing facilities can be contained. Should independent regulators identify that unacceptable risks exist or regulatory conditions are not met, they can require sites to undertake specific proportional improvements, set conditions on how the site operates or ultimately stop sites operating altogether.

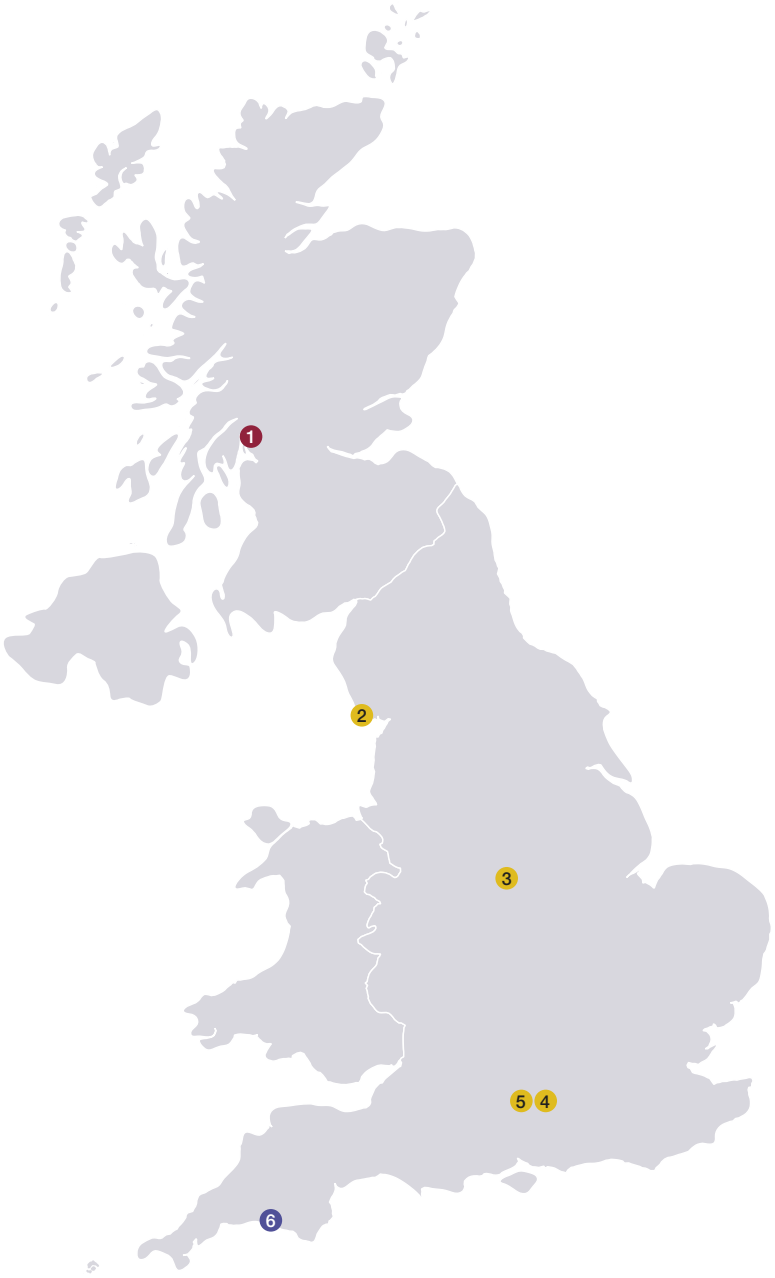
1.3 The Department uses eight nuclear-regulated locations to operate the continuous at sea deterrent. Of these, the government has a role owning and operating two, with contractors owning or operating the remainder. Two different regulators – the independent Office for Nuclear Regulation (ONR) and the Defence Nuclear Safety Regulator (DNSR) within the Department – regulate these sites depending on who operates them (**Figure 1** on pages 14 and 15). Other regulatory bodies, such as the Environment Agency, also oversee sites for reasons other than nuclear safety. To date, the regulators have always assessed these nuclear-regulated sites as safe to operate, although ONR continues to provide enhanced regulatory oversight over some sites given significant historic safety shortcomings (paragraph 2.11).

5 The Nuclear Enterprise comprises a network of programmes, equipment and people which together design, produce and maintain submarines and nuclear warheads, and provide the necessary infrastructure, people and support.

Figure 1

Summary of the main nuclear-regulated locations used by the Ministry of Defence

Different nuclear regulators oversee the Ministry of Defence's nuclear-regulated sites



Notes

1 In addition, the Defence Nuclear Safety Regulator (DNSR) oversees the nuclear components and materials handled on sites. The term 'nuclear-regulated' refers to sites for which the Office for Nuclear Regulation issues a licence and where the DNSR approves the use.

2 Although the Ministry of Defence retains legal ownership of the Atomic Weapons Establishment sites, AWE Plc operates the sites.

3 The Ministry of Defence uses further nuclear-regulated sites across the Nuclear Enterprise such as in Rosyth, to dismantle out-of-service submarines, and the Vulcan nuclear reactor testing site in Dounreay, Scotland.

Source: National Audit Office

1 HM Naval Base Clyde

Owner/operator: Ministry of Defence

Regulator: Defence Nuclear Safety Regulator

The base covers:

- Faslane, which supports in-service submarines.
- Coulport, where nuclear weapons are stored, maintained and issued.

The Ministry of Defence is progressing upgrades to both non-nuclear regulated and regulated areas.

2 Barrow shipyard

Owner/operator: BAE Systems

Regulator: Office for Nuclear Regulation

Currently the only UK site capable of building submarines. Includes nuclear-regulated areas, for example for handling nuclear reactor cores. The Ministry of Defence is undertaking a site-wide programme to upgrade infrastructure built in the 1950s and ensure facilities can be used to manufacture Dreadnought.

3 Raynesway

Owner/operator: Rolls Royce

Regulator: Office for Nuclear Regulation

Site builds and tests the nuclear propulsion-related submarine components and reactor modules (cores). Within Raynesway there are two nuclear-licensed areas.

4 Burghfield and Aldermaston

5 Owner: Ministry of Defence

Operator: AWE Plc

Regulator: Office for Nuclear Regulation

Sites, established from the 1950s, support the design, manufacture, maintenance and decommissioning of nuclear weapons. They were largely built in the 1960s. The regulator conducts an enhanced regulatory arrangement across these sites.

6 Devonport Royal Dockyard

Owner/operator: Ministry of Defence/Babcock

Regulator: Office for Nuclear Regulation/Defence Nuclear Safety Regulator

Site maintains and defuels submarines and covers nuclear-licenced docks, operated by the Ministry of Defence. Babcock owns and operates other areas licensed by the Office for Nuclear Regulation.

- Ministry of Defence sites primarily regulated by the Defence Nuclear Safety Regulator
- Contractor sites primarily regulated by the Office for Nuclear Regulation
- Site regulated by a combination of the Defence Nuclear Safety Regulator and the Office for Nuclear Regulation

Office for Nuclear Regulation

1.4 In line with legislative requirements set by the Energy Act 2013 and the Nuclear Installations Act 1965, the ONR licenses defence sites operated by third parties, rather than the Department. The ONR carries out the same legislative role for civil nuclear sites such as nuclear power plants. As at April 2019, it employed almost 600 staff.

1.5 To be licensed, sites need to have in place adequate arrangements to satisfy 36 licence conditions relating to, for example, how new facilities are constructed; the periodic review of safety cases; and the capability, capacity and competence of the site operator. Where conditions are met, the ONR issues each nuclear site operator with a licence which allows them to undertake specified activities. By law, such sites cannot operate without this ONR-issued licence. Across the Enterprise, site operators include BAE Systems (BAE) in Barrow-in-Furness, Rolls Royce in Raynesway and AWE plc (AWE) in Aldermaston and Burghfield.[6] The senior executives of the site operators have personal responsibility for a site's safe operation.

Defence Nuclear Safety Regulator

1.6 As the ONR's legislative remit does not extend to regulating nuclear safety for sites under Departmental control, the DNSR oversees those sites owned and operated by the Department. The Secretary of State for Defence, who oversees the DNSR, has committed to it applying the same standards as ONR as far as reasonably practicable. It does not have statutory authorisation to grant or remove site licences, but does authorise sites to operate. The DNSR's remit also extends to assessing the safety of submarine nuclear reactors and warheads.

1.7 While their remits are distinct, to fulfil their respective responsibilities across certain sites, the ONR and DNSR work together to develop a shared understanding of nuclear-related risks. For example, both the ONR and DNSR oversee aspects of the Devonport dockyard. On occasions, the ONR can take assurance from DNSR, such as to assess the nuclear safety of warheads. The Department and regulators are currently seeking to ensure that their respective roles and responsibilities work in practice across all nuclear-regulated sites.

6 The Department contracted with AWE Management Limited to manage and operate the Department-owned Atomic Weapons Establishment sites which include Burghfield (Reading). AWE Management Limited operates these sites through AWE Plc. In this report AWE refers to both AWE Management Limited and AWE Plc.

Complying with nuclear-regulatory arrangements

1.8 The standard conditions attached to each nuclear site licence, granted under the Nuclear Installations Act 1965, set out the site operator's responsibilities for constructing or modifying facilities within the site. The DNSR sets similar requirements for projects planned on Department-operated sites. When constructing new facilities which have significant nuclear safety implications, the site operator will usually be required to obtain the regulator's agreement that the design and construction meet safety and regulatory requirements (**Figure 2** overleaf).[7] Where regulators are not content, they can intervene to prevent or stop construction until the operator addresses their concerns.

1.9 Safety cases are complex documents, typically thousands of pages long, which can take the site operator years to compile. They must contain enough information for regulators to draw evidence-based conclusions on whether nuclear standards have been met. They usually include:

- a fully documented audit trail for all materials used in the construction of the facilities from the extraction of raw materials to how they are processed, manufactured, transported and used;
- design and construction data showing how a facility has been built to the required engineering standards, including the results of any testing to show facilities can withstand, for example, seismic or extreme weather events;
- requirements for examination, inspection, maintenance and testing of safety-related equipment and structures;
- proposed management and staffing levels for the facility, their training needs and the organisation's capacity to manage and operate the facility safely; and
- evidence that nuclear risks have been reduced so far as is reasonably practicable.

1.10 The need to meet these requirements means nuclear-regulated site infrastructure projects can be costlier and more complex than conventional projects. They can also be more complicated because, for example, they require a higher standard of welding, thicker walls and deeper foundations; for raw materials to be sourced from specific suppliers; and a higher level of quality assurance. We have identified similar challenges with building on other nuclear-regulated sites, as described in paragraph 3.19.[8]

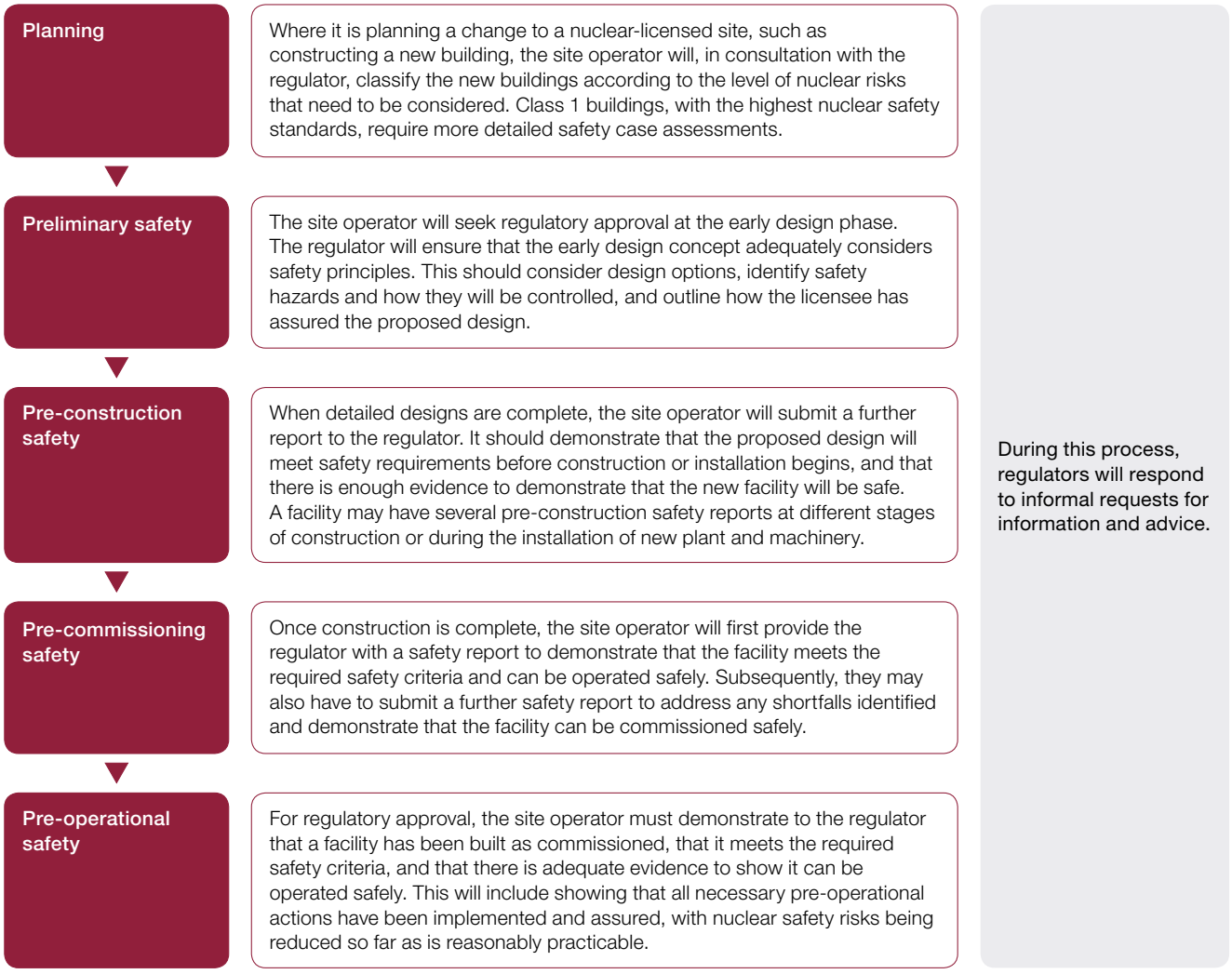
7 Site operators must also meet broader health and safety requirements associated with any construction project.

