National Audit Office

MINISTRY OF DEFENCE

The United Kingdom's Future Nuclear Deterrent Capability

REPORT BY THE COMPTROLLER AND AUDITOR GENERAL | HC 1115 Session 2007-2008 | 5 November 2008

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CONTENTS

SUMMARY

1 This report takes an initial look at the Ministry of Defence's (the Department's) programme for implementing the Government's decision to maintain the United Kingdom's nuclear deterrent capability beyond the life of the current Trident system. The programme is at an early stage with the Department currently engaged in a two-year concept phase, focused on the new class of submarine, which is due to finish in September 2009. This phase will establish the principal design parameters of the submarines and consider how to deliver other aspects such as manning, training and infrastructure. Other work is focused on assembling the information necessary to inform decisions on whether and how it may be necessary to refurbish or replace the current nuclear warhead that are expected to be necessary in the next Parliament. Our report therefore focuses on the major risks to delivery as they currently stand, and the actions that the Department is taking to manage those risks.

2 The United Kingdom deployed its first submarine-launched nuclear deterrent in 1968, known as Polaris, with the commissioning of the Resolution class submarine fleet. Polaris stayed in service until the mid-1990s, when it was replaced by the Trident system, deployed on Vanguard class submarines, the first of which came into service in 1994. Since the introduction of Polaris, successive governments have been committed to a policy of continuous at sea deterrence, meaning that at least one nuclear-armed submarine is on patrol at any time. Continuous at sea deterrence is a clear and demanding operational requirement which has been met since 1968.

3 The nuclear deterrent currently comprises four principal elements: a fleet of four Vanguard-class submarines; access to a pool of Trident D5 missiles, shared with the United States; a stockpile of nuclear warheads; and a range of support infrastructure.

In 2006, the Government announced its intention to maintain the UK's nuclear deterrent capability, focussed primarily on the acquisition of a new class of submarines. The Government also set out its plans to participate in the United States of America's programme to extend the life of the Trident D5 missile and to make a decision in due course about whether and how it may be necessary to refurbish or replace the current nuclear warhead.

Main findings

4 Our main findings are as follows:

5 There is a challenging timetable to meet if continuous at sea deterrence is to be maintained. The critical path for provision of a future deterrent capability is the delivery of the nuclear-powered submarine platform in time to meet an in-service date of 2024. But there are also possible time constraints from other areas of the programme. There is currently little scope for incorporating time contingency in the overall programme to deal with slippage in any of these areas. The Department is currently examining how it might mitigate this risk.

6 The current two-year concept phase involves a range of important and difficult decisions which must to be taken in a timely manner in order to keep the programme on track. The technical complexity and the involvement of a wide range of partners, including other government departments and the United States of America, makes developing the design specification for the future submarine a challenging task. There are still major decisions to be made if this work is to be completed on time by the formal end of the concept phase in September 2009.

7 The Department has developed management and decision-making arrangements during the concept phase, but recognises that these arrangements will need to be strengthened as the programme develops. Our work has identified challenges which need to be addressed in the short term, such as the overall coordination of the programme. The Department is developing work schedules, progress monitoring and risk management arrangements, but these are not mature yet.

8 The Department has made good progress in identifying, engaging and communicating with important partners including other government departments and industry. Whilst communications across the programme are generally good, further opportunities exist, such as secure video conferencing with the United States and improved IT infrastructure, which would increase working efficiency.

9 The Government's White Paper predicted an acquisition cost for the new system of £15-20 billion in 2006-07 prices. The White Paper also concluded that the operating costs would be similar to the current deterrent at between 5 and 6 per cent of the annual defence budget, but did not quantify those costs. The Department is improving the White Paper cost estimates but they are not yet sufficiently robust to support the future deterrent programme throughout its planned life. There remain a number of major areas of uncertainty in the budget, including the provision for contingency, inflation and Value Added Tax. Budgetary control arrangements are still being developed and there are some areas of potential risk which need to be addressed.

10 The 2005 Defence Industrial Strategy sets out the Government's intention that Royal Navy submarines will be built in the United Kingdom. Suppliers to the submarine industry constitute a highly specialised industrial sector with a number of monopoly suppliers. There are difficulties inherent in providing the right incentives for monopoly suppliers to deliver to time and budget. Currently, there is no single document which sets out convincing evidence of how the Department intends to assure value for money from its suppliers throughout the life of the programme. The Department is aware of this and will include criteria for assessing value for money in the procurement strategy it has under preparation.

11 Both the Department and its industrial suppliers have identified skills shortages and are considering how to address them. These shortages relate to submarine building expertise within the industrial supply chain and financial, commercial, programme management and nuclear-related expertise within the Department.

Overall Conclusion

12 The programme to maintain the UK's nuclear deterrent capability is at an early stage. It is therefore not surprising that some critical arrangements and decisions required to deliver the future deterrent are still being developed. For example, there are considerable challenges in ensuring that the Department's suppliers perform effectively and that the new submarines are delivered on time and at an acceptable cost. The Department has, however, made good progress in establishing programme management arrangements, coordinating all aspects of the future deterrent capability and engaging industry and other government departments. The risks identified in this report will need to be managed carefully if value for money is to be achieved over the life of this programme.

Recommendations

13 **Box 1** sets out the principal areas of risk that need to be managed to ensure the successful delivery of the future deterrent on time and on budget. These risks are interdependent but each alone has the potential to undermine the Department's ability to deliver continuous at sea deterrence in the future. The Department is aware of these risks and is monitoring them through its newly established Programme Support Office, reporting to the Senior Responsible Owner.

14 Within those five areas of risk, we have identified a number of elements of the programme which require particular attention in the short term.

a The successful delivery of the future deterrent capability will require co-ordinated and timely action from a range of senior decision-makers across government, internationally and in industry. The inherent complexity of the delivery arrangements increases the risk of poor or cumbersome decision-making. The Department faces a challenge in ensuring that the leadership arrangements are fit for purpose as the programme evolves. **The Department should:**

i **Establish and communicate to decision-makers within the Department, across government and in industry a clear timetable for decisions with the specific deliverables required to achieve them clearly identified and agreed with those responsible.**

ii **Take stock after Initial Gate, and certainly by Main Gate, on the evolution of the Senior Responsible Owner role and supporting structures, ensuring that the experience, seniority and time commitment required of the individual or individuals charged with coordinating decision-making and providing overall direction for the programme, which will change as the programme matures, are taken into account.**

iii **Encourage decision-makers to work in a collegiate manner by more closely aligning incentives to improve joint working and identifying and rewarding behaviours which will underpin this.**

b The Department needs to create a single, consistent and accurate dataset for the programme to ensure that decision-makers have the relevant information required when making decisions and to provide clear data for oversight of the programme. **It should put in place, by no later than the end of the concept phase, a single set of performance indicators demonstrating progress on key time, cost, performance and risk metrics across the programme. These indicators should be managed by the Programme Support Office on behalf of Director Strategic Requirement and the Senior Responsible Owner.**

c There is a need, recognised by the Department, to refine and update the initial estimates of the costs of the programme set out in the White Paper and, in particular, to produce robust estimates of whole-life costs. In undertaking this work, there is a balance to be struck between producing whole-life cost estimates with sufficient detail to support key decisions and introducing spurious accuracy before many technical aspects of the programme are understood. **By September 2009 the Department should have more robust cost estimates that make provision for the areas of uncertainty raised in this report, as well as developing fuller cost estimates for other areas such as infrastructure and training. Within that revised cost estimate and given the uncertainties involved, the Department will need to decide what period its provision for elements such as contingency and inflation will cover.**

BOX 1

Principal areas of risk which need to be managed

1 Meeting a challenging timetable.

2 Making decisions about the design on time.

3 Ensuring effective governance arrangements.

4 Developing a robust budget and exerting financial control.

5 Applying effective procurement practices.

d To ensure effective oversight of in-year expenditure on the programme, it is essential that the programme team supporting the Senior Responsible Owner have detailed visibility of the budget once it is distributed through the integrated project teams responsible for delivery. **The Department should mandate that the Programme Support Office, on behalf of Director Strategic Requirement and the Senior Responsible Owner, has access to each integrated project team's financial management information and that information is held in a common form, with common assumptions.**

e Critical to the successful maintenance of continuous at sea deterrence is establishing with greater certainty how far the life of the current Vanguard class of submarines can be safely extended. **While the assessment of risk will continue until the Vanguard class goes out of service, the various parts of the Department involved need to provide the Programme Board with a thorough analysis by September 2009 to show what the full implications of this work are. Those teams should agree dates for critical decisions, as well as responsibilities for work required to meet those dates.**

f Making certain that its suppliers deliver on time and at an acceptable cost is a major challenge for the Department, which requires a comprehensive strategy to bring together all elements of the programme. **The Department should implement the lessons it has learnt from similar projects and previous NAO guidance, and work with industry to develop a commercial strategy which provides a clear picture of how it will incentivise performance in the context of its overall relationship with the suppliers concerned.**

g A range of government departments are involved in nuclear-related policy-making, regulation and oversight across the civilian and military sectors. This work requires a range of specific skills. The Department and its industrial partners are facing some skills gaps, including programme management, submarine construction expertise and nuclear-related experience. Although the Department is introducing some sensible short-term measures to alleviate those gaps, it needs to pursue urgently measures to resolve these problems in the long term if it is to mitigate the risks facing the programme throughout its life. **By September 2009 and working in conjunction with key industrial suppliers, the Department should produce a report analysing the lessons learned from practices adopted to date, identifying specific skills gaps and setting out a long-term strategy to fill those gaps. As part of this analysis the Department should continue to engage with other government departments involved in the civil nuclear field to maximise the United Kingdom's skills base as a whole.**

INTRODUCTION

1 This section sets out some key facts about the United Kingdom's nuclear deterrent and the Government's plans to maintain it. It also highlights some of the challenges involved in delivering complex defence projects and notes the need for the Department to learn from the experience of the current Astute submarine acquisition.