8 Reports by the Comptroller and Auditor General, *The Nuclear Decommissioning Authority: progress with reducing risk at Sellafield*, Session 2017–2019, HC 1126, National Audit Office, June 2018; *Managing risk reduction at Sellafield,* Session 2012-13, HC 630, National Audit Office, November 2012.

Figure 2

Formal process for regulating new infrastructure on nuclear-regulated sites

For infrastructure projects to meet regulatory requirements, the regulator needs to sign-off safety cases throughout the process



Notes

1 Process based on the Office for Nuclear Regulation's prescribed approach. The Defence Nuclear Safety Regulator follows a similar process.

2 The Ministry of Defence will determine with regulators the process and timeframes for each site modification given the underlying project risks. Projects cannot progress until the regulator has approved the preceding safety case.

Source: National Audit Office

Infrastructure projects at nuclear-regulated sites

1.11 The Department currently forecasts to spend £2.5 billion on the construction of facilities at three nuclear-regulated sites. These projects (see **Figure 3** overleaf and Appendix Three) include buildings to assemble and disassemble nuclear warheads at the AWE-operated Burghfield site (project MENSA); for Rolls Royce to construct nuclear reactor cores in Raynesway (core production capability (CPC) facilities); and for BAE Systems to construct the new Dreadnought-class submarines in Barrow-in-Furness (primary build facility). Together they make up an estimated quarter by initial project value of the Department's 52 nuclear infrastructure projects, which were initially valued at £4.9 billion.

1.12 The Department is also developing other projects across its nuclear-regulated sites. These include upgrading the dock facilities in Devonport, building nuclear-related storage and manufacturing facilities at the AWE-operated site at Aldermaston, and updating the infrastructure at HM Naval Base Clyde. These projects affect all parts of the Enterprise and are critical to maintaining the continuous at sea deterrent. However, as they are at an early stage of development, this report does not evaluate them.

1.13 The Department's decisions to carry out infrastructure projects have resulted from various factors. These factors include the need to:

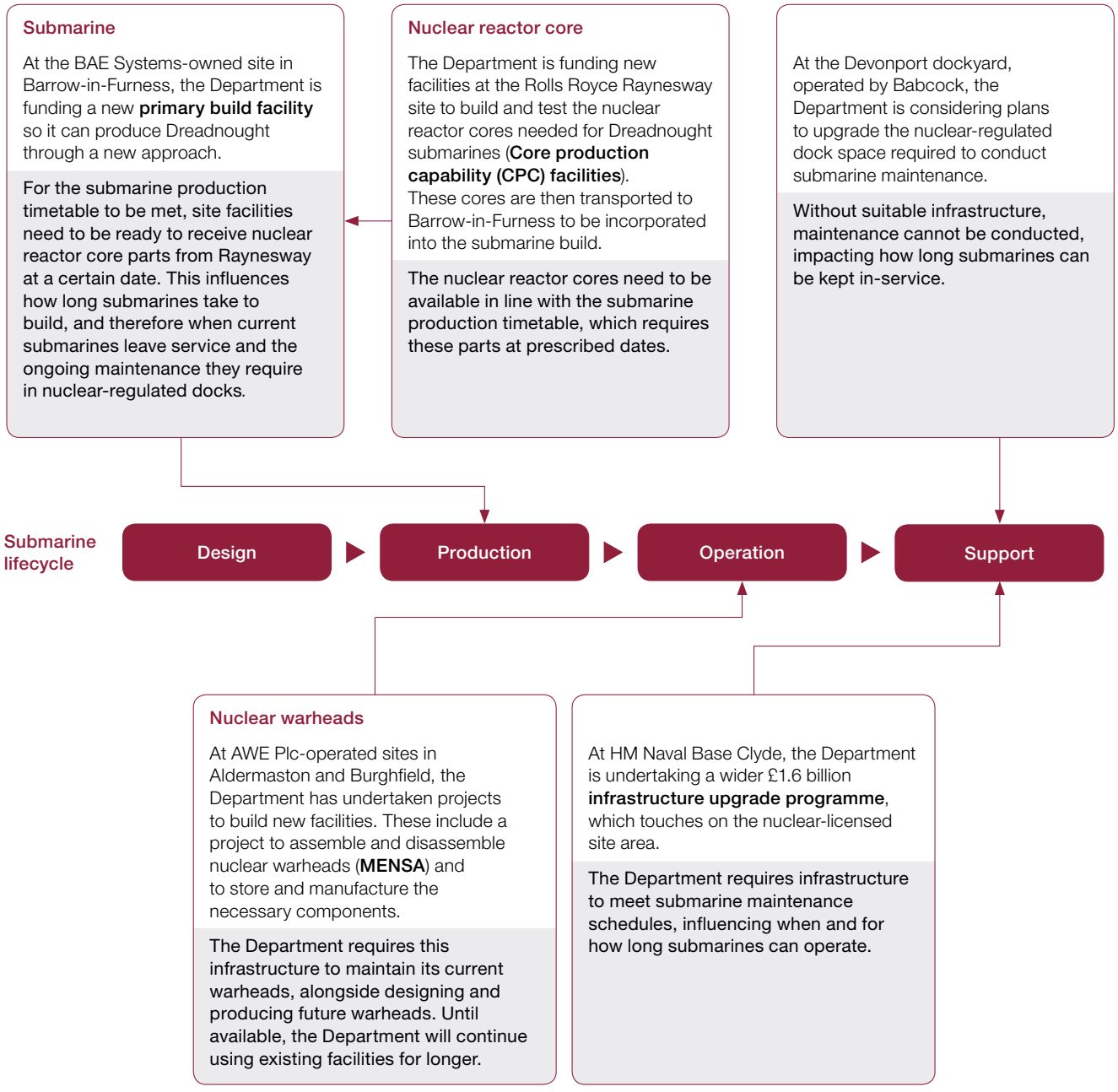
- **replace ageing facilities:** As we reported in 2018, the age and condition of the nuclear estate varies. The Department's investment in nuclear infrastructure has broadly fluctuated in line with decisions to invest in building submarines. Existing facilities at AWE and Rolls Royce sites were built as early as the 1950s when the UK first developed its nuclear deterrent. As these facilities are now reaching the end of their expected lifespan at a similar time, the current replacement projects create cyclical periods of investment. Peaks and troughs in investment can affect the ability of the Department and its contractors to secure and maintain the skills and expertise needed; and

- **introduce more efficient ways of working:** For example, the Department is building the new Dreadnought-class submarines using a more modular approach than before. To provide the facilities needed to produce, integrate and quality-assure large sections of the submarine before final assembly, it is undertaking a Barrow-in-Furness site-wide infrastructure programme. A number of these buildings will be within the nuclear-regulated sections of the site. The Department expects to spend £1.1 billion (£577 million more than initially expected) developing the full site, which it needs to complete by 2025.

Figure 3

Summary of infrastructure projects across nuclear-regulated sites

The Ministry of Defence's (the Department's) nuclear-regulated site infrastructure projects are critical to the Nuclear Enterprise



Describes the potential impact if appropriate facilities were not in place.

Source: National Audit Office analysis of Ministry of Defence information

1.14 There are interdependencies both between individual infrastructure projects, and with broader projects across the Enterprise. Other projects can influence when facilities are needed and what they need to look like. Decisions made by the Department as part of the Dreadnought-class submarine production programme will influence the type of facilities required in Barrow-in-Furness and Raynesway, and when they are needed. In addition, the Department's broader nuclear weapons commitments influence AWE-operated sites. It needs to complete project MENSA to replace the current facilities to assemble, inspect and disassemble current, and any potential future, warheads.

Project progress

1.15 To date, each of the three infrastructure projects in our review has faced delays and cost increases early in their lifecycle (**Figure 4** on pages 22 to 25). Two projects were re-baselined so that requirements could be better aligned to the funds available.

1.16 Cumulatively, the three projects we examined have experienced cost increases of £1.35 billion, with delays of between 1.7 years and 6.3 years since they were approved (**Figure 5** on page 26). The cost increases and delays have, or could have, broader impacts across the Enterprise. For example, given the six-year delay to the MENSA project at the AWE-operated Burghfield site, the Department has continued to use ageing facilities. The ONR has only supported continued operations for a limited period, with further work needed for longer-term operations. In 2016, the regulator authorised a three-year extension. The Department expects to spend £21 million between 2016-17 and 2019-20 on site upgrades to maintain regulatory approval to use the site. In 2019, the ONR reported that upgrades were ongoing, with AWE continuing to use ageing facilities.

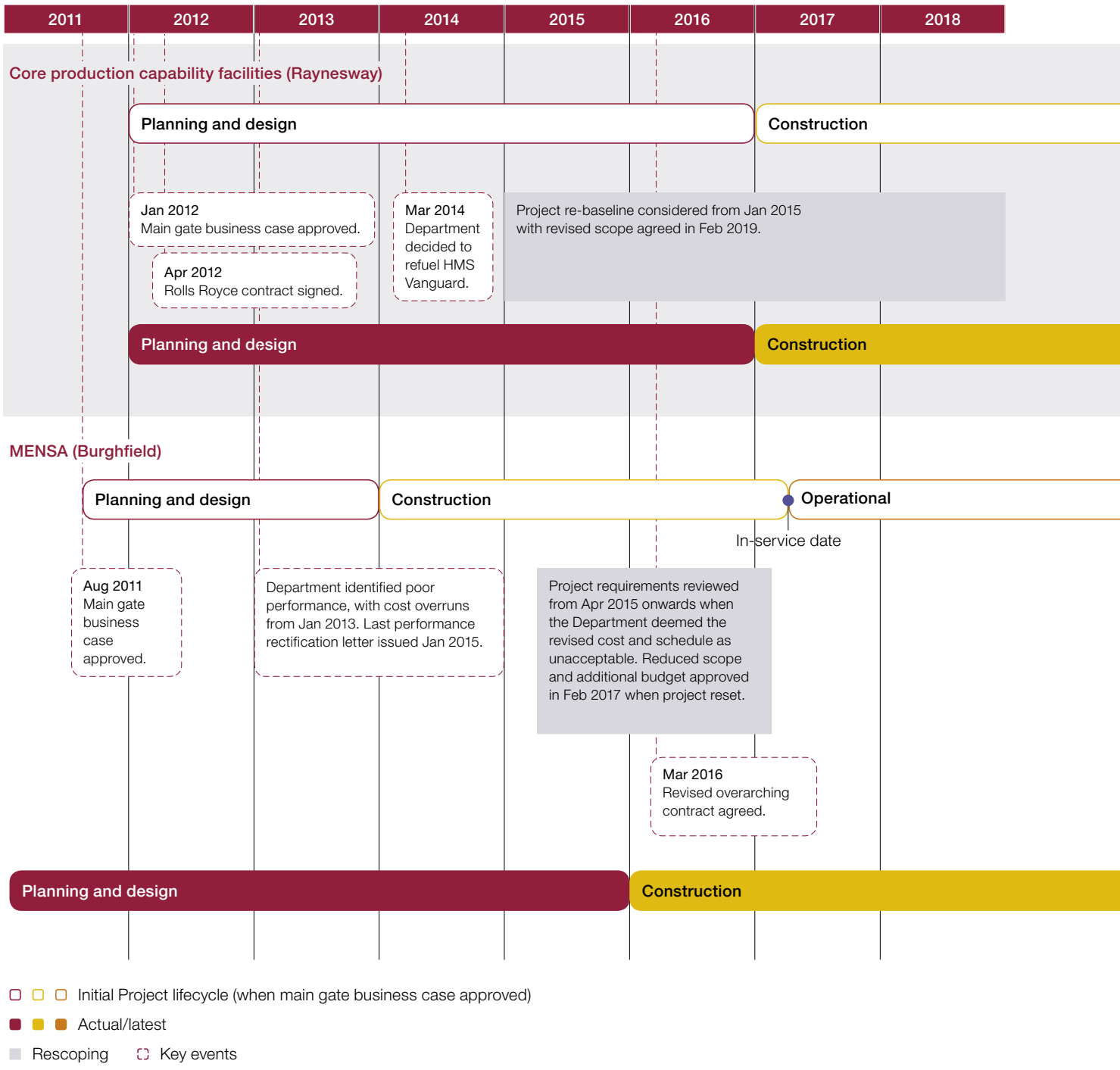
1.17 Cost increases and delays have been caused by various factors (**Figure 6** on page 27). For the three projects in our review, the factors included:

- **MENSA** – construction starting with immature designs; initially limited commercial incentives for the Department to penalise delays; and a lack of project oversight and information.
- **CPC facilities** – the Department's unexpected decision to refuel *HMS Vanguard*, and the Department starting construction before designs were sufficiently mature.
- **Primary build facility** – the Department needing to spend a further £11 million on preliminary works after finding objects which could be potentially hazardous given the history of the Barrow-in-Furness site and which took time to investigate.