Key facts about the nuclear deterrent

2 The nuclear deterrent currently comprises four principal elements: a fleet of four Vanguard-class submarines; access to a pool of Trident D5 missiles, shared with the United States; a stockpile of nuclear warheads; and support infrastructure. These are set out in **Box 2** below.

3 A typical ballistic missile submarine and its principal compartments are shown in **Figure 1**. The illustration shows the considerable amount of space required by the engine room and the missile compartment and the importance of their dimensions to the overall size and shape of the submarine.

4 Since the introduction of Polaris patrols in 1968 the United Kingdom has ensured that at least one nuclear-armed submarine is on patrol at any time and has recently achieved 300 consecutive patrols without a break. This is known as continuous at sea deterrence. The Department's rationale behind this concept is as follows:

BOX 2

Principal elements of the United Kingdom's current nuclear deterrent

Capability	Description
4 Vanguard class submarines	Also known as SSBNs (Ship Submersible Ballistic Nuclear). Each submarine has a 146-man crew and 16 missile tubes. The first of class began deterrent patrolling in 1994. Based on current assumptions about extending its planned service life, the Vanguard class is likely to start leaving service from the early 2020s.
Trident D5 missile	Each missile has a range of over 4,000 nautical miles. The United Kingdom does not have any sovereign missile production capacity and is reliant on the United States of America for supply.
Nuclear warhead	Produced and supported in the United Kingdom by the Atomic Weapons Establishment with certain United States-supplied non-nuclear components. The United Kingdom has a stockpile of fewer than 160 operationally available nuclear warheads. Vanguard-class submarines carry up to 48 nuclear warheads.
Crews	The Royal Navy is responsible for recruiting and training the crews who operate the submarines.
Support infrastructure	Comprises support and overhaul facilities at the HM Naval Base sites at Faslane and Coulport in Scotland and Devonport in Plymouth; in-service operational support; and the infrastructure associated with the command and control of the submarines.

- the submarine on patrol is less vulnerable to attack, providing assurance that the nuclear deterrent is available at all times. This feature is particularly important given that, in contrast to all other declared nuclear powers, the United Kingdom has no alternative nuclear deterrent capability such as air- or ground-launched weapons;
- the Government considers that this invulnerability contributes to stability by removing the incentive for a pre-emptive attack on its nuclear forces; and
- if continuous deterrent patrols ceased, the United Kingdom could be deterred or prevented from deploying a nuclear armed submarine in a crisis.

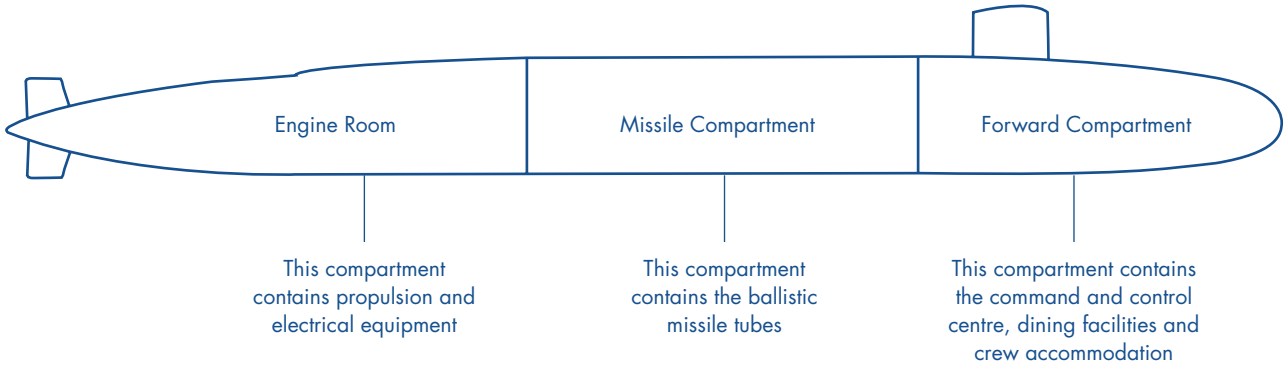
5 In its 2006 White Paper[1], the Government explained the reasons for its decision to maintain the United Kingdom's nuclear deterrent capability beyond the life of the current Trident programme. The White Paper also explained why the decision needed to be taken at that point, what further decisions were likely to be necessary, what the estimated procurement costs would be and what the United Kingdom's international obligations in relation to the deterrent were. It considered four possible generic delivery options for the future deterrent: a large aircraft equipped with cruise missiles; silo-based ballistic missiles; a surface ship equipped with ballistic missiles and a submarine equipped with ballistic missiles.

6 The White Paper's principal conclusions were as follows:

- the Government had decided to take the steps necessary to sustain a credible deterrent capability in the 2020s and beyond;
- a review of the available delivery options against cost, vulnerability and effectiveness criteria had demonstrated that a submarine-based system equipped with ballistic missiles continues to provide the most effective deterrent and that no credible alternative would be more cost-effective; and
- the Government had decided to build a new class of submarines, at an estimated procurement cost of £15-20 billion, and participate in the United States life extension programme for the Trident D5 missiles.

7 The conclusions of the White Paper and the subsequent House of Commons debate in March 2007 constitute the starting point for our work.

1 A typical ballistic missile submarine and its principal components



Source: National Audit Office

1 *The Future of the United Kingdom's Nuclear Deterrent*, Cm 6994, December 2006.

The challenges of delivering complex defence projects

8 Our annual Major Projects Reports and other value for money work on large defence acquisition projects show that complex projects such as the Type 45 Destroyer and the Nimrod Maritime Reconnaissance and Attack Mark 4 aircraft have suffered considerable delays and cost overruns. The Major Projects Report 2007[2] showed that these two projects had reported delays of 36 and 89 months and cost overruns of £989 million and £687 million respectively.

9 These delays and cost increases cause several problems. As well as costing the taxpayer more money than should have been the case, they can delay the delivery of military capability to the front line or force the Department to reduce the project's capability in order to save money. They can also hinder the delivery of other associated projects. The renewal of the nuclear deterrent poses a particular challenge in this regard, in that it must be in service with the Royal Navy by 2024. The fact that it cannot be delayed means that the Department can only compromise on cost or performance if the programme is at risk of not being delivered on time.

10 One defence acquisition project which is of particular importance to the renewal of the nuclear deterrent is the Astute submarine project. This project has suffered various problems during the last decade. These are set out in **Box 3**, together with the actions taken by the Department and the contractor, BAE Systems, to remedy them. The five principal difficulties encountered during the Astute project to date are as follows:

- slow contract negotiations;
- an ill-advised attitude to risk on the part of the Department;
- difficulties encountered by the contractor with a computer assisted design tool untested in the ship-building industry;
- the loss of key skills and experience as a result of a gap between submarine construction programmes; and
- various types of unplanned cost growth.

These difficulties may not all materialise on the future deterrent programme, but Risk Area 5 of this report, covering the Department's relationship with its suppliers, sets out how these kinds of issues are being addressed.

11 Because of the similarities between the Astute project and the future submarine class which will carry the future nuclear deterrent, the Department needs to ensure that it has learnt these lessons of the Astute project and is putting them into action in the new programme.

2 *Major Projects Report 2007*, Report by the Comptroller and Auditor-General, HC 98, Session 2007-2008, 30 November 2007.

BOX 3

Problems associated with the Astute submarine programme and actions undertaken by the Department to resolve them

The Astute submarine programme

The Astute class of nuclear-powered, conventionally-armed submarines is the replacement for the existing Swiftsure and Trafalgar classes. As well as fulfilling the traditional anti-submarine warfare role, the Astute class is designed to provide a wide range of support to joint operations, including land attack, intelligence gathering and special forces operations. HMS Astute was launched on 8 June 2007 as the first of class. She displaces 7,800 tonnes dived and is 97 metres long.

A prime contract was awarded to GEC-Marconi (subsequently BAE Systems) in March 1997 for the design, build and in-service support of the first three of class. The Department approved the contract at a cost of £2,578 million, with a planned in-service date for the first of class of June 2005. The Department expects to buy seven submarines in total.

Problems encountered to date

The programme has suffered a number of problems, which have caused delays of 41 months and cost overruns of £1,220 million to date. The principal problems are as follows.

Slow contract negotiations: The contract negotiations were lengthy and delayed the in-service date by nine months at the beginning of the programme.

Ill-advised attitude to risk: The contract was let under the philosophy of transferring as much risk as possible to industry, including full responsibility for both design and construction. Previously the Department had produced the design and then contracted with industry to deliver it. Given GEC Marconi's (and subsequently BAE Systems') lack of ship-building experience at the prime contractor level at that point, the Department were over-optimistic in their assessment of the contractor's capacity to deliver.

Computer Aided Design: The contractor encountered difficulties with a computer aided design (CAD) tool which had not previously been used for ship-building, and the anticipated and contracted schedule and cost benefits did not materialise.

Gap between Astute and previous submarine construction programmes: The time delay between the construction of the Vanguard-class submarines and the beginning of the Astute programme meant that key skills and submarine-building experience had been lost. The awarding of other ship-building work to the Barrow shipyard did not prove sufficient to maintain those skills specific to the design and construction of submarines.