Figure 4

Summary of nuclear-regulated site infrastructure project progress, as at October 2019

The Ministry of Defence's (the Department's) infrastructure projects have experienced delays early in their lifecycle



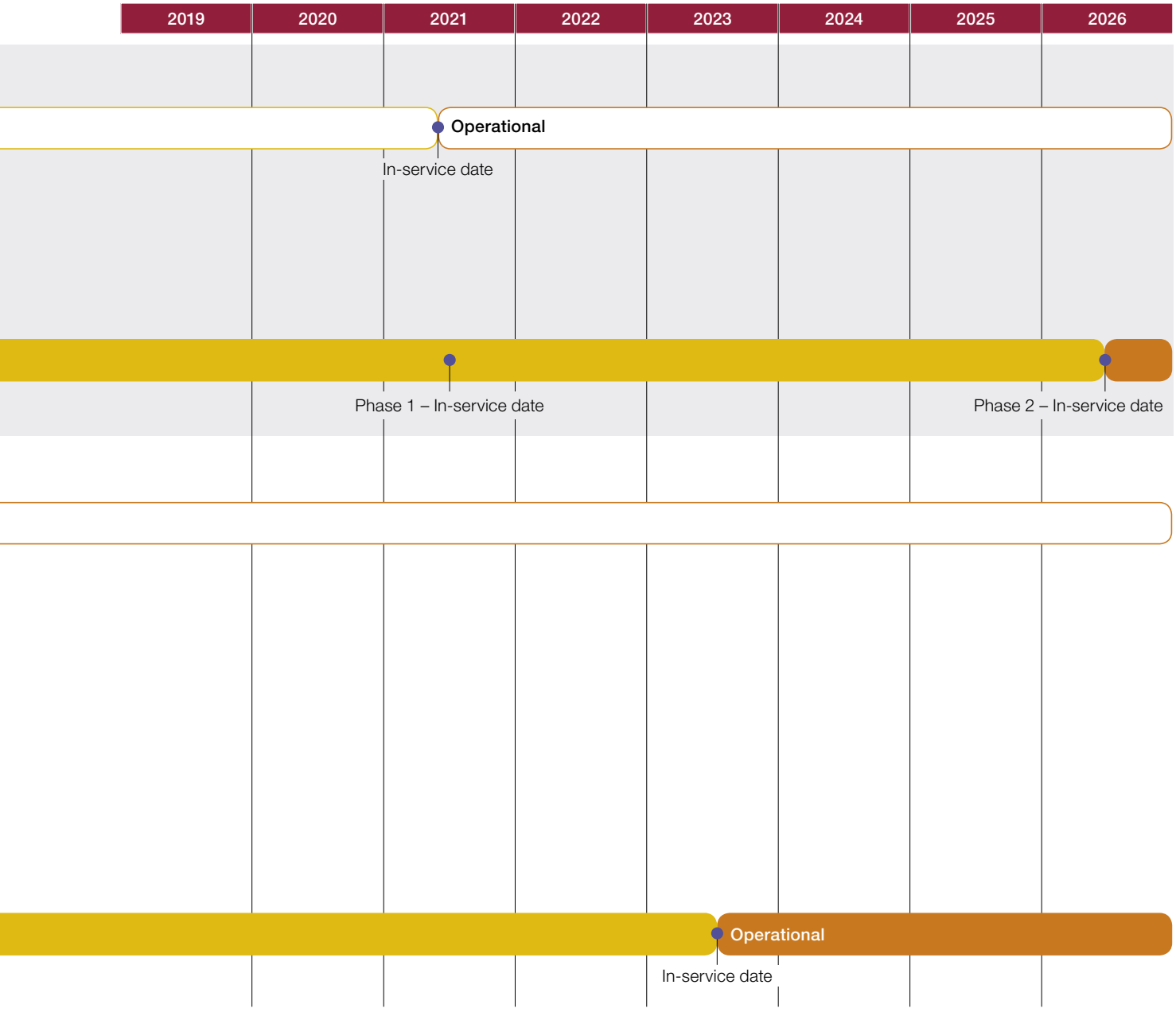
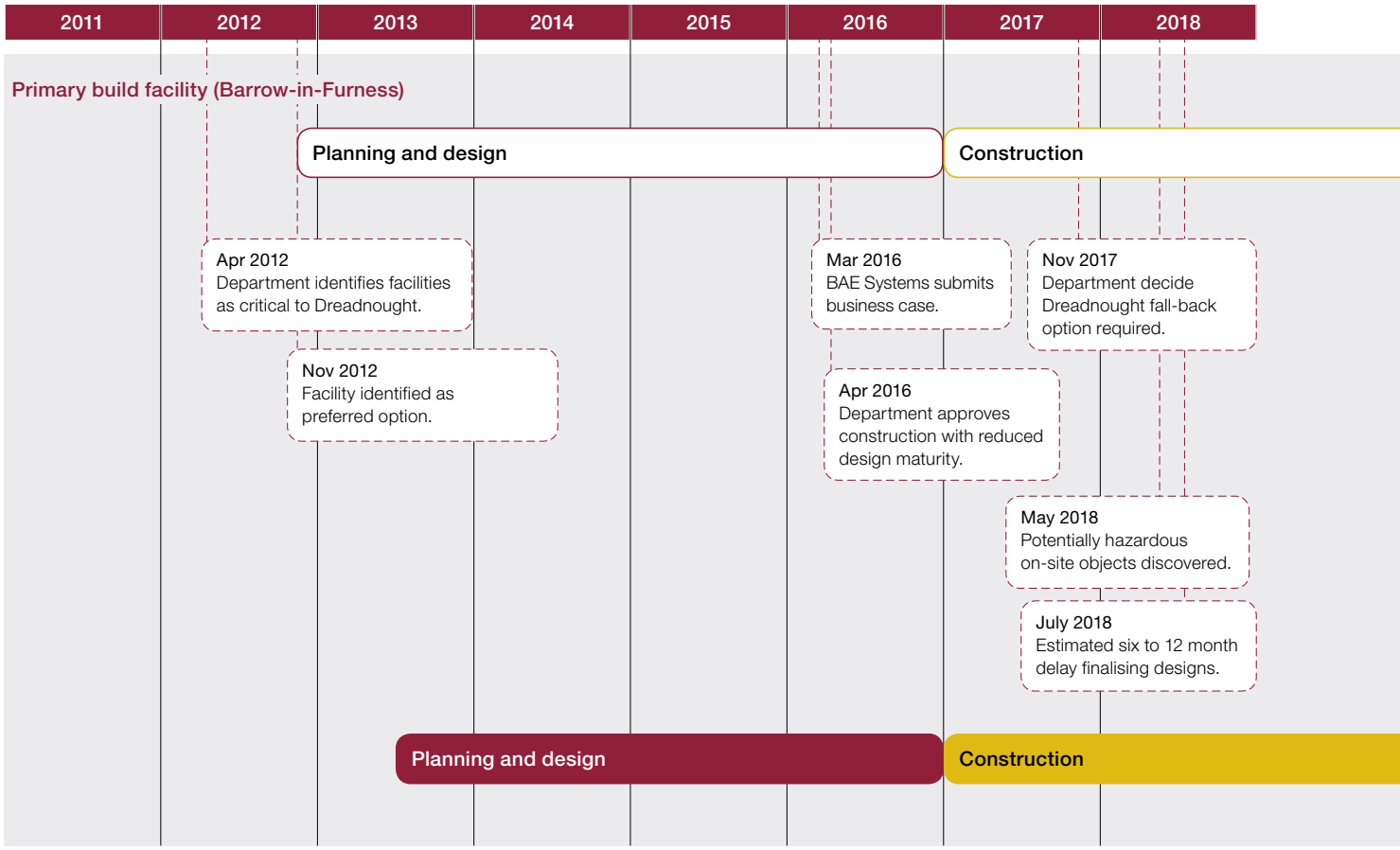

2019
2020
2021
2022
2023
2024
2025
2026
Operational
In-service date
Phase 1 – In-service date
Phase 2 – In-service date
Operational
In-service date

Figure 4 *continued*

Summary of nuclear-regulated site infrastructure project progress, as at October 2019



Notes

1 The Department would have been undertaking early work before main gate business case approval. The planning and design, construction, and operational project phases are shown concurrently for presentational purposes. In practice, these phases will overlap.

2 Core production capability facilities: new facilities at Rolls Royce operated-site to produce the latest nuclear reactor core designs. The project consists of two phases covering new facilities to manufacture new reactor cores (Phase 1) and nuclear fuel (Phase 2).

3 MENSA: new nuclear warhead assembly and disassembly facility at AWE Plc-operated site.

4 Primary build facility: new facilities at the BAE Systems-operated shipyard to allow a modular submarine-build approach for Dreadnought. Figure shows dates for the latest building being available.

5 Project lifecycle timelines are approximate and may overlap.

Source: National Audit analysis of Ministry of Defence information

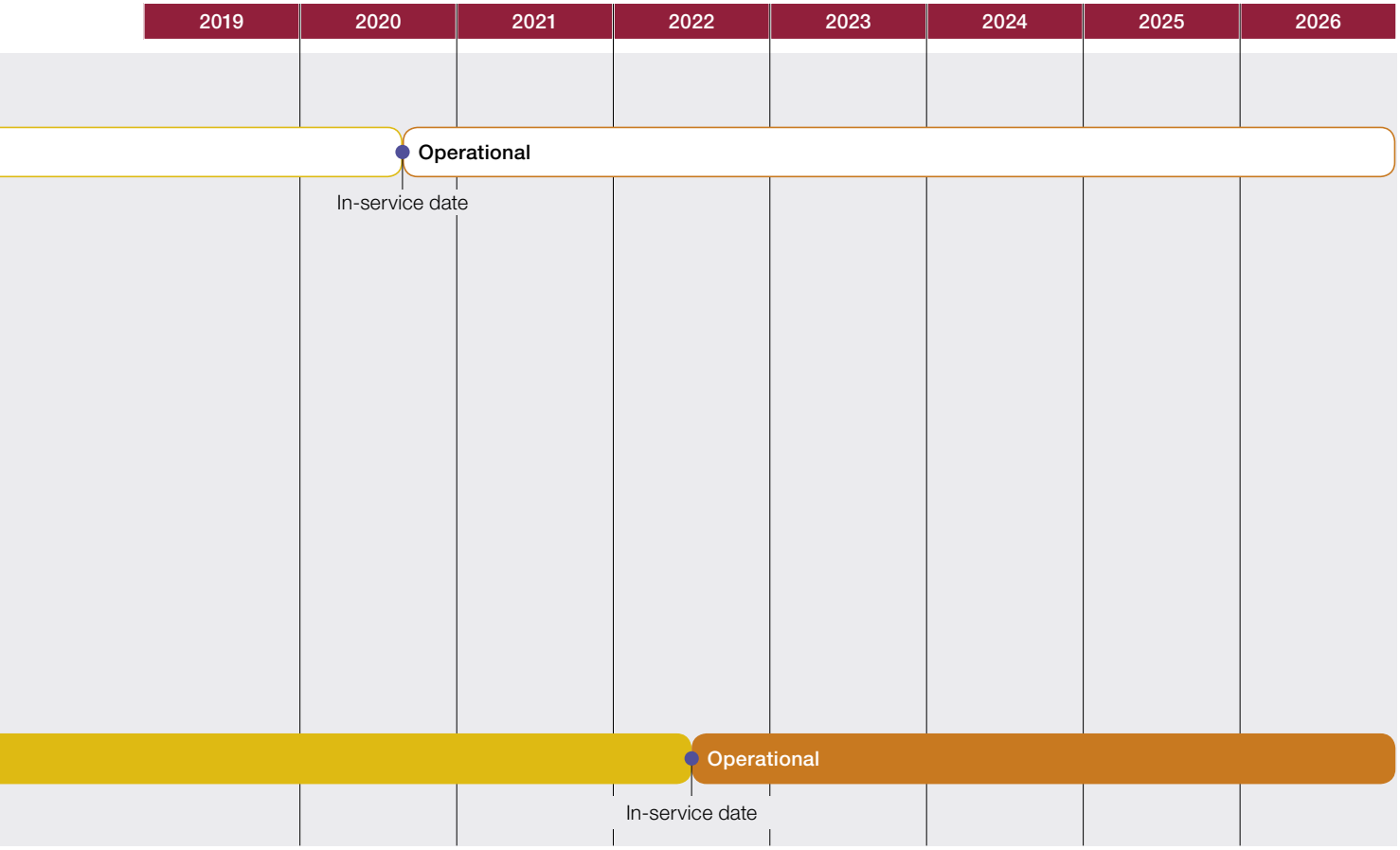
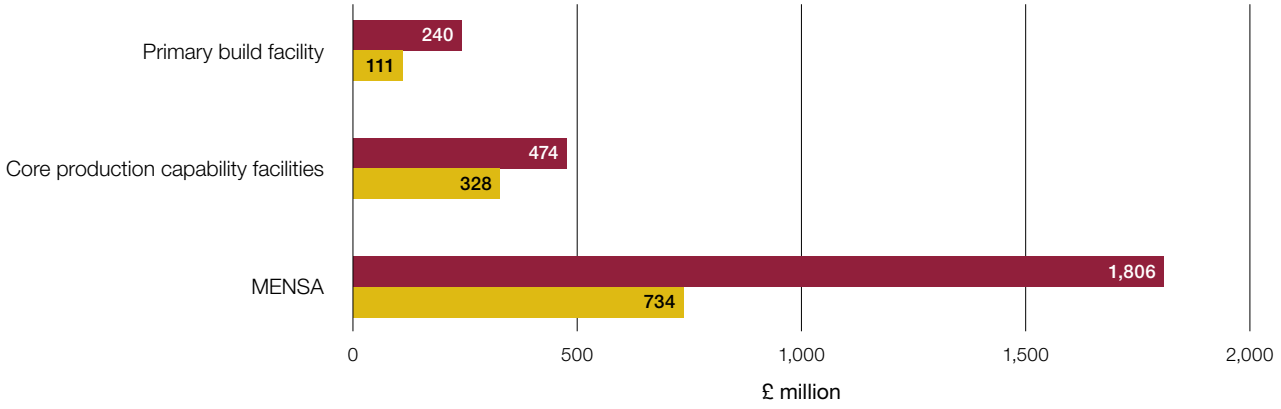

2019
2020
2021
2022
2023
2024
2025
2026
Operational
In-service date
Operational
In-service date

Figure 5

Cost increases and delays with infrastructure projects at nuclear-regulated sites

The Ministry of Defence's (the Department's) projects have experienced delays and cost increases

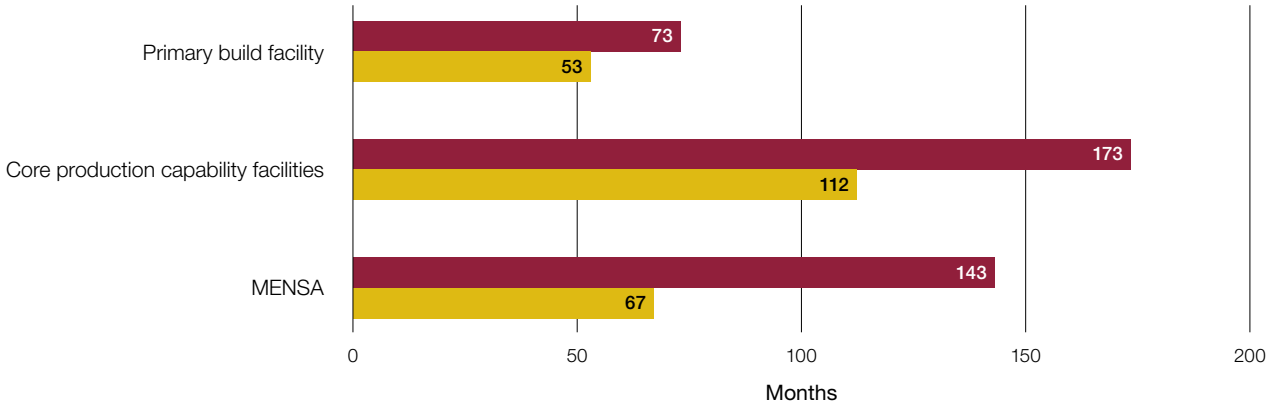
Difference between the initial and latest cost forecasts



Most recent cost estimate

Original cost estimate

Difference between the initial and latest time taken to deliver infrastructure



Current estimated length

Original length

Notes

1 Initial costs and timeframes reflect those approved as part of the main gate business case.

2 Primary build facility: new facilities at the BAE Systems-operated shipyard in Barrow-in-Furness to allow a modular submarine-build approach. Latest forecast cost represents the best judgement as at October 2019, subject to contractor discussion and cost modelling.

3 Core production capability facilities: new facilities at Rolls Royce-operated site to produce the latest nuclear reactor core designs.

4 MENSA: new nuclear warhead assembly and disassembly facility at AWE Plc-operated site.

Source: National Audit Office analysis of Ministry of Defence data

Figure 6

Summary of Ministry of Defence factors behind nuclear-regulated site infrastructure project cost increases

Almost half of cost increases to date across the three projects relate to construction starting before designs were sufficiently mature

Factor		MENSA	Core production capability facilities	Primary build facility	**Total**	
		(£m)	(£m)	(£m)	**(£m)**	(%)
Design maturity	Construction started before requirements or designs clear	399	139	108	**647**	**48**
Contractor performance	Contractor failure to deliver to time or quality requirements	87	–	–	**87**	**6**
Changes to approach	Changes to project management or commercial approach	150	–	1	**151**	**11**
Additional contractor fees	Primary contractor fees earned on cost increases	97	7	10	**114**	**8**
Unforeseen events	Emerging factors which the Department or contractors could not have reasonably foreseen	–	–	11	**11**	**1**
Other	Other factors leading to cost increases	339	–	–	**339**	**25**
Total		**1,072**	**146**	**130**	**1,349**	**100**

Notes

1 Figures may not sum due to rounding.

2 Factors are not mutually exclusive, with costs categorised by the Ministry of Defence according to the main factor behind cost increases.

3 MENSA: new nuclear warhead assembly and disassembly facility operated by AWE Plc at the Burghfield site.

4 Core production capability facilities: new facilities at Rolls Royce operated-site in Raynesway to produce the latest nuclear reactor core designs.

5 Primary build facility: new facilities at the BAE Systems-operated shipyard in Barrow-in-Furness to allow a modular submarine-build approach.

Source: National Audit Office analysis of Ministry of Defence data

1.18 Comparable infrastructure projects in the United States (US), as well as on UK Nuclear Decommissioning Authority (NDA) sites, have experienced cost increases and delays for similar reasons. In 2018, we reported that of 14 NDA projects at Sellafield, six had accumulated a combined delay of 186 months, with six more expected to be over budget (by a total of £1.1 billion). Our previous work in 2012 found, for example, cost increases resulting from Sellafield Limited, now a subsidiary of the NDA, starting to build before designs were sufficiently mature, and with designs that far exceeded the requirements set by nuclear regulations resulting in unnecessary costs. Cost increases for projects in the US have resulted from insufficient management oversight, the approval of schedules before designs were complete and difficulties retaining suitably qualified staff. For example, a new US uranium processing facility was estimated to cost $1.1 billion in 2004, but by 2012 was expected to cost $6.5 billion because initial plans had included inaccurate assumptions.

1.19 Despite the challenges at their early stages, the three projects in our review have made progress since 2016. In particular:

- **MENSA (71% of forecast cost spent as of April 2019)**

  As at October 2019, the Department had completed building the MENSA facility, with the remaining work focused on procuring and fitting out the necessary equipment and seeking regulatory approvals. In 2018, the Infrastructure and Projects Authority (IPA) assessed MENSA as 'Amber' in terms of delivery confidence.

- **CPC facilities (83% of forecast cost for the first building and design of the second building spent, as of April 2019)**

  The Department is in a similar position regarding the first building of the CPC facilities project. With construction complete and outfitting under way, the Department expects this first building to be completed in early 2020. It also expects the second phase, for which construction funding has not yet been approved, to be ready in 2026. In July 2019, the IPA published as 'Amber' its assessment of the broader capability programme covering the new facilities and site operations.

- **Primary build facility (33% of forecast cost spent as of April 2019)**

  Construction for one of the facilities' buildings is largely complete. For the other, foundation construction has started following delays to resolve design issues and conduct further investigative work on potential site hazards. This facility comprises part of a Barrow-in-Furness site-wide facilities project, which is itself part of the Dreadnought-class submarine production programmes. In July 2019, the IPA published an 'Amber' assessment in terms of delivery confidence for the submarine production programme.

Part Two

Managing regulatory challenges

2.1 The need for infrastructure projects on nuclear-regulated sites (sites) to meet nuclear standards presents specific challenges for the Ministry of Defence (the Department). Challenges include developing cost-effective designs that meet regulatory standards, alongside demonstrating these standards have been met. This part assesses how well the Department has addressed these challenges.

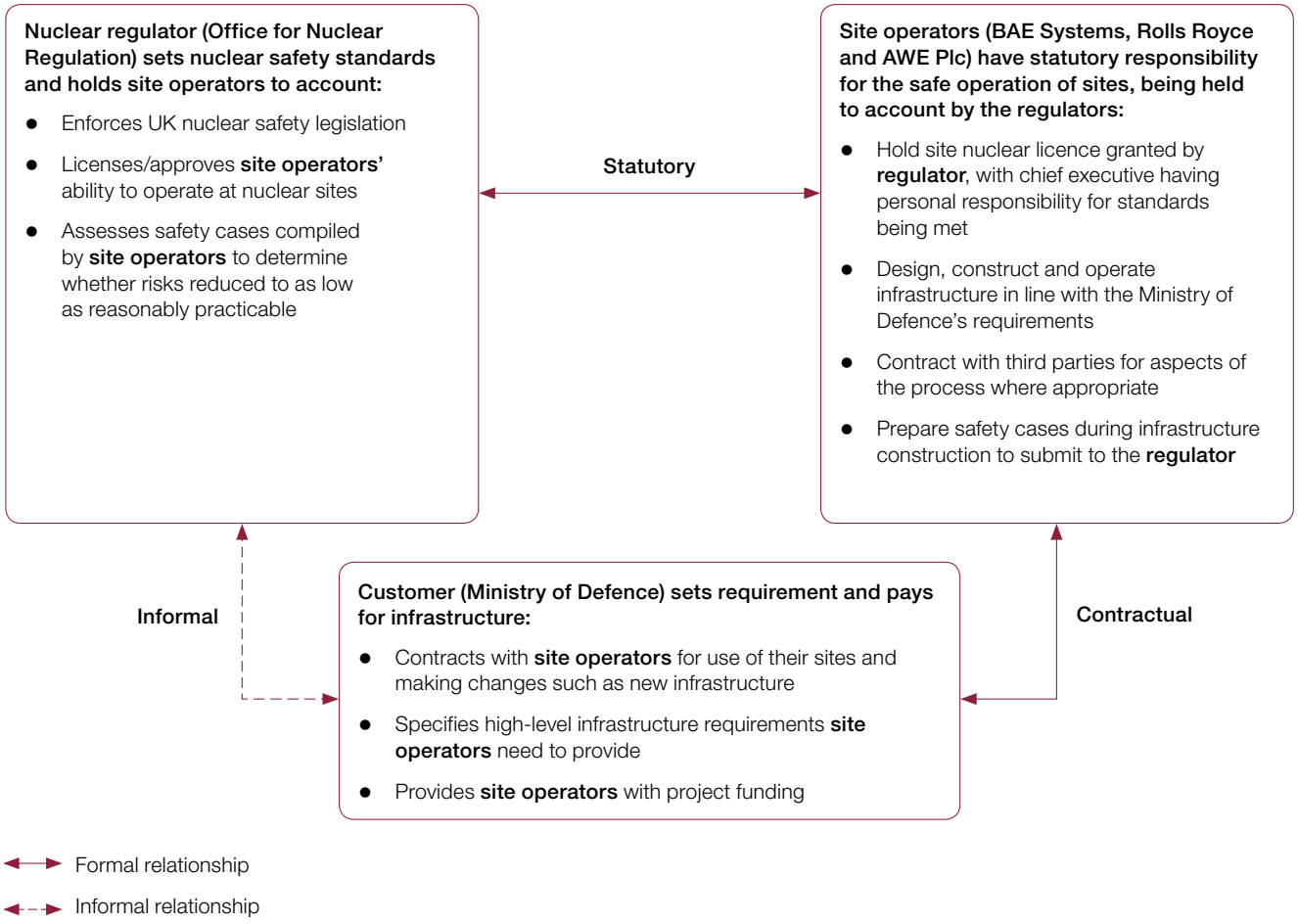
Roles and responsibilities

2.2 The regulatory arrangements for nuclear sites bring together several parties – the Department, the site operators and the Office for Nuclear Regulation (ONR) and/or the Defence Nuclear Safety Regulator (DNSR) as regulators (**Figure 7** overleaf). Each plays a different role. The Department pays for the infrastructure it needs, while the site operators – the Department's contractors – hold the site's nuclear licence and are thus legally accountable to the regulator for ensuring site risks are reduced "as far as is reasonably practicable".

2.3 For the regulator to assess that licensing conditions are met, it needs, among other things, assurance that the site operator has reduced nuclear risks "as far as reasonably practicable". Site operators have the flexibility to develop different designs as long as regulators assess these as meeting overarching nuclear safety standards. Regulators must make evidence-based judgements on whether the design submitted by the site operator meets standards. The regulator does not prescribe a specific option and is not obliged to provide alternative suggestions.

Figure 7
Nuclear regulatory responsibilities

The Ministry of Defence does not have a formal relationship with the statutory regulator, which presents additional challenges to achieving value for money



Notes

1 The Defence Nuclear Safety Regulator does not have a statutory remit to license sites, but has agreements in place with the Ministry of Defence for sites that it oversees.