Cost growth in other areas: The programme has suffered from unplanned cost growth in various areas, including increases of £164 million and £68 million in 2006-07 for materials and labour respectively.

Ministry of Defence action to resolve problems

Following BAE Systems' disclosure during 2002 of significant delay and projected cost overrun on the Astute programme, the Department reached agreement on how to address those difficulties. A formal agreement was reached in February 2003 which reduced risk (principally by separating the design, development, build and acceptance of the first of class from the production of the second and third submarines), and placed new incentives on the company to perform. An amendment to the Astute contract to enact the agreement was signed in December 2003. Since the agreement, all the programme's anchor milestones have been met and new project management disciplines have been implemented to achieve better planning and performance monitoring.

Revised payment arrangements: As part of the February 2003 Agreement, a revised Target Cost Incentive Fee arrangement was put in place for Boat One; Boats Two and Three were allowed to proceed on a cost-plus basis, pending final pricing. Prices were concluded for Boats Two and Three in 2007; a Target Cost Incentive Fee arrangement with a maximum price was agreed for each Boat.

Joint problem-solving: The Department agreed to increase its cash funding for Astute by around £430 million, against an increased contribution by the company of £250 million. This was primarily in recognition of the greater than expected difficulty in applying CAD techniques. BAE Systems also invited the General Dynamics' Electric Boat shipyard to provide assistance in developing the CAD implementation.

Improvements in construction performance: BAE Systems has made a series of changes to construction methods at the Barrow shipyard to improve performance and efficiency. For example, the pressure hull units of boats 2 and 3 are positioned on their end to assist the workforce during the assembly phase, thereby reducing the time required.

Joint action to reduce costs: In partnership with BAE Systems, the Department has undertaken a range of activities to save money and make efficiencies. For example, the Department has saved £33 million by compressing the sea trials programme.

RISK AREA 1

Meeting a challenging timetable

1.1 This section considers the challenges in meeting the tight timetable that has been set to ensure the seamless transition from one class of submarines to the next and the time constraints imposed by other elements of the programme. The consequence of not managing this risk will be the late delivery of the future deterrent capability. This in turn may jeopardise continuous at sea deterrence unless the Department has been able to extend the life of the Vanguard class beyond its current assumptions.

Meeting a challenging timetable to maintain continuous at sea deterrence

1.2 The current fleet of four Vanguard-class submarines were designed for an operational life of 25 years. The first, HMS Vanguard, commenced contractor sea trials (the start of a submarine's design life) in 1992 and began its first deterrent patrol in 1994. The fourth, HMS Vengeance, commenced contractor sea trials in 1999 and undertook its first deterrent patrol in 2001.

1.3 The Department anticipates that it will be possible to extend the life of the Vanguard submarines to maintain a continuous at sea patrol until 2024, at which point two of the four submarines will have gone out of service. Beyond this date therefore, the first replacement submarine must be in service with the Royal Navy to be assured of maintaining continuous at sea deterrence.

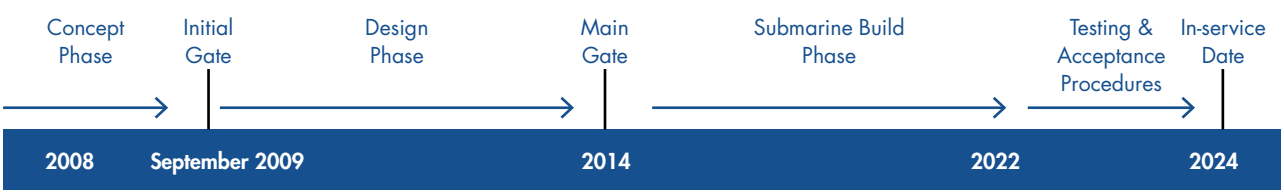
Renewing the submarine fleet

1.4 The critical path for provision of a future deterrent capability is the delivery of the submarine platform in time to meet an in-service date of 2024. The Government's White Paper on the Future of the United Kingdom's Nuclear Deterrent dated December 2006 stated that it is likely to take 17 years to design, build and test a replacement to the Vanguard-class submarines. A 17-year timescale provides a projected in-service date of 2024 for the first of the new class of submarines, which allows no time for slippage if continuous at sea deterrence is to be maintained.

1.5 Working backwards to meet this date, a series of other milestones must be hit, as **Figure 2** shows. According to the Department's current plans:

- the submarine build process must be complete by 2022 so that two years of testing and acceptance procedures can begin;
- the submarine build process is likely to take eight years and must begin in 2014;
- the Main Gate investment decision must therefore be taken no later than 2014, with approval for the procurement of long-lead items for the submarine achieved by 2011; and
- the Initial Gate decision to enter the Assessment Phase and place a full design contract for the submarine must be taken by September 2009.

2 Summary timeline for the development of the future submarine class



Source: National Audit Office/Ministry of Defence

1.6 **Figure 3 overleaf** shows the timelines for the capability as a whole. This includes the withdrawal of the Vanguard class, the introduction of the future submarine class and the replacement or extension of the other elements. The Department's plans show that the missile procurement, warhead development and infrastructure projects do not currently lie on the critical path, because its strategy, in general terms, is to upgrade existing technology and facilities in these areas. As paragraphs 1.11 to 1.20 explain, these elements of the nuclear deterrent capability may feature more strongly on the critical path once the Department has made the high-level design decisions on the submarine in 2009.

1.7 A critical element of the timetable for the introduction of the future submarine class is establishing how long the Vanguard-class submarines can be life-extended. The White Paper suggested that it would be possible to extend the life of the Vanguard class by five years but that any further extension would require the replacement or refurbishment of vital components. Predicting future submarine availability is inherently uncertain, particularly beyond its planned life, since many of its systems and components will have been designed with that life in mind.

1.8 The Department is undertaking further work to gain a better understanding of the risks involved in the transition phase. There are three strands to this work, involving assessment of the policy, operational and technical elements of the transition phase. The majority of effort expended thus far has been on the technical strand. This primarily revolves around the Vanguard Life Optimisation Programme (VLOP), designed to examine the planned five-year life extension of the submarine fleet. As might be expected this far ahead of any life-extension programme, VLOP remains an area of considerable uncertainty, with the potential for rapid cost and risk growth.

1.9 The Department's Chief Strategic Systems Executive leads the VLOP programme and has spent around £3 million to date on preparatory studies. As the programme progresses, he will need to liaise closely with other teams involved in maintaining the current fleet and bringing the future deterrent into service. It will be important for the Future Submarines Integrated Project Team and the Programme Support Office to have a clear view of all risks emanating from the transition phase in order to incorporate them in their plans.

1.10 Nuclear activity in the Ministry of Defence is covered by various acts, including the *Health and Safety at Work Act,* the *Nuclear Installations Act* and the *Radioactive Substances Act*, but does have some exemptions. The Defence Nuclear Safety Regulator is responsible for regulating those areas of exemption and producing independent reports, although working closely with the other regulators involved. The Regulator's view is that, providing all the issues are considered early enough, it should be possible to safely extend the life of the Vanguard-class submarines. His view was that determining the safe life-extension of the nuclear reactor vessel was likely to be the most critical decision and that the Department should undertake a thorough cost-benefit analysis to show what the full implications of the VLOP programme might be.

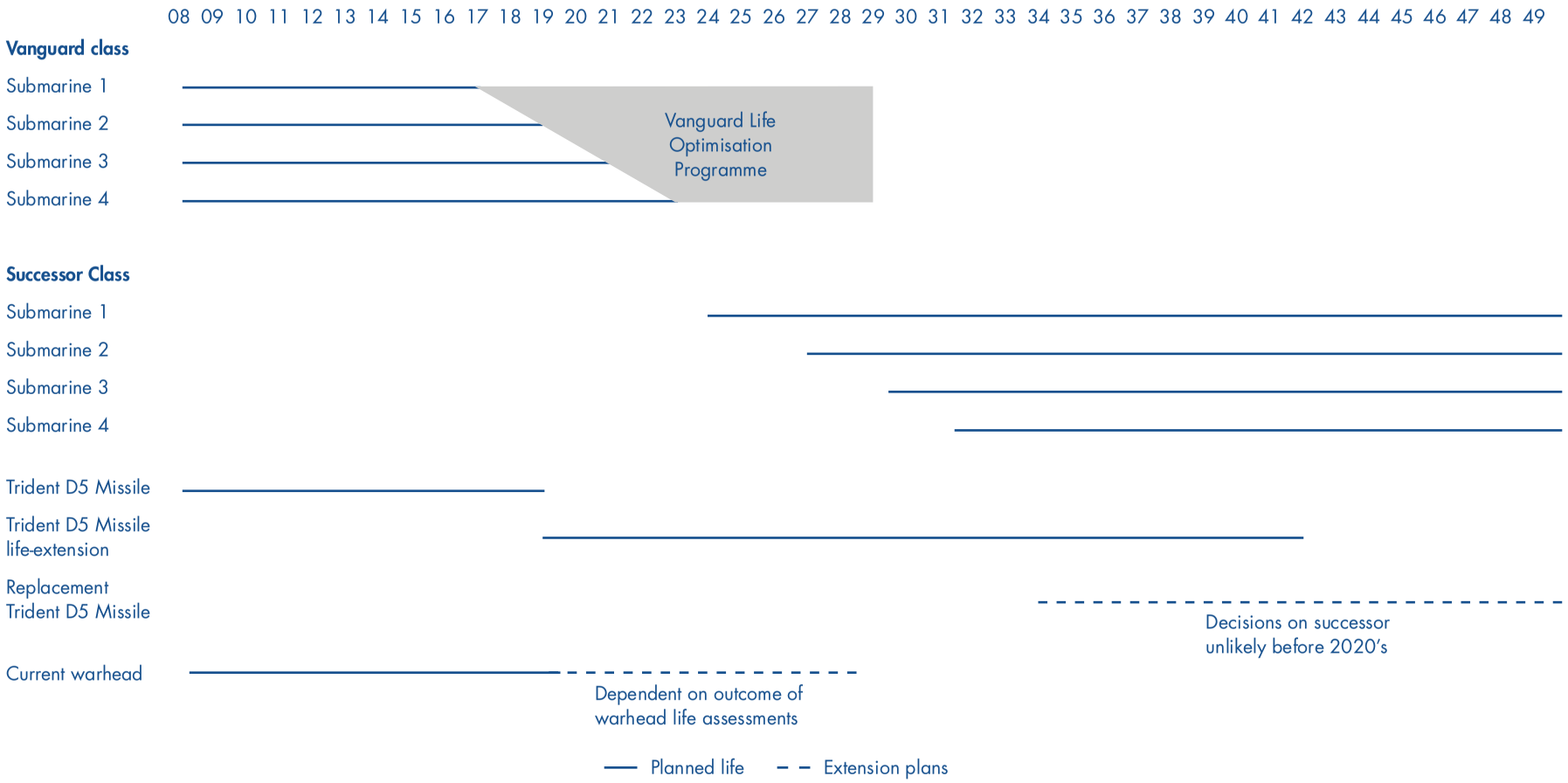
Time constraints from other areas of the programme