2 Figure does not show any informal working groups.

Source: National Audit Office

Controls over value for money

2.4 Under statute, neither the site operator nor the regulator has formal responsibility for ensuring infrastructure designs are cost-effective, with value for money not one of their primary responsibilities. Their respective value for money-related responsibilities are:

- **Regulators**

  The ONR and DNSR must ensure that site operators meet the expected standards for nuclear safety. While achieving value for money is not part of ONR's statutory remit, the UK's Regulators' Code does require ONR to minimise the costs of complying with regulation. The ONR told us that, while maintaining its independence, it has sometimes provided feedback on designs and plans, resulting in reduced costs and shorter timetables for projects. The DNSR told us that it actively considers whether proposals represent value for money and will challenge plans that it sees as not being so.

- **Site operators**

  From the regulator's perspective, the site operator has responsibility for considering safety measures and demonstrating whether their cost would be grossly disproportionate to the risk reduction that would be achieved. The site operator's commercial arrangements with the Department may include value-for-money mechanisms.

2.5 As the Department does not operate most of the nuclear-regulated sites, it does not hold a formal regulatory role. It therefore has less opportunity to secure value for money, even though by paying for the infrastructure it holds the risk of cost increases. The current regulatory structures, and the Department's commercial arrangements with site operators (see Part Three), therefore create barriers the Department needs to overcome to balance nuclear safety and value-for-money considerations. Although not having a similar three-way regulatory arrangement, Nuclear Decommissioning Authority (NDA) projects have also experienced over-specified designs. In 2012, for example, we found a design for a new evaporator at Sellafield was based on standards for withstanding earthquakes far beyond what was necessary. Subsequent changes in design and construction requirements contributed to cost increases and delays.[9]

9 Comptroller and Auditor General, *Managing risk reduction at Sellafield*, Session 2012-13, HC 630, National Audit Office, November 2012.

2.6 In the past, the Department has not had the controls in place to overcome these barriers and prevent infrastructure designs being over-specified and therefore poor value for money (a situation often termed 'gold-plating'). This may result from various factors such as a tendency to make risk-averse decisions or a lack of skills to develop or challenge designs. Both the Department and site operators continue to face challenges recruiting staff able to develop and challenge complex nuclear regulatory designs. As detailed in our 2018 report on the Defence Nuclear Enterprise, continuing knowledge and skills gaps across the Enterprise are widely recognised. For project MENSA, the Department acknowledges that neither it nor the site operators have the skills and knowledge to challenge regulators, leading to the site operator developing over-specified designs. The Infrastructure and Projects Authority continues to identify a lack of skills as a risk.

2.7 Without an in-depth, technical review of infrastructure designs against nuclear regulatory requirements, it is difficult to establish the scale of any 'gold plating', which is a subjective assessment. However, throughout our study, the Department, regulators and site operators all considered it had occurred and remained a potential risk. As well as the project cost increases identified during the design stages (see Part One) and a lack of controls, other indications of 'gold-plating' include:

- When rescoping the MENSA project in 2015, the Department identified that its failure to oversee AWE led to overly complex designs. This included the specialist blast doors, which were over-engineered.
- The DNSR has highlighted over-specified facilities, which took too long to deliver and did not represent value for money.
- An independent review covering the primary build facility at the BAE Systems shipyard at Barrow-in-Furness identified that designs intended to meet nuclear regulations were over-specified and had not been effectively challenged, which led to a complex build.
- The ONR told us it did not generally feedback formally on whether designs were over-specified, although it had suggested alternative approaches to the site operator after designs were approved. It told us that AWE had previously identified examples of over-specification before submitting designs to them, although we did not see evidence of this.

2.8 In recent years, the Department, site operators and regulators have sought to establish more regular, constructive and open engagement. Although it is too early to assess the effectiveness of these arrangements, all parties we spoke to consider relationships have improved. We found:

- **on AWE sites** a senior leadership forum had been created, bringing together AWE, the Department, DNSR, ONR and other regulators. Those we spoke to considered this forum, as well as staff changes and a better mutual understanding of roles, had contributed to improved relationships, and to a greater understanding of requirements; and
- **at HM Naval Base Devonport**, the Department concluded that an initial estimate to redevelop its nuclear-regulated docks was too expensive, in part because of over-engineered designs. It subsequently held joint conversations with the ONR, DNSR and site operators. These were designed to establish a broader understanding of the nuclear safety risks and develop a more cost-efficient design. The Department currently estimates dock upgrades will now cost between a quarter and a half of the original forecast. The Department is in the process of establishing a similar forum for the primary build facility project in Barrow-in-Furness.

2.9 In changing how it engages with regulators, the Department's arrangements are becoming more aligned with the civil sector, where greater liaison has contributed to performance improvements. As we reported in 2018, site operator Sellafield Limited considered that a better coordinated relationship with the regulator and other key stakeholders had improved its ability to manage project performance. This was due mainly to the establishment of a working group of relevant parties to discuss effective approaches to reducing hazards, balancing short-term risks and removing barriers to progress. In 2018, we reported that since 2015-16, the NDA had reduced the expected delays in delivering most of its major projects.[10]

Meeting regulatory requirements

2.10 As discussed in Part One, regulators require site operators to provide documentation and analysis (safety cases) to demonstrate that any proposed changes to nuclear-regulated sites will meet regulatory standards. Not doing so increases project delivery risks by affecting the regulator's ability to review cases, which takes an average of three months or more depending on the complexity. Throughout the three infrastructure projects in our study, the regulator continues to assess sites as being safe to operate.

10 Comptroller and Auditor General, *The Nuclear Decommissioning Authority: progress with reducing risk at Sellafield*, Session 2017–2019, HC 1126, National Audit Office, June 2018.

2.11 In two of the three projects we reviewed (the core production capability facilities and the primary build facility) site operators have met the required timeframes for submitting safety cases to the ONR. However, although AWE provided the first three of its four pre-construction safety reports on time, it expects to submit the final report four years later than initially planned. The project reset contributed to this delay, along with shortages in nuclear safety case professionals. Partly given its concerns about AWE's capacity and capability to submit safety cases of the appropriate quality, the ONR has applied an enhanced regulatory approach from 2011-12 (**Figure 8**). This involves more regular and detailed inspections.

Figure 8

Office for Nuclear Regulation regulatory regimes across Ministry of Defence sites, 2012-13 to 2018-19

The Office for Nuclear Regulation has applied an enhanced regulatory regime to AWE Plc sites

	Nuclear-licensed site				Percentage of all ONR-licensed sites under prescribed regimes			
	AWE Aldermaston	AWE Burghfield	Rolls Royce (Raynesway)	BAE Systems (Barrow-in-Furness)	Significantly enhanced (%)	Enhanced (%)	Routine (%)	Total number of sites
2018-19	**Enhanced**	**Enhanced**	Routine	Routine	8	18	74	**38**
2017-18	**Enhanced**	**Enhanced**	Routine	Routine	8	15	77	**39**
2016-17	**Enhanced**	**Enhanced**	Routine	Routine	8	16	76	**38**
2015-16	**Enhanced**	**Enhanced**	Routine	Routine	5	18	77	**39**
2014-15	**Enhanced**	Routine	Routine	Routine	3	19	78	**36**
2013-14	**Enhanced**	Routine	Routine	Routine	3	17	81	**36**
2012-13	**Enhanced**	**Enhanced**	Routine	Routine	3	14	83	**35**

Notes

1 Information published since the Office for Nuclear Regulation's (ONR) creation in 2012-13.

2 'All ONR-licensed sites' covers civil and other military nuclear sites, including the Devonport Royal Dockyard Limited used by the Ministry of Defence to maintain its submarines. Since 2012-13, the ONR has applied an enhanced regulatory regime across this site.

3 ONR determines whether to apply a routine, enhanced or significantly enhanced regulatory regime by considering various factors such as safety performance, control of hazard and risks, safety leadership and culture and security operations. Enhanced-regime sites are those requiring more regulatory activity, with significantly enhanced regimes recognising additional factors such as emergent or long standing safety and/or security issues and/or the risks associated with the facilities.

Source: National Audit Office analysis of Office for Nuclear Regulation annual reports

Part Three

Managing project and commercial challenges

3.1 As set out in Parts One and Two, the Ministry of Defence (the Department) requires complex and costly infrastructure projects across the nuclear-regulated sites (sites) of the Nuclear Enterprise (the Enterprise). The challenges of these programmes make it important that the Department meets good project and commercial management standards. These include having commercial arrangements that work, effective governance, and an understanding of project interdependencies. This Part assesses how the Department has met these standards.

Handling commercial challenges

3.2 As we reported in 2018, the monopolistic commercial environment across the Enterprise means the Department faces an inherent challenge in incentivising contractors and holding them to account.[11] At that time, four contractors held 97% by value (£47.3 billion) of Enterprise-related contracts. The same contractors act as the Department's nuclear-regulated site operators, providing any new facilities required on these sites (**Figure 9** overleaf). Broader agreements restrict the Department's ability to expand the market. For example, the 1958 Mutual Defence Agreement with the United States requires the Department to use a British or American company to design and manufacture nuclear submarine propulsion systems. Rolls Royce is currently the only British contractor with this capacity.

3.3 To build new infrastructure, the Department's site operators sub-contract responsibilities such as design and construction to third parties. This is partly because they themselves lack experience or capability in building this specialist infrastructure. Given the nature of the work, only a small number of contractors can design and construct these buildings – in the three projects we examined in detail, many of the same firms played roles.

11 Comptroller and Auditor General, *The Defence Nuclear Enterprise: a landscape review*, HC 1003, Session 2017–2019, National Audit Office, May 2018.

Figure 9

Summary of contracts covering nuclear-regulated site infrastructure projects

The Ministry of Defence (the Department) relies on three contractors to complete its infrastructure projects

Project	Contractor	Percentage of all Enterprise contracts by value (2017-18)	Overarching Contract	Contract start	Contract end	Recent changes	Current contract	
							SSCR-compliant	Cost basis
MENSA	AWE Management Limited	52	Nuclear Warhead Capability Sustainment Programme	2000	2025	In 2016 contract revisited to: • split into different activities • introduce annual cost and activity resets; and • be SSCR-compliant	Yes	Target cost
CPC facilities	Rolls Royce	10	Core Production Capability	2012	2056 (scoped and costed to 2023)	In 2019, design and construction phases separated out for the second phase of the project	No	Ascertained cost
Primary build facility	BAE Systems	27	Dreadnought-class submarine build programme	2016	2021	N/A	No	Ascertained cost

Notes

1 For Single Source Contract Regulations (SSCR) contracts the Department requires cost transparency and has statutory backing to negotiate prices with a regulated and benchmarked profit rate. For ascertained cost contracts, the contractor receives an estimate of incurred costs, overheads and an agreed profit margin.

2 MENSA: New nuclear warhead assembly and disassembly facility operated by AWE Plc at the Burghfield site. Core production capability (CPC) facilities: New infrastructure at the Rolls Royce operated-site, Raynesway to produce the latest nuclear reactor core designs. Primary build facility: New facilities at the BAE Systems-operated shipyard in Barrow-in-Furness to allow a modular submarine-build approach.

3 The Department's remaining Nuclear Enterprise contracts include those with Babcock (9% of total), which operates the dockyard in Devonport.

Source: National Audit Office

Contract approach

3.4 In 2014, the government introduced the Single Source Contract Regulations (SSCRs), which are designed to increase transparency of defence procurement costs while paying contractors a sustainable profit rate. The Department uses the regulations for one of its three contracts. Although the AWE contract, covering MENSA, was originally signed before they came into force, in 2016 the Department revised the contract to comply with the SSCRs. It is yet to revise its contract with Rolls Royce, covering the core production capability (CPC) facilities, which it signed in 2012. To do so, it will need Rolls Royce's agreement, which has not yet been provided. In 2017, the Department was aiming for all eligible contracts to be within the SSCRs by 2019-20.[12]

3.5 As discussed in Part Two, given the regulatory arrangements, the Department relies on its commercial arrangements to mitigate value-for-money risks. Previously, it has not agreed contract terms that share financial risks with its contractors, who have little or no incentive to manage projects cost-effectively. The Department's exposure to cost growth has also increased given how its contractors engage with their supply chain. Across government we have seen how a monopolistic supplier environment, the need to meet fixed timetables and requirement immaturity make it difficult to transfer these risks. Government organisations do not always understand the risk allocation to manage these effectively.[13]

3.6 In the projects we reviewed, we found that:

- **Primary build facility**

  Under the contract, BAE Systems gets paid all costs, including those incurred through its supply chain, plus an agreed profit margin. This means the Department holds the full risk of cost increases for the project. As a result, BAE Systems passed on to the Department the full £65 million increase in costs associated with the construction sub-contractor's compensation claims. This is where, under the fixed-price contract terms, the sub-contractor can claim the cost increase arising from problems that affect price, but which are not its fault. In addition, BAE Systems receives a management fee, which increases alongside the costs it incurs. Following cost increases, BAE Systems earned an additional £10 million in fees, leading to a total £16.5 million management fee. The Department recognised that its contract terms are particularly favourable to the contractor as, for example, BAE Systems has no liability for costs and damages relating to non-performance.

12 Comptroller and Auditor General, *Improving value for money in non-competitive procurement of defence equipment*, Session 2017–2019, HC 412, National Audit Office, October 2017.

13 Reports by the Comptroller and Auditor General, *Completing Crossrail*, Session 2017–2019, HC 2106, National Audit Office, May 2019; *Commercial and contract management: insights and emerging best practice*, National Audit Office, November 2016.

- **MENSA**

  Up until 2016, the Department's commercial arrangements meant AWE received additional fees when work got deferred to the next year. Deferrals partly resulted from the Department needing to achieve in-year affordability savings. The contract classed these deferred costs as a saving, for which AWE would receive a gainshare payment. In addition, the Department continued to pay all the management fees incurred by AWE during the delays. This contributed to a £97 million cost increase.

  In renegotiating the broader nuclear capability programme contract in 2016, the Department revised these arrangements. The new contract met the SSCRs, and the Department and AWE agreed for the scope, schedule and costs of work to be decided on a regular one- to three-year basis. This improved the Department's oversight but in 2017 an independent review identified that, despite the positive changes, these arrangements were not well suited to a large-scale, long-term build such as MENSA.

  In 2014, 91% of AWE's supply chain contracts were agreed on a cost-reimbursable basis. Therefore, given the Department's contract terms with AWE, the Department was liable for cost increases within AWE's supply chain. Since the 2016 project reset, and with greater certainty over the design, AWE's contractors have taken on more risk, with 85% of these contracts now placed on a firm price or target cost basis.

Contract management

3.7 In two of the three projects in our review (MENSA and the primary build facility), we identified Departmental concerns with the performance of both primary- and sub-contractors. These concerns related, for example, to AWE not adequately overseeing its sub-contractors, leading to inaccurate forecasting and overly complex designs, as well as sub-contractors not delivering the designs and materials required. For the three projects in our review, the Department continues to identify contractor performance as a risk.

3.8 As the Department holds the risks associated with these contracts, it needs to ensure it has the skills, information and arrangements in place to understand contractor performance on a timely basis. As mentioned in paragraph 3.15, there remain gaps across nuclear skills.

3.9 The Department's potential contract levers are limited by its ongoing need for the underlying infrastructure – it cannot simply terminate contracts as it continually needs, for example, a facility to produce nuclear cores. In addition, it has not always set up contracts to ensure it has the levers to both oversee contractors and respond to poor performance. For example, the Department's overarching contract with Rolls Royce covering the CPC facilities does not include indicators for the Department to assess performance, with limited incentives to improve contractor performance such as key performance metrics linked to costs and profit. The Department recognises these challenges and aims to address them in the second phase of the CPC facilities project.

Project management

3.10 We reported elsewhere that for complex major projects to be successful, they require strong leadership, with the necessary decision-making authority and structures that provide strong and effective oversight, challenge and direction. For example, for rail infrastructure projects we have seen how having an integrated programme view, as well as collaboration and transparency between those involved, contributes to more efficient and better project delivery.[14]

Project oversight

3.11 Historically, the Department failed to exercise effective oversight over its two AWE infrastructure projects, including MENSA. Several independent reviews commissioned by the Department since 2014 found weaknesses with the Department's organisational structure, which hindered its project oversight. As a result, the Department did not identify poor progress with projects approved in 2011 until late 2013, with the scale of the problems not fully understood until 2015. In 2014 and 2015, the Department issued AWE with two formal notices highlighting poor performance and requiring it to put forward plans to resolve the problems.

3.12 In managing MENSA as part of its broader £20 billion, 25-year nuclear weapon capability sustainment programme, the Department contributed to its oversight difficulties. Although this allowed the Department to better understand project interdependencies, it meant that it had more limited project controls. This made it harder to identify MENSA-specific budgets and, therefore, cost growth. Given an original forecast cost of £734 million, the Department could have classed MENSA as a major project in its own right, with accompanying governance arrangements. The Department adopted a similar approach for the primary build facility. This project, initially valued at £111 million, was incorporated into a broader Barrow-in-Furness redevelopment programme (where forecast costs have increased from £524 million to £1.1 billion), which is itself part of the £31 billion Dreadnought-build programme.

3.13 From March 2016, the Department introduced several measures to improve its governance of the AWE-operated site projects. After reassessing the projects, it agreed with AWE a revised contract and oversight structure. In 2018, a subsequent independent review found that in general governance arrangements had evolved, having significantly improved from 2016. There were closer working relationships between AWE and the Department and positive progress reported by both. Independent reviews identified good progress in the frequency and quality of management information, but more remained to be done. To also improve oversight and the management of interdependencies, in 2017 AWE sub-contracted the management of the MENSA project. However, the Department assesses that the MENSA project is still very challenging, with successful completion dependent on managing significant delivery risks.

14 Reports by the Comptroller and Auditor General, *Framework to review programmes, update 2018-19*, National Audit Office, April 2019; *Modernising the Great Western railway*, Session 2016-17, HC 781, National Audit Office, November 2016.

3.14 Since 2016, the Department has also made broader organisational changes with the aim of establishing more direct project oversight and a central view on interdependencies across the Enterprise (**Figure 10**). These include establishing the:

- **Defence Nuclear Organisation (DNO),** headed by the Director General Nuclear, to oversee the whole Enterprise. In addition, the Department transferred responsibility for the AWE contract and associated infrastructure projects to a new warhead team within the DNO. This had sat within the Department's strategic weapons team, with progress reported outside the Enterprise structure;
- **Submarine Delivery Agency (SDA)** as an executive agency from April 2018 to manage contracts, other than for AWE, with site operators. Since that date the SDA has sought to improve project governance by, for example, more than doubling the size of the project team responsible for the core production capability, from seven people in 2011. It has also co-located staff with the contractor Rolls Royce and reorganised project governance;
- **Dreadnought Alliance** to provide a joint management organisation for the Dreadnought-class submarine programme. The Alliance, formed in 2018, brings together the SDA, BAE Systems and Rolls Royce to develop joint schedules with the aim of improving information, cost control and contractor performance; and
- **Single Senior Responsible Owners (SRO)** to oversee interdependent projects. In 2015, the Department considered responsibility for nuclear projects had become fragmented. It now has one SRO responsible for submarine-related programmes, including infrastructure projects, and another for nuclear weapon-related programmes. These SROs are located within the DNO, rather the SDA, to increase central oversight.

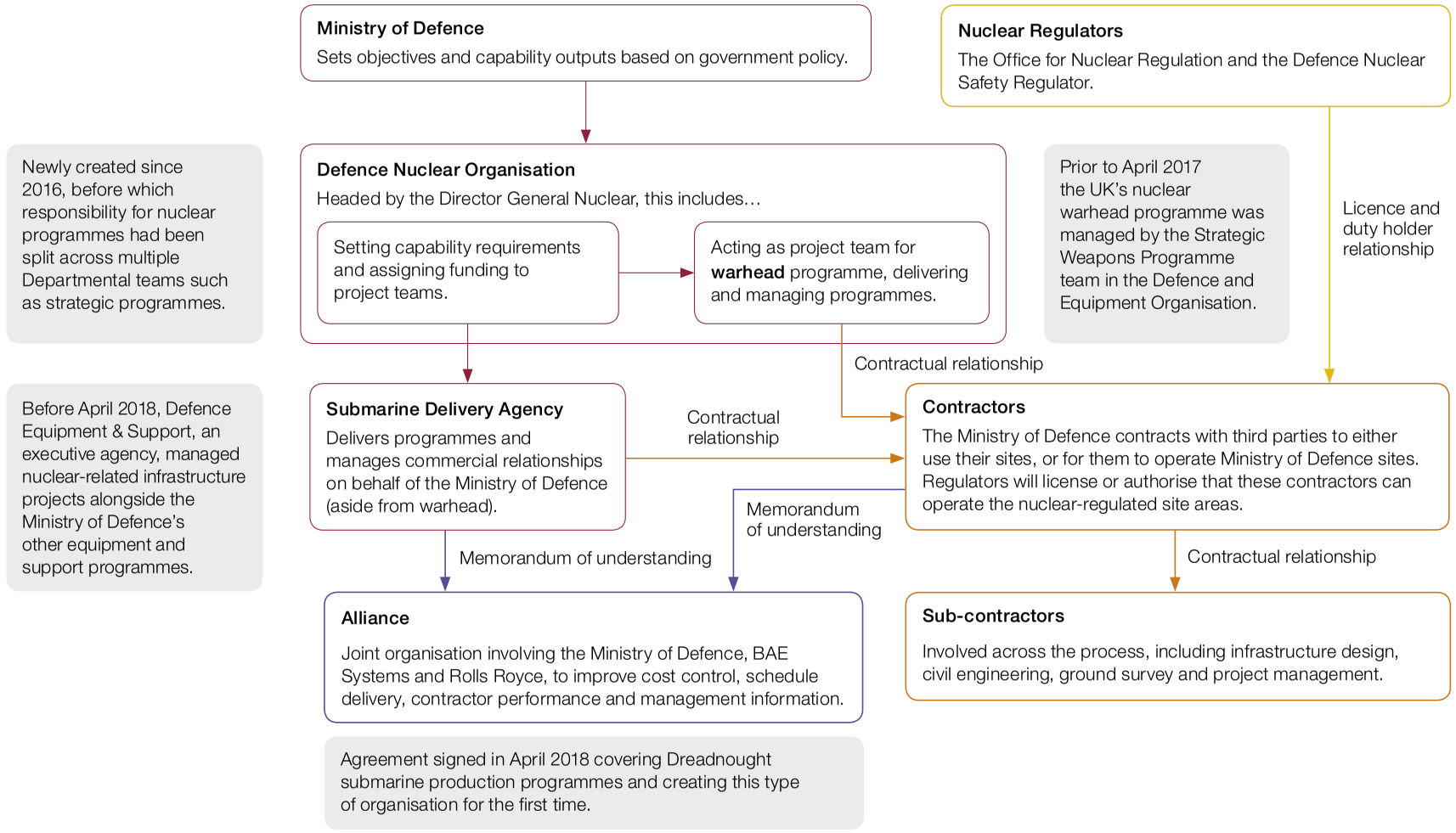
It remains too early to assess the full impact of these changes.

3.15 Following these organisational changes, the Department must still ensure that it has the capacity and capability to manage these projects. Although it and the SDA have sought to increase staff numbers, funding constraints and the inherent difficulty of securing nuclear-skilled staff remain as challenges. In September 2018, an independent review highlighted commercial, financial and technical personnel gaps within DNO. Also, in 2017, a specific project MENSA review identified immediate and pressing shortfalls of infrastructure, commercial and project control staff within DNO and its delivery agents.

Figure 10

Changes to the oversight of infrastructure projects at nuclear-regulated sites

The Ministry of Defence has changed organisational arrangements to try and improve project oversight



Source: National Audit Office analysis of Ministry of Defence data

Handling programme interdependencies

3.16 Constructing buildings before finalising requirements or developing detailed designs increases the likelihood of later changes. As we have seen, making later changes can often be costlier and more time-consuming than earlier in the process.[15] For each of the three programmes in our review, the Department approved the start of construction either before the facility requirements were fully understood or the designs were sufficiently mature. As we highlighted in Part One, this has led to almost half of the cost increases for the projects we reviewed, explaining some 48% of the £1.35 billion increase.

3.17 The reasons given for starting early include infrastructure being needed to meet Enterprise-wide programme timescales and to reduce broader risks. The Department has not always managed the resultant risks of starting projects early, such as by building in additional flexibility or milestones. For example:

- **CPC facilities, Raynesway**

  In 2011, the Department decided to develop a new pressurised water reactor for the Dreadnought-class submarine, needing the CPC facilities to build the new designs. Construction of the facilities started before the Department fully understood the new reactor designs and how they would be built. Given the new facility had to produce these reactors to meet the submarine build programme, the Department started construction based on assumptions around what the reactor would look like and how it would be built. As the design matured and building requirements became clearer, the Department realised the facility was too small, leading to increased costs. The Department attributed all the £146 million project cost increase to design change, alongside the resultant increase in contractor fees.

- **MENSA, Burghfield**

  The Department decided to build a new warhead facility following changes to the warhead design and the government's decision to reduce the number of warheads and extend their life. To reduce the regulatory risks around completing a complex facility in one go, AWE and the Office for Nuclear Regulation decided to split MENSA into four distinct regulatory phases. However, this also meant the mechanical and electrical systems were designed and constructed separately from the building itself. Given when the new facility was required, the Department took the risk of starting construction before all designs were complete and interdependencies fully managed. This decision resulted in a £399 million cost increase (37% of the total project cost increase), with external and internal designs not matching, and delays with the Department and AWE taking three years to re-scope the project.

15 Reports by the Comptroller and Auditor General, *The Nuclear Decommissioning Authority, Managing risk reduction at Sellafield*, Session 2012-13, HC 630, National Audit Office, November 2012; *Modernising the Great Western railway*, Session 2016-17, HC 781, National Audit Office, November 2016.

- **Primary build facility, Barrow-in-Furness**

  The first of the new Dreadnought-class submarines must enter service in the early 2030s. This defined schedule led to fixed dates for when interdependent projects, such as the primary build facility, had to be ready. This led the Department to start construction before designs had reached their industry-recommended levels of maturity. Proceeding with an immature design resulted in a £108 million cost increase (83% of the total project cost increase).