The warhead

1.11 Continuous at sea deterrence also relies on there being an operational warhead. The existing warhead was designed and manufactured in the United Kingdom by the Atomic Weapons Establishment. The Government explained in the 2006 White Paper that decisions on whether and how it may be necessary to refurbish the current warhead design are likely to be needed in the next Parliament. The Department assesses that the current warhead design is likely to last into the 2020s, although it does not yet have sufficient information to judge precisely how long it can be retained in service.

1.12 Detailed work is in hand to review the optimum life of the existing warhead stockpile and to analyse the range of options that might be available to replace it, which is being conducted within the United Kingdom's commitments under the Comprehensive Test Ban Treaty. Some of the work is being undertaken with the United States under the 1958 United Kingdom-United States Agreement for Co-operation on the Uses of Atomic Energy for Mutual Defence purposes.

3 Summary timeline for the replacement of nuclear deterrent capability



Source: National Audit Office/Ministry of Defence

The missile system

1.13 The United States Government has a programme to extend the life of the Trident D5 missile to around 2042 to match the life of their Ohio-class submarines. The United Kingdom has committed to participating in that programme. The new submarines are therefore likely to remain in service beyond the extended life of the Trident D5 missile. The Government has said that decisions on whether we wish to acquire a successor to the life-extended D5 missile and what form any successor might take are unlikely to be necessary until the 2020s. The Government has also sought and received assurances from the United States Government that the United Kingdom will have the option of participating in any United States programme to develop a successor to the Trident D5 missile and that any new missile will be compatible, or be capable of being made compatible, with the launch system to be installed in the United Kingdom's new submarines. The Future Submarines Integrated Project Team is therefore attempting to ensure that the current submarine design is capable of being integrated with these future developments.

The nuclear reactor

1.14 The timetable may also be affected by developments in pressurised water reactor technology. The Department needs to decide if it should use a variant of the current reactor design – 'PWR2' – or develop a new reactor – 'PWR3' – for the new submarine. There are risks attached to both of these options. The PWR2 reactor has the benefit of being based on existing technology, but will still require some updating to deal with obsolescent components and emerging regulatory requirements.

1.15 The PWR3 proposal offers the prospect of a more efficient and cheaper reactor through life. This option nonetheless presents more of an immediate risk to the timetable, since it will require a major research and development effort, although work is underway to see how this risk can be minimised. Whichever option it chooses, the Department will need to develop it in close cooperation with the regulatory authorities. The Department began considering propulsion requirements for future submarine fleets in 2005, independently of the Government's consideration of the future of the nuclear deterrent, and let an initial contract with Rolls-Royce in May 2007. The reactor design needs to be completed by the middle of the next decade, however, if it is not to hold up the rest of the submarine design.

Manning issues

1.16 There are currently shortages of various trades, such as nuclear watchkeepers (those crew members responsible for the safe operation of the nuclear propulsion plant) and medical assistants[3], within the submarine branch of the Royal Navy. This problem is exacerbated by the introduction of the future class of submarines, since more crews will be required to manage the so-called 'manning bulge'- the transition phase in which crews will be required to operate both Vanguard and the future class concurrently.

1.17 Possible mitigation actions such as automating processes to reduce crew numbers and introducing female personnel are likely to have a major impact on both operating procedures and submarine design and therefore need to be taken while there is still scope for their incorporation in the latter. The Royal Navy is currently undertaking two studies to determine the likely impact of this issue. The Royal Navy's Second Sea Lord is responsible for all naval crewing issues and is the owner of this risk, but the Senior Responsible Owner for the deterrent will have a key role in ensuring that the Royal Navy's work is incorporated into the future deterrent timetable in a timely way.

Infrastructure

1.18 A range of infrastructure is required to support the deterrent. This includes buildings and specialist facilities at Devonport, Coulport and Faslane, security and the infrastructure associated with command and control of the submarines. Significant elements of this infrastructure are required in order for the United Kingdom to comply with its obligations under the Polaris Sales Agreement. Many of the existing facilities will be able to support the current deterrent into the 2020s. Further work will be required to confirm that these facilities are able to support the future deterrent throughout its planned life, although the Department's working assumption is that the future submarine class will be able to use all existing facilities, suitably modernised and properly maintained.

1.19 In addition, a decision about facilities at the Rolls-Royce reactor core manufacturing plant in Derby is required in around 2009, with work expected to begin on the new core in 2012. Whilst this work is not currently on the critical path, our previous analysis of the D154 project to design and build new and upgraded facilities at Devonport dockyard shows the risks of cost overruns where nuclear-related facilities require updating.[4] This project

3 *Recruitment and Retention in the Armed Forces*, Report by the Comptroller and Auditor-General, HC 1633 I/II 2005-06, 3 November 2006.
4 *The Construction of Nuclear Submarine Facilities at Devonport*, Report by the Comptroller and Auditor-General, HC 90 Session 2002-03, 6 December 2002.

suffered delays in design and construction work because of difficulties in delivering technically challenging components whilst meeting exacting nuclear safety standards. As a result, total project costs at the time of our report were estimated at £933 million, 31 per cent more than the approved budget. Rolls-Royce's view is that the new manufacturing plant is less complex than the D154 project, although they are aware of the risks involved.

1.20 The Health and Safety Executive's Nuclear Installations Inspectorate expressed concern that time pressure could impact negatively on regulation and safety. They quoted the D154 project as an example of what can happen if these pressures are not well managed. The Future Submarines Integrated Project Team is aware of the lessons from the D154 project and is looking at when to schedule design freezes and formal review points with regulators.

Considering time contingency in the programme to allow for unforeseen delays

1.21 Time contingency needs to be incorporated into a programme to allow for optimism bias, particularly if the programme is complex and has various interdependencies and relationships with other teams, as is the case with the future deterrent.

1.22 The Department and its industrial partners are considering how to build in more time contingency during the concept and design phase. The submarine construction programme already contains overlaps between work strands, meaning that construction will commence before the design is complete. This overlap has the potential to save time but could significantly increase risk. Creating further contingency will be difficult given the fixed delivery date, placing additional pressure on the Department and its suppliers to deliver all elements of the programme on the critical path to time. The Department is considering a number of different submarine designs during the concept phase and part of the rationale for selection of one design will be the degree to which it removes risk from the timetable.

RISK AREA 2

Making decisions about the design on time

2.1 This section considers the challenges involved in the concept phase and the decisions that have to be taken in order to keep the programme on track. During the ongoing concept phase, the Department will make important design and budgetary commitments. The consequence of not finalising the design will be that the Department either makes poor decisions or does not coordinate the teams involved to make decisions on time, placing further pressure on what is already a challenging schedule.

The challenge of developing the design specification

2.2 The Department is engaged in a two-year concept phase to develop the design requirements targeted towards a submission for Initial Gate approval in September 2009. In undertaking this work, the Department is considering the future deterrent as a capability, not simply an equipment project to buy a new fleet of submarines. The programme management arrangements for the delivery of the future deterrent therefore include consideration of aspects such as manning, training, infrastructure and the procurement or development of missiles and warheads.

2.3 The key challenge of the concept phase up to 2009 is the selection of the principal design parameters of the new class of submarine. This is a technically complex undertaking, since it must take into account a number of design constraints or emerging technologies in other areas, as set out in paragraphs 1.11 to 1.20. Following its own acquisition principles, the Department will have to plan for every phase of the submarine's life, including its eventual disposal and the decommissioning of its nuclear reactor.

2.4 The programme management of the future deterrent includes a wide range of internal and external teams, all of whom have to be coordinated to keep the programme on track. They are set out in **Box 4.**

The wide range of organisations involved represents a challenge for the programme managers, who must balance efficient decision-making with the need to consult.