3.18 The Department has started to better manage project interdependencies and the risks of starting construction early by building in flexibility and contingency. For example, in finalising the design and construction of project MENSA, the Department and AWE sought to future-proof designs given the uncertainty over any future warhead design. Although leading to additional cost, this should ensure the facility can handle any future requirements. The Department also set aside a £138 million reserve to mitigate risks to the project's completion. In addition, for the CPC facilities, the Department split the second building into design and then construction. It believes this will ensure a mature design, avoiding the risks and cost escalation experienced during the first phase.

Learning from others

3.19 The Department's nuclear-regulated site infrastructure projects have experienced similar challenges to those previously undertaken by the Department, third parties such as civil nuclear site operators, and the Department's counterparts in the United States (**Figure 11** on pages 44 and 45). Reviews of similar projects identified common challenges such as overseeing projects, starting construction early and sharing risks with contractors. In the absence of formal arrangements or detailed comparative exercises, we consider that to date the Department has not systematically learned lessons or shared insights either from third parties or its own project teams.

Figure 11

Comparison of issues identified by the National Audit Office and United States Government Accountability Office in infrastructure projects at civilian and defence nuclear-regulated sites

Across various sites, similar factors have contributed to delays and cost increases

Themes		United Kingdom defence (1987–2002)
Commercial	Limited sharing risks with contractors	**Atomic Weapons Research Establishment refurbishment (1987):** Controller Research & Development Establishments, Research and Nuclear Programmes (CERN) asked the Atomic Weapons Research Establishment to extend competitive fixed prices as far as practicable in the management and early design of contracts. **Trident works programme (1994):** Some efforts to share risk with industry on some contracts, but these had been met with limited success.
	Poor contractor performance	**Devonport facilities upgrade (2002):** cost increases and delays (£86 million – £106 million) due to poor performance of Devonport Management Limited and its subcontractors.
Nuclear requirements	Starting construction too early	**Atomic Weapons Research Establishment refurbishment (1987):** To meet the overarching Trident timetable, the Ministry of Defence let building contracts before designing the equipment it would house, a departure from normal processes. This contributed to a significant cost increase. **Trident works programme (1994):** The Ministry of Defence presented the Trident timetable as non-negotiable, leading to contracts being let before designs were complete, and construction starting before safety cases approved. The main contract for the explosives handling jetty was awarded on the basis of a tender which included provisional quantities for steel reinforcement. Late provision of reinforcement schedules delayed construction and increased costs.
	Cost estimation weaknesses	**Trident works programme (1994):** The Ministry of Defence's estimates for technically demanding projects, such as the explosives handling jetty, seriously underestimated the complexity and impact of nuclear safety requirements.
Governance	Weaknesses in project reporting and monitoring	**Atomic Weapons Research Establishment refurbishment (1987):** The lack of a management plan led to a lack of overall control and project coordination. **Devonport facilities upgrade (2002):** The Ministry of Defence had originally been more 'hands off', but had recently sought to improve its project grip, including by being more closely involved in nuclear regulation and in determining the scope and design of the work.
Interdependencies	Delays in one work stream impacting progress in others	

Source: Reports by the Comptroller and Auditor General and the Government Accountability Office, United States

Civil nuclear sector (2012–2018)	United States defence (2000–2014)
Sellafield (2012): The Nuclear Decommissioning Authority's (NDA) contract to manage decommissioning at Sellafield did not pass on the risk of cost increases or delays to the site operator and supply chain.	
Sellafield (2012): Subcontractors had not welded a new evaporator to the nuclear regulatory standards required by the Office for Nuclear Regulation (ONR). This led to a cost increase of £50 million and contributed to an 18-month delay.	**Uranium Processing facility (2013):** Following its poor coordination of subcontractors, the contractor had to raise the roof to fit equipment into the building, costing $540 million.
Sellafield (2012, 2018): Uncertainties about the nature of the waste, and therefore the design requirements for a waste retrieval facility, contributed to construction delays. The NDA spent £500 million on its first two attempts to build the facility but in both those cases the design and technology could not handle the waste the facility was supposed to treat. In 2018, we reported that the NDA cancelled its third attempt after spending a further £477 million constructing the outer shell and agreeing a different strategy with the ONR.	**Surplus weapons-grade plutonium (2014):** Programme cost and schedule were approved before designs were complete. The cost of critical system components then averaged 60% higher than estimated, with programme costs expected to be $3 billion higher.
Sellafield (2012): Most major projects at Sellafield are complex and unique chemical engineering projects, making cost estimation difficult especially during design. We found that the costs of major projects under construction had increased up to 117%, with indications that the NDA did not fully consider contingencies in the original costs, including optimum bias.	**Uranium Processing facility (2013):** Total cost estimates increased from $1.1 billion in 2004 to $6.5 billion in 2012. Original estimates were based on the cost of building a uranium storage facility, assuming it would be similar in design. But the Uranium Processing facility needed to house more complex operations and the assumptions proved inaccurate.
Sellafield (2012, 2018): When constructing an evaporator, the NDA did not monitor the use of contingency, which accelerated rapidly during 2010. Had it been collecting information, the NDA would have had much earlier warnings of the emerging problems. In 2018, we reported that the evaporator construction had completed three years late and costed £352 million more than planned.	**National Ignition Facility (2000):** The US Department of Energy lacked staff with sufficient management and technical skills to oversee construction, leading to a six-year delay and $1 billion cost increase. **National Nuclear Security Administration (2010):** GAO observed a lack of accurate and reliable data on the condition and replacement value of facilities. **US Department of Energy (2007):** Nine out of 12 major projects exceeded original cost estimates and / or experienced schedule delays. This was mainly because of ineffective oversight, partly due to inadequate systems for measuring contractor performance, alongside insufficient staffing and project management experience.
Sellafield (2018): By cancelling a project to retrieve waste from a high hazard silo, the NDA found that another facility envisaged as part of the same waste stream was no longer required. The NDA had already spent £66 million and is now seeking alternative uses for the facility.	

Appendix One

Our audit approach

1 This report examines the Ministry of Defence's (the Department's) management of its large and complex infrastructure projects at nuclear-regulated sites. By examining three projects, valued at £2.5 billion in total, and constituting all the Department's current such projects under construction, it assesses whether the Department's management of these projects has represented value for money. In doing so, we aim to set out lessons for the Department, in both completing these projects and considering its next cycle of such projects, and for other organisations which manage similarly complex builds. We examined:

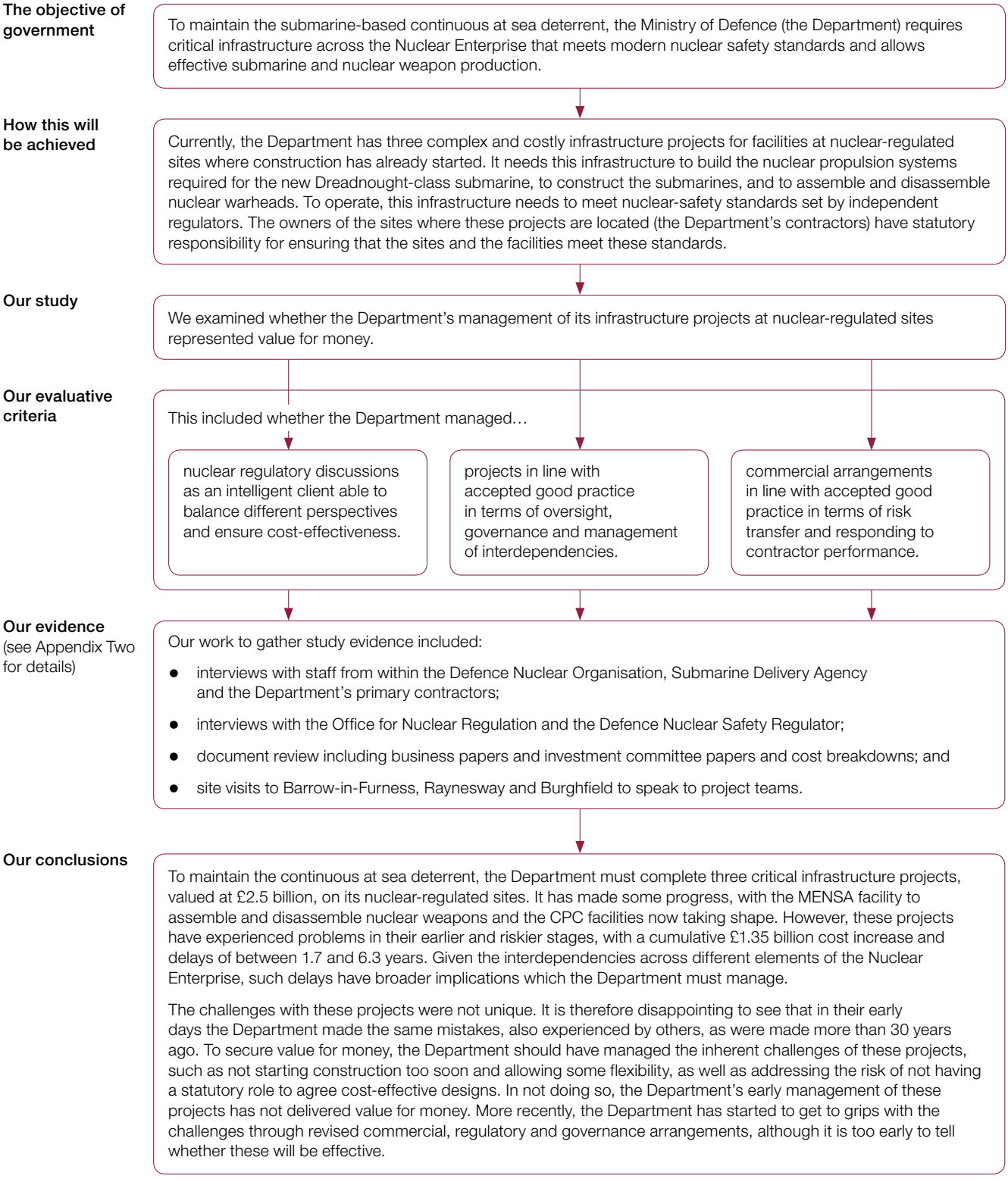
- progress to date across infrastructure projects on nuclear-regulated sites;
- the Department's approach to the nuclear regulatory environment; and
- whether the Department's management of the projects aligns with accepted programme and commercial management standards.

2 To ensure value for money during the early project stages, the Department must overcome both the inherent risks of all complex infrastructure projects, and unique nuclear regulatory challenges. When considering value for money, we applied an analytical framework and evaluative criteria drawn from both our past value for money and other 'lessons learned' reports. These include:

- **Projects at civil nuclear-regulated** sites such as *Managing risk reduction at Sellafield*, Session 2012-13, HC 630, November 2012, and *The Nuclear Decommissioning Authority: progress with reducing risk at Sellafield*, Session 2017-19, HC 1126, June 2018.
- **Complex and costly infrastructure projects**: *Ministry of Defence: Management of the Trident Works Programme*, Session 1993-94, HC 621, July 1994; and *Framework to review programmes*, April 2019; and
- **Commercial challenges**: *Completing Crossrail*, Session 2017-19, HC 2106 May 2019; and *Commercial and contract management: insights and emerging best practice*, November 2016.

3 Our audit approach is summarised in **Figure 12**. Our evidence base is summarised in Appendix Two.

Figure 12
Our audit approach



Appendix Two

Our evidence base

1 We reached our independent conclusions on whether the Ministry of Defence's (the Department's) management of its infrastructure projects at nuclear-regulated sites represents value for money after conducting fieldwork between May and September 2019. Our overall audit approach is outlined in Appendix One.

Case study approach

2 Our report draws overarching conclusions on the Department's management of projects through analysing three individual projects – the MENSA project in Burghfield, the core production capability project in Raynesway, and the primary build facility in Barrow-in-Furness. As construction has started for each of these projects, they have advanced sufficiently for us to draw our insights and evaluate progress. These projects comprise 24%, by initial project value, of the Department's infrastructure projects in 2018, and each acts as a critical enabler across the Defence Nuclear Enterprise. The Department has other infrastructure projects at nuclear-regulated sites, which are at an earlier stage. They include project Pegasus at the Atomic Weapons Establishment site and a project at the HM Naval Base Devonport. Although we have not focused on these projects as part of this report, we touch on relevant learning where appropriate.

3 To better understand the background of each project, the challenges faced and recent changes, for each of the case study projects we reviewed:

- **we held interviews with project teams** within the Submarine Delivery Agency, the Defence Nuclear Organisation and the Department's contractors. The contractors included AWE Management Limited (AWE), BAE Systems and Rolls Royce;
- **we undertook detailed reviews of various project documentation** including investment approval committee submissions; board papers; organisational structures; Defence Nuclear Safety Regulator reports; Infrastructure and Projects Authority programme assessments; and external programme reviews;

- **we analysed cost data for individual projects,** as well as for the broader programmes within which projects sat, such as the Barrow-in-Furness site redevelopment programme and the AWE nuclear warhead capability sustainment programme. This work included drawing on the Department's independent Cost Assurance and Analysis Service's analysis and scrutiny reports; and
- **we made site visits** to the Atomic Weapons Establishment Burghfield, the BAE Systems dockyard in Barrow-in-Furness, and the Rolls Royce site at Raynesway, Derby.