BOX 4

Teams involved in the acquisition of the future deterrent

- The Cabinet Office and Foreign and Commonwealth Office who, together with the Ministry of Defence, share responsibility for setting the strategic requirements for the deterrent. The Cabinet Office provides guidance on United Kingdom nuclear deterrence policy and related advice to Ministers.
- Various Ministry of Defence teams:
  - Director Strategic Requirement;
  - nuclear policy;
  - current Trident operations; and
  - Integrated Project Teams within the Director General Submarines cluster, with responsibility for nuclear weapons, missiles, submarine support, nuclear propulsion and the Astute submarine programme.
- A large number of internal and external regulators, of which the most important are the Health and Safety Executive's Nuclear Installations Inspectorate, the Environment Agency and the Department's own Nuclear Safety Regulator.
- Industrial suppliers, from major companies to specialist sub-contractors.
- AWE Management Ltd, which operates the two Atomic Weapons Establishment sites at Aldermaston and Burghfield.
- The United States Department of Defense and the United States Navy.

Decision-making in the concept phase

2.5 The high-level requirement for the future deterrent has been established by the 2006 White Paper (namely, that a submarine-based system should deliver continuous at sea deterrence). Detailed objectives for the two-year concept phase include capability level study activities, concept planning, technology and product development and the engagement of external advice and support. During the concept phase, the Department is also leading a cross-government review to undertake a critical examination of design options.

2.6 The Department's Investment Approvals Board has approved a budget of £309.45 million for the concept phase work on the submarine platform and propulsion plant. Approved and actual expenditure is shown in **Box 5**. The budget for 2007-08 was underspent because the Department and its suppliers were unable to agree contracts as quickly as anticipated. To date the Future Submarine Integrated Project Team has committed to contracts to the sum of £79.5 million and the Nuclear Propulsion Integrated Project Team to contracts to a value of £86.1 million within the approvals totals, although clearly not all this expenditure has yet been incurred.

2.7 A detailed timetable exists for the concept phase, based on Initial Gate approval in September 2009 and an interim review point in autumn 2008. During 2008 the concept phase slipped by six weeks. However, the timetable has been rearranged and the Department is confident that the concept phase can still be delivered on time. While this may be possible any further delays will put significant pressure on the concept phase timetable.

BOX 5

Approved and actual expenditure to date for the concept phase

£ million	2006-07	2007-08	2008-09	2009-10	Total
Platform					
Approval	7.3	26.6	57.6	39.0	130.5
Expenditure	7.3	16.0	16.4[1]	–	–
Propulsion Plant					
Approval	9.7	24.6	80.3	64.4	179.0
Expenditure	9.7	22.9	10.0[1]	–	–

NOTE

1 Sums accrued up to the end of June 2008.

2.8 Despite the clear overall requirement from the White Paper, there are a number of decisions which need to be taken to design the submarine. Assumptions have been made about some of these design decisions to allow the design process to continue. There are a number of major decisions scheduled to be taken before the Initial Gate investment decision in September 2009, some of which can only be taken in conjunction with the Cabinet Office and other government departments. They include the following decisions, to be taken before September 2009:

- the design and size of the missile compartment;
- the type of nuclear propulsion plant to be used; and
- the high-level specification of the submarine design, including major trade-offs.

Failure to make these decisions on time will threaten the overall programme timetable by increasing technical and commercial risk. The decision to buy three or four submarines is not required until the Main Gate investment decision in 2014.

2.9 There is a judgement to be made about when to fix the design parameters for the submarine and how much more options analysis work to undertake first. On the one hand, the Department is conscious of the tight timescale; on the other, it would be a mistake to finalise the design too early without knowing enough about the requirement. Unresolved issues include the size of the missile compartment, which is a crucial factor in determining the overall design of the submarine. Following the example of the Resolution and Vanguard classes, the Department is negotiating with the United States on a new common missile compartment.

2.10 As the Department approaches important forthcoming decisions on submarine design, the Senior Responsible Owner and the Strategic Deterrent Programme Board will need to keep these competing considerations in balance in order to minimise the amount of nugatory work carried out.

Cooperation with the United States of America

2.11 There has long been close cooperation between the United Kingdom and the United States in nuclear matters. A 2006 exchange of letters between the Prime Minister and the President of the United States builds on the Polaris Sales Agreement and other arrangements and has had a beneficial impact on the United Kingdom's preparation for the future deterrent. This relationship brings challenges as well as benefits for the United Kingdom.

2.12 The United States has now approved a programme to construct a new class of ballistic missile submarines to replace its current Ohio class. There is an opportunity for the Ministry of Defence to work towards a similar arrangement to those on the Vanguard and Resolution classes for some components of the submarines and to pay a proportion of the costs equivalent to the proportion of submarine numbers in the respective fleets. In contrast to previous submarine programmes, the United Kingdom is ahead of the United States, which is both an opportunity and a risk. It is an opportunity for the Department to influence the design process as a full partner. However there is also a risk to the United Kingdom's timetable if the United States programme is delayed for any reason. In February 2008, the United Kingdom set up a programme office in the United States, alongside key American officials, to facilitate this liaison.

RISK AREA 3

Ensuring effective governance arrangements

3.1 This section describes the complexity of the programme management arrangements and the challenges which need to be managed in terms of communication, risk management, scrutiny, regulation and performance measurement. The Department is aware of the need to manage the risk that, because of the large number of people involved, decisions will be made too late, without vital information or without adequate scrutiny. Otherwise, it would fail to find the right balance between action, engagement and accountability and the programme would be delivered late, over budget or would not meet requirements.

Progress in establishing decision-making arrangements

3.2 Overarching policy-making responsibility for the future deterrent rests with the Cabinet Office and is exercised through the Nuclear Deterrence Policy Committee, drawn from the Cabinet Office, the Foreign and Commonwealth Office and the Ministry of Defence. The Ministry of Defence has sole responsibility for the delivery of the future deterrent capability.

3.3 In order to deliver the future deterrent, the Department has established a series of specific posts and committees. These include a Senior Responsible Owner (currently Director General, Equipment), a Strategic Deterrent Programme Board, a Director Strategic Requirement and a Capability Planning Group. **Figure 4** shows the relationships between these groups in terms of their responsibilities for the future deterrent.

3.4 Given the intention to manage the future deterrent as a capability, rather than simply a submarine procurement, and the need to involve other government departments in the decision-making process, the delivery arrangements are inherently complex. Guidance from the Office of Government Commerce suggests that a single point of accountability model is advisable in the delivery of programmes of this size and complexity.[5] The future deterrent is not yet at this stage, since the Department is still defining the requirements for a fully costed programme. In addition, this model does not take into account of the key roles of other government departments and international and industrial partners.

3.5 In line with established Departmental arrangements, responsibility for setting requirements and budgets for equipment capability programmes is based in the Department's Equipment Capability Customer area. Responsibility for delivering the programme rests with a number of Integrated Project Teams in the Defence Equipment and Support organisation under the direction of the Director General Submarines. As the programme moves from requirements setting to the full delivery phase, the role of the Senior Responsible Owner will change from the coordination of decisions to the direction of delivery. This has implications for the skills, experience, seniority and time commitment of future post-holders.

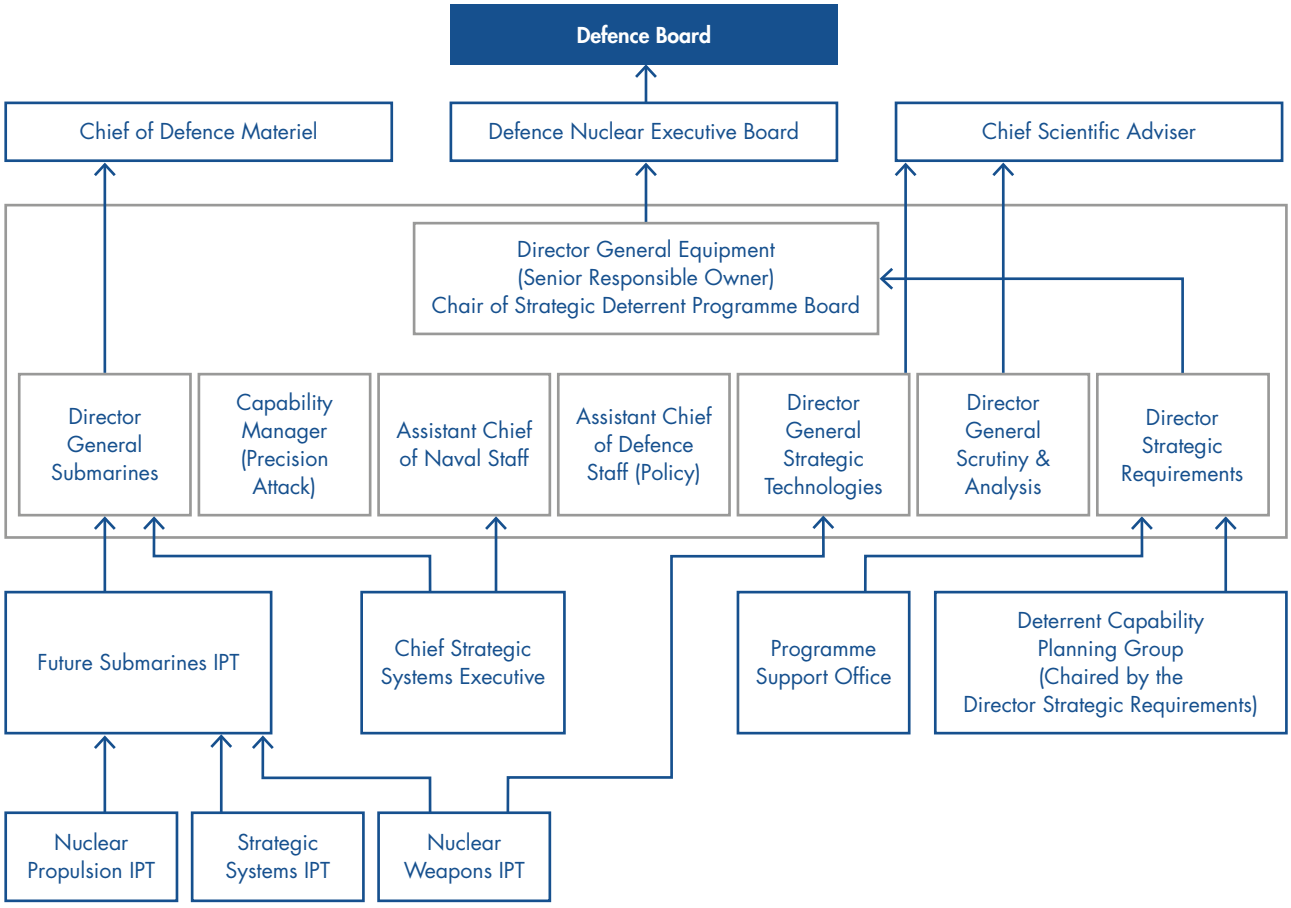
3.6 Under the current arrangements, Director General Equipment, in his role as Senior Responsible Owner, chairs the Programme Board, is responsible for establishing the requirements for the future deterrent capability and leads policy advice and finance work strands. He does not, however, have direct line management responsibility for the other members of the Programme Board and must therefore work in part by influence and consensus. The location of the current Senior Responsible Owner in the Equipment Capability Customer area means that he already allocates the budget for the future submarine programme, the United Kingdom's contribution to the Trident D5 missile life extension programme and the programme of investment in facilities and skills at the Atomic Weapons Establishment (see paragraph 3.20). The Senior Responsible Owner will, in due course, allocate the budget for all other procurement aspects.