Thematic approach

4 To better understand the nuclear regulatory environment, as well as the dialogue between regulators, site operators and the Department:

- **we held interviews** with staff from the Office for Nuclear Regulation (ONR) and the Defence Nuclear Safety Regulator (DNSR);
- **we reviewed published material from ONR**, including guidance for the licensing of nuclear-regulated sites, licence conditions and the requirements of safety cases; and
- **we met with representatives of site operators** responsible for implementing infrastructure programmes on nuclear-regulated sites.

5 To help develop our understanding of the challenges of both complex infrastructure projects and of operating in a nuclear regulatory environment, we reviewed previous audit reports across similar programmes. The reports included:

Comptroller and Auditor General reports:

- Ministry of Defence and Property Services Agency: *Control and Management of the Trident Programme*, HC 27, Session 1987-88, National Audit Office, July 1987.
- Ministry of Defence: *Management of the Trident Works Programme*, Session 1993-94, HC 621, National Audit Office, July 1994.
- Ministry of Defence: *The construction of nuclear submarine facilities at Devonport*, Session 2002-03, HC 90, National Audit Office, December 2002.
- Nuclear Decommissioning Authority: *Managing risk reduction at Sellafield*, Session 2012-13, HC 630, National Audit Office, November 2012.
- Commercial and contract management: *insights and emerging best practice*, National Audit Office, November 2016.

- *Modernising the Great Western railway*, Session 2016-17, HC 781, National Audit Office, November 2016.
- *Improving value for money in non-competitive procurement of defence equipment*, Session 2017-19, HC 412, National Audit Office, October 2017.
- The Defence Nuclear Enterprise: *a landscape review*, Session 2017-19, HC 1003, National Audit Office, May 2018.
- The Nuclear Decommissioning Authority: *progress with reducing risk at Sellafield*, Session 2017-19, HC 1126, National Audit Office, June 2018.
- *Framework to review programmes*, National Audit Office, April 2019.
- Department for Transport: *Completing Crossrail*, Session 2017-19, HC 2106, National Audit Office, May 2019.

United States Government Accountability Office (GAO) reports:

- *National Ignition Facility: Management and Oversight Failures Caused Major Cost Overruns and Schedule Delays*, GAO/RCED-00-141, August 2000.
- *Department of Energy: Major Construction Projects Need a Consistent Approach for Assessing Technology Readiness to Help Avoid Cost Increases and Delays*, GAO-07-336, March 2007.
- *Nuclear Weapons: Actions Needed to Identify Total Costs of Weapons Complex Infrastructure and Research and Production Capabilities*, GAO-14-10-582, June 2010.
- *Nuclear Weapons: Factors Leading to Cost Increases with the Uranium Processing Facility*, GAO-13-686R, July 2013.
- *Plutonium Disposition Program: DOE Needs to Analyze the Root Causes of Cost Increases and Develop Better Cost Estimates*, GAO-14-231, February 2014.

Appendix Three

Case studies

Case Study 1
Primary build facility, Barrow-in-Furness

The Ministry of Defence (the Department) is funding new facilities at the Barrow-in-Furness shipyard to help facilitate a more efficient submarine production process for the new Dreadnought-class submarine. This site-wide redevelopment plan, made up of 23 projects currently valued at £1.1 billion, covers buildings on the licensed and non-nuclear licensed areas of the site. New facilities within the nuclear-licensed area include the primary build facility, which comprises two separate buildings. The first is designed to manufacture components for the submarine reactor compartment. A second facility is designed to receive from Rolls Royce a nuclear reactor, so this can be integrated with other components before installation in the submarine.

Location	Barrow-in-Furness, Cumbria
Site owner and operator	BAE Systems BAE Systems is responsible for coordinating the design and construction subcontractors.

Key dates		**Forecast project cost**	
Need for new facilities identified	November 2012	Initial	£111 million
Funding/main gate business case approval	April 2016		
Initial forecast in-service date	Manufacturing facility 2018 Integration facility 2020	Revised	£240 million (best judgement as at October 2019, subject to contractor discussions and cost modelling)
Current forecast in-service date	Manufacturing facility March 2020 Integration facility May 2022	Percentage spend (as at April 2019)	33%

Current stage	Manufacturing facility construction largely complete and currently being fitted out with the necessary equipment and machinery. Integration facility design complete with construction of foundations having started.
Project risk rating	Red – Ministry of Defence project assessment based on risk to broader programmes (current). Amber – Infrastructure and Projects Authority delivery confidence in the Dreadnought submarine production programme, of which this project is a critical part (published July 2019).

Case Study 1 *continued*

Primary build facility, Barrow-in-Furness

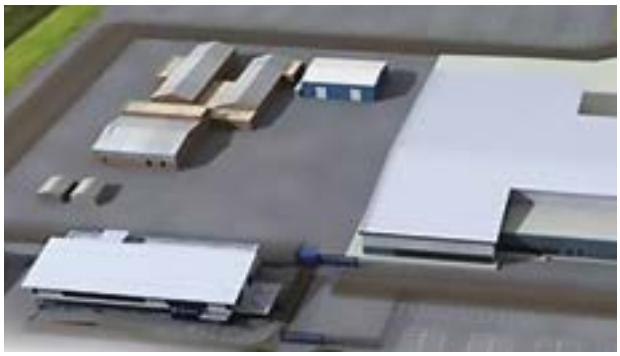
Thematic summary of findings

Commercial	Commercially, the Department holds the risk of cost increases by contracting BAE Systems on an ascertained cost basis. Also BAE Systems will not be liable for damages relating to non-performance and can recover all costs incurred in making good any capital works in the event of default. BAE Systems has so far incurred an additional £108 million because of design immaturity and £11 million for unforeseen events. In addition, BAE Systems' management fee rises in proportion with the cost, further limiting any incentive to control costs. BAE Systems has earned an additional £10 million in fees, to make the total £16.5 million for the project to date.
Regulation	No issues identified with regulatory interface, with the Department, site operator and regulator describing a constructive relationship. The Department is in the process of establishing a cross-group senior engagment forum.
Requirement setting	Given the potential impact should these facilities be delivered late, the Department started construction before completing designs to the industry standard of maturity. This led to design costs increasing from £5 million to £20 million due to the need for additional design work after construction had begun.
Interdependencies	The Department must complete these facilities in time so it can receive the nuclear reactor cores from Rolls Royce when required, and then make components in line with the broader Dreadnought production timetable. Given these interdependencies it decided to proceed with construction with immature designs.

Source: National Audit Office analysis of Ministry of Defence data

Case Study 2

Core production capability (CPC) facilities, Raynesway



The Ministry of Defence (the Department) is funding facilities for constructing and testing the new nuclear reactor cores to be used in its latest submarine fleet. They replace existing facilities at the Rolls Royce site in Raynesway, the only UK site licensed to undertake this type of work. In 2002, the regulator identified this site, constructed in the late 1950s, as no longer fit for purpose against modern standards. The project consists of two phases covering the construction of new facilities to manufacture new reactor cores (Phase 1) and nuclear fuel (Phase 2).

During the redevelopment, Rolls Royce must continue production of nuclear cores within the ageing facility, whilst ensuring the site remains compliant with nuclear regulatory safety standards. The regulator has not identified any specific safety concerns. Facilities redevelopment is part of a broader capability programme covering site operation and the manufacture of cores, maintaining the UK's ability to produce nuclear reactors for the foreseeable future. Since its approval in 2012, the costs of this broader programme have increased from £1.2 billion to £1.7 billion.

Location Raynesway, Derbyshire

Site owner Rolls Royce

Rolls Royce is responsible for coordinating the design and construction subcontractors.

Key dates

Need for new facilities identified	2002
Funding/main gate business case approval	2012
Initial forecast in-service date	May 2021
Current forecast in-service date covering both Phases 1 and 2	June 2026

Forecast project cost

Initial (not including Phase 2 construction)	£328 million (as at 2012)
Revised	£474 million
Percentage spend (as at April 2019)	83%

Current stage

Phase 1, the reactor core manufacturing facility, has been built and is being fitted out with the necessary equipment and machinery, expected to be in service from December 2020.

For Phase 2, the nuclear fuel facility, design work started in 2019 to inform planning estimates. The Department expects to approve plans and construction funding in 2022.

Project risk rating

Amber – Infrastructure and Project Authority's delivery confidence in the broader CPC programme (published July 2019).

Case Study 2 *continued*

Core production capability (CPC) facilities, Raynesway

Thematic summary of findings

Commercial	In 2012 the Department contracted Rolls Royce to provide the overarching core production capability through a long-term single-source contract lasting until 2056. Within this commercial arrangement, Rolls Royce and the Department agreed a costed scope of work up until 2023, which covered the expected infrastructure work to be undertaken over those 10 years alongside operations. The contract reimburses Rolls Royce on an ascertained cost basis and includes limited incentives to improve contractor performance, such as key performance indicators linked to costs and profit.
Requirement setting	The Department started constructing the first phase of the manufacturing facility before it had established how the new nuclear core, to be used in the latest submarines (the Dreadnought class), would be built. This contributed to a cumulative £146 million cost increase, which included the cost of constructing an additional building. To reduce the risks associated with design uncertainty, in 2019 the Department split the design and construction elements of the second phase of the regeneration project.
Governance	Given the project was originally governed within the overarching capability programme, a team of seven staff worked on this project when it was approved in 2012. In 2016-17, the Department increased this number to 18 staff, with some embedded within Rolls Royce. However, the Department has struggled to recruit suitably qualified and experienced staff to all these posts, with two vacant as of June 2019.
Interdependencies	The Department needs timely delivery of the nuclear reactor cores to meet its submarine production timetable. As such, this project needs to be completed in time for the new cores to be provided for Dreadnought-class submarines. Wider decisions also affected this facilities project. For example, the Department's decision to refuel *HMS Vanguard* meant existing facilities had to be used for longer, contributing to delays in the Department starting work and the overall five-year project delay.

Source: National Audit Office analysis of Ministry of Defence data

Case Study 3
MENSA, AWE Burghfield

As part of the broader Nuclear Warhead Capability Sustainment Programme, the Ministry of Defence (the Department) is funding new facilities to assemble and dissemble nuclear warheads at the AWE Plc-operated (AWE) site in Burghfield. This is partly because of the need to replace current facilities, which, given their age, have only received limited approval from the regulator for their continued operation. This new facility will ensure safety standards are maintained in line with regulatory requirements. The Department contracted AWE Management Limited to provide the new facilities as part of a broader 25-year £20 billion contract to operate nuclear sites. This project was approved in 2011 but was reset in 2016 as the Department reconsidered its options in the light of forecast cost increases.

Location Burghfield, Reading, Berkshire

Site operator AWE Plc, on behalf of AWE Management Limited to whom the Ministry of Defence contracted the site operation.

In 2017, AWE Plc contracted Costain as construction manager to coordinate the design and construction subcontractors.

Key dates		**Forecast project cost**	
Need for new facilities identified	2003	Initial	£734 million
Funding/main gate business case approval	August 2011	Latest	£1,806 million
Initial forecast in-service date	2017		
Current forecast in-service date	2023	Percentage spend (as at April 2019)	71%

Current stage Construction work has been completed and the facility is now being fitted out with the necessary equipment and machinery.

Project risk rating Amber – the Infrastructure and Project Authority's delivery confidence in the MENSA project (2018).

Case Study 3 *continued*
MENSA, AWE Burghfield

Thematic summary of findings

Commercial	Commercial arrangements in place before the project was reset in 2016 provided the contractor limited incentive to control cost increases. For example, the overarching contract which covered this programme led to AWE earning additional fees where work had been deferred, which partly resulted as the Department needed to achieve in-year savings. The Department revised the contract in 2016. In addition, with AWE contracting 94% of its supply chain on a cost-reimbursable basis in 2014, the Department was also liable for paying any increase in costs across the supply chain. The uncertainty over the final design contributed to contractors being unwilling to take on any cost risks at a price acceptable to the Department. Since 2016, AWE has renegotiated 85% of its sub-contracts onto a firm or target-cost basis.
Regulation	The Office for Nuclear Regulation increased its oversight of the Burghfield site, partly because of the lack of progress made with this project. It has only approved the use of existing facilities, which MENSA will replace, for a limited period, with the site currently being assessed as safe to operate. Looking ahead, the Department, site operator and regulator have established senior-level engagement to reduce the risk of over-specified designs.
Requirement setting	As construction started with an immature design, costs increased by at least £399 million given the amount of re-work required. Through the chosen design, the Department has sought to mitigate the impact of potential changes that may be required to the facility's design in the future.
Governance	As the Department recognises, a lack of oversight and poor contractor information meant cost increases and delays went unnoticed for at least three years and it took seven years for the full implications to be understood. In addition, AWE failed to adequately oversee sub-contractor performance, leading to inaccurate forecasting, overly complex designs and misleading progress reporting. Combined with a lack of nuclear expertise in sub-contractor design firms, this led to schedule delays and cost growth. Following the creation of the Defence Nuclear Organisation in 2016, the Department now has more direct oversight of these programmes. In addition, in July 2017, AWE contracted Costain to replace it overseeing the project and supply chain.
Interdependencies	Wider projects within the nuclear warhead capability programme depend on completion of the MENSA facility, with this project itself dependent on the timing of wider programme decisions. Delay has resulted in the need to run on existing ageing facilities at additonal cost and enhanced regulatory attention.

Note

1 Revised forecast project cost does not include £21 million additional costs to maintain current facility until MENSA available.

Source: National Audit Office analysis of Ministry of Defence data

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