5 http://www.ogc.gov.uk/User_roles_in_the_toolkit_senior_responsible_owner.asp.

3.7 There have already been two changes of Senior Responsible Owner since the beginning of the programme, arising from unplanned staff moves. Two of the three incumbents, including the current post-holder, have taken on the role in a part-time capacity. Whilst this latter development reflected the move of the post into the centre of the Equipment Capability Customer area and provided some associated benefits, it would be desirable to improve continuity in such an important post, as frequent changes have the potential to dilute oversight and coordination.

3.8 A number of other senior officials sit on the Strategic Deterrent Programme Board either because they have linked policy roles or because they are responsible for related programmes, such as the operation of the current deterrent or the management of the programme of investment at the Atomic Weapons Establishment. The Senior Responsible Owner has recently clarified the roles and responsibilities of other Programme Board members in relation to the future deterrent via a formal programme mandate. There was general agreement from all our interviewees that the Programme Board includes the right people.

4 The future deterrent programme governance arrangements show the large numbers of people and teams involved and the complex relationships between them



Source: Ministry of Defence

NOTE

Posts marked in grey and in the central box are members of the Strategic Deterrent Programme Board. This figure is not intended to and does not necessarily reflect normal line management relationships.

3.9 Our work has identified some challenges to be addressed as the programme moves forward. These are set out in **Box 6** below.

Regulation and external scrutiny

3.10 A programme of this complexity needs strong governance. There is a risk that, under the obvious time and cost pressures, the programme may move forward without having met all the criteria set out in the project milestones. As a result, work may be shifted to the right where it would become more expensive or would have to be done more quickly. In addition to its established scrutiny and approvals processes, the Department is putting in place a variety of internal and external review processes to mitigate this risk, which are set out in **Box 7**.

3.11 There are a number of internal and external regulators involved in the future deterrent programme, whose responsibility it is to manage equipment and sites involving nuclear and other hazardous technology. The Department has a challenge to balance the need for regulation and scrutiny with the risk of cumbersome processes and slow decision-making and has established a forum to coordinate regulatory activity and reduce duplication.

3.12 The Health and Safety Executive's Nuclear Installations Inspectorate (NII) issues operating licences to industrial sites supporting the current and future deterrent programmes, but have no legal responsibility for licensing the Department's nuclear submarine reactors. They told us that they had a very strong relationship with the Atomic Weapons Establishment, but that their involvement with the submarine and nuclear reactor teams was less strong. They also noted that their role in regulating civil nuclear activity put them in a strong position to share good practice and that the Department could make better use of its cross-sector expertise.

Developing management information for the programme

3.13 The Department is developing a detailed programme plan, with high-level objectives and a work breakdown structure. The Department recognises that there are critical interdependencies at a high level between programme strands and between this and other programmes, such as the Transforming Submarine Support and Astute submarine programmes. Although these interdependencies have been considered, they have not all been mapped out in detail, so the Department is not yet aware of all the critical links to be managed.

3.14 Metrics and performance measures are important to assess whether or not the programme is on track to deliver against time, cost and quality targets and to encourage both a through-life focus and regulatory compliance. Performance reporting arrangements are gradually being put in place. In the early stages of the programme, too much detail was being reported upwards, without any consistent measures being presented. Despite some progress in recent months in developing a reporting system, it is still not fully developed and is not yet giving the Senior Responsible Owner or Programme Board members the information they need to take a view on progress.

BOX 6

Future programme management challenges

- The Programme Board is currently directing the concept phase as an information/advisory board. It has not yet been required to come to agreement over difficult decisions or trade-offs between different elements of the programme.
- Decision escalation criteria are being developed. There are other government departments involved so timely decision-making will be paramount.
- The size and complexity of the programme means that the Department will have to examine the leadership arrangements as the programme evolves.
- Three posts at the same grade share responsibility for the deterrent programme although the Senior Responsible Owner has overall control. There is a risk that this structure could dilute accountability or lead to cumbersome decision-making.
- The Department has not yet decided how arrangements for the future deterrent will fit with the Trident Management Committee and other existing deterrent working groups.

BOX 7

Extant or planned review and reporting mechanisms

- Director Strategic Requirement has established six-weekly programme reviews.
- A client adviser call-off contract has been established for the concept phase to offer ongoing external scrutiny and advice (see Risk Area 5 for more detail).
- The programme is subject to the Office of Government Commerce gateway review process.
- The Department plans regular reports to Parliament once the initial investment decision has been taken in 2009.
- The Treasury's Major Projects Review Group is planning to review the programme.

3.15 The approval paper for the concept phase set out a number of activities to be undertaken. Some of these lack precision, quality definitions or deadlines, making it more difficult to know if they have been completed in a satisfactory manner. Subsequent to this paper, the Director Strategic Requirement team provided further detailed direction on what work should be undertaken to support key decisions. At the start of the concept phase the Future Submarines Integrated Project Team was responsible for providing programme support to the Senior Responsible Owner and Programme Board. They compiled detailed schedules of performance, with milestones, responsibilities and timelines. However, they reported problems in receiving sufficient timely information from other teams to allow effective monitoring of progress.

3.16 This and other factors led to the Department identifying a need for its programme support function to be more independent. A formal Programme Support Office was therefore established on 31 March 2008 with all associated project teams contributing staff. This arrangement should help establish a clear set of performance indicators for the deterrent capability as a whole, rather than simply focusing on the replacement submarines.

Risk management

3.17 Risk management activities are being undertaken at many levels within this programme. Some of these activities, for example within individual integrated project teams, have been in place for some time and are relatively well established. At the programme level, a detailed risk register has been produced and risk management arrangements are being developed, but these are not yet mature. For example, mitigating activities have not yet been costed and 'traffic light' reporting for the Programme Board is still being developed.

3.18 Of the risks emanating from these processes, some are beyond the Department's immediate control. One example of these is the relationship with the United States. The Department is considering how to address the possible impact of these risks and developing contingency plans where it is feasible to do so. As the programme develops, decision-makers should have sufficient information to be able to make informed decisions should the risks materialise.

3.19 Other risks are within the Department's control and need further mitigation. For example, the Nuclear Installations Inspectorate has noted that there are a number of specific health and safety arrangements at the Atomic Weapons Establishment which should be strengthened. These include highly enriched uranium facilities and assembly/disassembly buildings and facilities known as 'Gravel Gerties'. Gravel Gerties are facilities designed for the safe inspection, handling or dismantling of nuclear weapons. Their name derives from the use of large amounts of gravel which are placed on the roof to reduce the potential dispersal of contamination from the radioactive material contained within the warhead in the event of an accidental detonation of the conventional explosives.

3.20 The Atomic Weapons Establishment is required to address the Nuclear Installations Inspectorate's concerns, but needs to do so in the context of the Department's long-term plans for the estate. The Department recognises that it needs to decide which facilities will be required in the long-term to sustain the United Kingdom's nuclear weapons capability. There is a programme of investment in sustaining key skills and facilities at the Atomic Weapons Establishment (the Nuclear Warhead Capability Sustainment Programme), which commenced in 2005. This programme will enable the Department to make decisions about whether buildings should be refurbished, replaced or demolished.

Communications between the Department and partner organisations

3.21 The Department has made good progress in identifying and engaging key partners, many of whom are involved in the programme via committee memberships, official forums, joint teams, secondments and informal consultations. Communications between the different groups involved in the future deterrent seem to be working well at the programme level.

3.22 Some improvements could be made at the working level. The Department's co-location of the Future Submarines Integrated Project Team from several separate sites was slow to happen but has now taken place in the Defence Equipment and Support site in Abbey Wood. Given the large volumes of technical information which are beginning to flow between the Department's sites, industrial partners and the United States, there is a need for secure video conferencing and an IT infrastructure that allows large volumes of information to be passed securely and quickly.

3.23 The future deterrent programme team are keen to learn from experience. Arrangements have been put in place to learn lessons from the Astute submarine and Trident nuclear deterrent programmes. These include dissemination of lessons learnt papers, the interchange of staff and the use of learning logs, joint meetings and study days. One example was a 'Learning from Experience' seminar held on 18 October 2007 with many retired officials from the Trident programme. This seminar highlighted, among other things, the need for clear roles and responsibilities, the lack of suitably qualified and experienced staff and the need for close collaboration with the industry.

3.24 Given the wide range of cooperation with the United States, there are inevitably multiple points of contact between the United Kingdom and the United States. As a result, there is a risk that the United States may be receiving different messages from different parts of Government. The Department is therefore working on a communications plan to agree key messages. The plan will seek to make the best use of existing channels of communication, set up under the Polaris Sales Agreement and the 1958 Mutual Defence Agreement.

RISK AREA 4

Developing a robust budget and exerting financial control

4.1 This section considers the budget for the future deterrent capability, and the arrangements being introduced to manage this budget. The sums involved in this programme are considerable and the money is being spent by several different teams. If the programme is not managed effectively, there will be a risk that that decision-makers will not have the financial information they require to manage the programme effectively as a capability.

Improving the White Paper cost estimates

4.2 The Government's 2006 White Paper provided an initial estimate for the costs of sustaining the nation's deterrent capability. The estimates for the ballistic submarine option were developed using cost data from the existing deterrent capability. The Department carried out a probability analysis and an assessment of risk to arrive at a likely range of costs. The Department, the Treasury and the Cabinet Office carried out a further review and concluded that the acquisition cost for a four-boat submarine option would be between £15 billion and £20 billion in 2006-07 prices. This cost estimate would be divided between the submarines (£11-14 billion), support infrastructure through life (£2-3 billion) and the replacement of the warhead should that be necessary (£2-3 billion).

4.3 The planned £15-20 billion acquisition cost does not include all of the likely costs associated with the future deterrent capability. The White Paper noted that in-service support costs for the future deterrent would be similar to the current deterrent, equivalent to between five and six percent of the defence budget each year, but did not quantify those costs.

4.4 In addition to the acquisition costs and in-service costs, the Department has also estimated that there will be some 'preparatory and enabling' costs associated with maintaining or extending the existing deterrent and developing future systems. The Department estimates that these costs will amount to some £2 billion in 2006-07 prices. Among other things, these costs cover:

- elements of the Nuclear Warhead Capability Sustainment Programme at the Atomic Weapons Establishment;
- the Vanguard Life Optimisation Programme required to extend the life of the current submarine fleet until the successor submarine is ready. In previous evidence to Parliament, the Department suggested that the costs of this programme could be in the order of hundreds of millions for the four submarines, although it has yet to produce detailed cost estimates;[6] and
- the Trident D5 life extension programme, at a cost of some £250 million.

The Department considers that the cost of any new missile design, to replace the Trident D5 when it reaches the end of its life-extended service, would be incurred from the 2030s and that any estimate of cost at this stage would be highly speculative.

6 *The Future of the UK's Strategic Nuclear Deterrent: the White Paper*, House of Commons Defence Select Committee, HC 225-I, Ninth Report, 7 March 2007, paragraph 142.

4.5 The Department accepts that the White Paper cost estimates are not sufficiently robust to provide:

- an accurate baseline against which progress can be measured and budgetary control exercised;
- a sufficiently detailed cost model which can be used to manage cash flow and make informed decisions about the balance between time, cost and capability constraints; or
- confidence among suppliers that sufficient funding will be available to support their investment in the programme.

4.6 The White Paper stated that procurement costs would need to be refined as work on the concept phase is taken forward. This work is underway, but until some of the key design decisions set out in Risk Area 2 of this report are taken, it will inevitably be difficult. The Department is planning to announce more accurate cost estimates to Parliament at the end of the concept phase in autumn 2009. Remaining major areas of uncertainty are set out in **Box 8** below.

BOX 8

Future deterrent cost estimates – major areas of uncertainty

Inflation: The cost estimates have been produced in 2006-07 prices. A ten-year cash flow estimate was produced for the latest spending round using a range of indices. The estimate for the submarine used an index of 3.5 per cent, based on the example of the Astute submarine project. The Department is planning to develop more accurate cash flow forecasts using more appropriate indices tailored to each category of expenditure (such as labour and steel). These would enhance the Department's capacity to manage cash flow effectively and provide assurance that funds will be available to meet commitments as they fall due. Inevitably, cash flow estimates in the near future will be more certain than longer-term estimates.

Value Added Tax: The existing cost estimates exclude a provision for Value Added Tax. The Department has assumed that Value Added Tax relating to submarine construction will be recoverable in keeping with the tax treatment of the Astute programme. The tax treatment of the programme as a whole is yet to be determined.

Comparability of Vanguard costs: Future deterrent cost estimates were based on the cost of the existing deterrent system. The existing system provides a useful starting-point for budgeting purposes but more detailed analysis is required to take into account differences between the two systems. For example:

- variations in the operational requirement;
- developments in the submarine industry and expected profit margins;
- fluctuations in the cost of materials; and
- variations in dollar/sterling exchange rates.

The Department is now planning to produce a 'bottom up' estimate based on detailed engineering analysis.

Design specification and assumptions: The existing cost estimates are based on assumptions which could change during the concept phase as the Department develops the design specification. One example is the assumption that the United Kingdom submarine industry will be sustainable and that the costs of supporting it will not fall on the future deterrent programme.

Exchange rates: The Department is planning to source a range of components from the United States. Existing cost estimates assume that future exchange rates between the dollar and the pound will remain constant over the life of the programme. It would be misleading to attempt to predict exchange rate movements over the entire programme but there is the potential for currency fluctuations in the short to medium term to pose a risk to affordability.

Contingency: Treasury guidance recommends that budgets for major projects should be adjusted to include a contingency to allow for the observed systematic tendency for the costs to be underestimated.[1] Existing cost estimates for the future deterrent are expressed as a range to reflect the uncertainty attached to the budget at this early stage of the programme. There is a risk that the existing estimates do not allow sufficient contingency. The cost estimate at the high end of the £15-20 billion figure provided by the Department was calculated by taking the 90 per cent estimate for individual projects in the programme plus an additional sum reflecting a judgement of programme risk (some of which included interdependency risk where this could be estimated). To the extent that this contingency does not fully take into account the risks arising from interdependencies in the programme it may not be sufficient.

NOTE

1 *The Green Book: Appraisal and Evaluation in Central Government*, HM Treasury, 2007.

Risks from existing budgetary control mechanisms

4.7 The Department is setting up three separate but linked cost models – covering submarine, capability and enterprise costs. Each of these models is important to provide accurate data on the costs of the submarine design, the overall programme costs and the likely industrial cost base. Ensuring that the links between each model work well will be important to mitigate the risk that data held in each one becomes inconsistent and therefore gives divergent pictures.

4.8 The programme is subject to the standard Ministry of Defence expenditure control mechanisms. Funding is authorised by the Senior Responsible Owner and allocated to the various Integrated Project Teams responsible for delivering different elements of the programme. Financial controllers in each of the Integrated Project Teams are responsible for management accounting and financial reporting. They produce budget forecasts, monitor expenditure against budget, manage cash flow and provide assurance on financial regularity. During the concept phase funding has been allocated to Future Submarines and Nuclear Propulsion project teams although more project teams will receive funding as the programme progresses. In addition, the Senior Responsible Owner continues to allocate funding for the full costs of the Nuclear Weapons Capability Sustainment Programme, at a cost of around £2.65 billion from 2008-09 to 2010-11.

4.9 These arrangements give rise to the following risks:

- the Senior Responsible Owner is able to request information from each of the project teams on financial performance. This information is drawn from a number of sources, with a risk of causing delays. There could also be a lack of consistency in the data, particularly as the programme becomes more complex. The recent appointment of a financial controller in the Programme Support Office, reporting to Director Strategic Requirement's team, should help mitigate this risk; and
- project teams responsible for managing aspects of the future deterrent programme are also responsible for managing other programmes. There will inevitably be some grey areas, such as the allocation of the industrial overhead and development costs for propulsion. As with all similar arrangements in the Department, there is a risk that in-year management of funding between cost categories and programmes may obscure the lines of accountability and budgetary control, as well as potentially diminishing the funding available for the deterrent programme.

4.10 When the existing deterrent was procured a single financial controller was responsible for in-year expenditure. A similar system would help to mitigate the risks highlighted above but is not compatible with the Department's financial control arrangements whereby each individual project team has its own financial controller. The Director General Submarines is however responsible for managing in-year expenditure for the whole cluster of project teams within his management area, including those for support to in-service submarines and the Astute programme. In addition, a financial controller in the newly formed Programme Support Office (which works for Director Strategic Requirement and the Senior Responsible Owner) will pull together in-year expenditure so that the Senior Responsible Owner and the Programme Board have oversight of the coordinated picture of in-year spending on the deterrent.

RISK AREA 5

Applying effective procurement practices

5.1 This section considers the issues the Department faces in buying and supporting the principal equipment elements of the future deterrent. It sets out the importance of creating the right incentives for monopoly suppliers to deliver to time and budget and notes the additional problem of widespread skill shortages. Failure to manage these issues is likely to lead to cost and time overruns.

The nature of the industrial base

5.2 The 2005 Defence Industrial Strategy[7] established the principle that, for the foreseeable future, the United Kingdom would retain all of those capabilities unique to submarines and their nuclear reactors, to enable their design, development, build, support, operation and decommissioning. Suppliers of submarine, nuclear propulsion and other equipment constitute a highly specialised industrial sector whose sustainability requires careful management. The industry is made up of a number of monopoly suppliers, including BAE Systems and Rolls-Royce, the likely suppliers for the future submarine class and nuclear reactor respectively.

5.3 This sector is dependent on a sufficient and continuous flow of Ministry of Defence business to maintain submarine-building capacity and preserve the relevant specialist skills. The effect of not managing this flow effectively is shown by the ongoing Astute submarine programme which suffered from a gap in production between the Vanguard and Astute classes. This led to industrial decline and meant that the Astute programme bore the cost and timescale implications of restoring the skills base and infrastructure to build submarines. One assumption of the future deterrent programme is that the United Kingdom submarine industry will be sustainable and that the costs of supporting it will not fall directly on the future deterrent programme.

5.4 The Department's submarine build programme is designed to ensure that there is no gap between Astute and the future deterrent. The Department intends to continue monitoring this risk to ensure that there is no recurrence of the damaging consequences of the significant gap in production that occurred between Vanguard and Astute. The Department will also use the opportunities presented by the Astute programme to save money and de-risk new technology for the future deterrent. In addition, as delivery of the Astute programme builds submarine manufacturing skills and capability, confidence should grow among government and industry partners that the future deterrent will be delivered on time and to budget.

5.5 In addition to the challenges of procurement within the United Kingdom, the Department is planning to source a range of components from the United States and draw on American technical expertise and information. The procurement challenges associated with this procurement route are entirely different. While the Department can in some cases gain considerable savings from being part of much larger United States orders, it may have less control over the specification of requirements and the delivery timetable. The Department will have to factor this unpredictability into its planning.

Creating incentives for industry to deliver to time, cost and quality

5.6 In addition to being bound to its monopoly suppliers, the Department has disclosed the forecast acquisition cost and set a deadline for the entry into service of the first of the new submarines which cannot be missed if continuous at sea deterrence is to be maintained. This gives the Department little manoeuvre in contractual negotiations with its suppliers.

7 *Defence Industrial Strategy*, Cm 6697, December 2005.

5.7 In order to deal with this challenge, the Department must undertake a range of actions. The first is the development of a commercial strategy for the acquisition and support of the future deterrent. Whilst some work has been done, including the production of an initial timetable, this work is not yet complete and significant actions are still to be completed before the Initial Gate investment decision in September 2009. These include formulating the Department's approach to risk and incentives, payment mechanisms, establishing a negotiation strategy and undertaking initial discussions with suppliers. As it stands, there is no single document which sets out convincing evidence of how the Department intends to assure value for money from its suppliers throughout the life of the project. The Department is aware of this and the Defence Commercial Director is leading the Department's efforts to draw one up.

5.8 The Department's commercial strategy will need to consider second tier suppliers as well as prime contractors. Many of the sub-contractors are also monopoly suppliers. The Department is engaging second tier suppliers in a key supplier forum, designed to highlight opportunities to make cost-effective changes either to the design or to the programme. In addition, the Department has established a Supply Chain Council to engage and manage lower level sub-contractors known as tier 2 and tier 3 suppliers.

5.9 The Department is also in dialogue with the maritime industrial base as regards the whole of the United Kingdom's submarine programme. In order to manage this coherently, the Department is in the early stages of establishing a Submarine Enterprise Collaborative Agreement between the principal industrial suppliers: BAE Systems, Rolls-Royce and Babcock Marine. Through the agreement the Department is seeking to deliver, design, build, support and dispose of nuclear submarine platforms, so that unique skills and resources may be maintained within the United Kingdom submarine industrial base.

5.10 The Department's intention is that the agreement will create an open commercial environment through collaboration between the key industry suppliers. Work towards an agreement is at an early stage and the Department plans to have prepared a business case to support the initial stage of the agreement by the end of 2008. The Department will need to coordinate commercial work on the deterrent with progress on the agreement if it is to maximise the benefits to itself and to industry.

Mitigating monopoly supplier risks

5.11 There is no single means of eradicating monopoly supplier risk. There are, however, a number of measures which can minimise that risk and incentivise performance through the life of the project. These include, but are not confined to, the following: effective performance targets which focus on delivering cost-effective through-life capability and avoid a short-term focus; ensuring clarity over who owns which financial risks; agreeing provisions to resolve disputes quickly; gain/pain-sharing provisions in the contract; and managing performance in the context of the overall supplier relationship.

5.12 Effective partnerships will also be vital to the success of the future deterrent programme. Some typical features of strong partnerships include co-location of project teams, transparent relationships, regular independent assessments of the client-contractor relationship, strong arrangements for dispute resolution and clear allocation of responsibilities. Again, this is not intended to be a prescriptive or exhaustive list, but these kinds of measures should help build the strong, long-lasting partnerships that the Department needs for this programme.

5.13 The relationship between the Department and the various industrial partners is a positive one at this point in the programme, with a strong sense of collaboration. Rolls-Royce and BAE Systems have seconded staff into the Nuclear Propulsion and Future Submarines Integrated Project Teams and both companies told us that their relationships with the Department were working well.

5.14 Sustaining and further developing these strong working relationships is important to the successful delivery and support of the future deterrent. Within this context, the onus will be on the Department to ensure its staff have the necessary commercial, financial, technical, and project management skills to be able to act as an intelligent customer. It will also need to establish effective procedures to ensure that those suppliers represented within the Department's teams cannot exert undue influence which might undermine the cost-effective spending of public money.

Addressing skills shortages

5.15 The Department and industry have identified a skills shortage in terms of submarine-building expertise as well as nuclear-related experience and programme management, commercial and financial expertise. This shortage is particularly evident in the nuclear propulsion area, where the Integrated Project Team expressed real concerns about their ability to act as a smart customer. The United Kingdom's resurgent civil nuclear industry increases the likelihood of a skills shortage.

5.16 In addition, a notable lesson from the Astute submarine programme was that the Department should only transfer to industry those risks which the latter is capable of dealing with. In response, the Department plans to act as design authority for the future deterrent, meaning that they will take responsibility for the key design decisions throughout the construction of the future submarine. The Department are aware that they will need to develop the necessary technical skills to do so effectively, but are still in the early stages.

5.17 The Department has plans to address these shortages. Studies are underway within the Future Submarines Integrated Project Team to assess the skills needed in terms of suitably qualified and experienced personnel. A range of collaborative actions are also under way, including the establishment of joint teams, secondments and the use of staff from the Astute Integrated Project Team. In addition, the Department is making use of consultancy support. The Department has procured the services of client advisers under two separate call-off contracts to provide commercial and technical advice during the concept phase. It has spent £1.25 million and £350,000 under the commercial and technical contracts so far, against contract approvals of £2 million and £3.74 million respectively.

5.18 Lessons can be learnt from the Atomic Weapons Establishment which identified a similar shortage of expertise a few years ago and has taken steps to address it. The Atomic Weapons Establishment took a long-term view of their staffing requirements based on work scheduled under the Nuclear Warhead Capability Sustainment Programme. They also modified their overall work programme with a capped annual growth figure to ensure that work and human resource were matched. In addition to this overarching planning effort, particular schemes such as skilled apprenticeships have helped to deliver the skills required.

APPENDIX ONE

Study methodology

Scope of the study

1 In undertaking this study we were seeking to determine whether the Ministry of Defence is well placed to deliver on time and to budget a future nuclear deterrent that meets the stated requirements.

Methodology

2 We undertook an Issue Analysis examining:

- whether the Department has made good progress developing the plan for the future deterrent;
- whether the Department has the skills and resources to deliver the future deterrent; and
- whether effective governance arrangements are in place to deliver the future deterrent.

3 We carried out a review of programme management good practice, drawing together good practice identified by the NAO and others to help develop the interview questions and inform our assessment of the governance and programme management arrangements. We also reviewed previous National Audit Office work on the Astute submarine programme and the D154 project.

4 In collecting evidence in support of our findings we interviewed individuals from a number of organisations. **Box 9 overleaf** sets out the list of people or organisations interviewed for this study. The interviews identified major risks to successful delivery, assessed the Department's progress to date and considered the arrangements in place to deliver the future deterrent successfully.

5 We attended a number of meetings of the Department's Strategic Deterrent Programme Board and Capability Planning Group in the capacity of observers to monitor progress to date, identify major issues and risks and assess whether governance arrangements were working well.

6 We conducted a file review of the Department's documents, including policy papers, approvals papers, risk registers, cost plans, Strategic Deterrent Programme Board papers and working documents.

BOX 9

Study Interviewees

Ministry of Defence

Submarine Support Integrated Project Team

Future Submarines Integrated Project Team

Attack Submarines Integrated Project Team

Nuclear Propulsion Integrated Project Team

Nuclear Weapons Integrated Project Team

Chief Strategic Systems Executive

Director Submarines

Director General, Submarines

Defence Nuclear Safety Regulator

Director Strategic Requirement

Director General, Strategic Technologies

Defence Commercial Director

Staff representing the Assistant Chief of Naval Staff

Assistant Chief of Defence Staff (Policy)

Director, Chemical Biological Radiological and Nuclear Policy

Director General Equipment – Programme Senior Responsible Owner

Capability Manager (Precision Attack)

Director of Equipment Capability (Deterrent)

Director of Equipment Capability (Under Water Effects)

Other Government Departments

Cabinet Office

HM Treasury

Foreign and Commonwealth Office

Third Parties

Nuclear Installations Inspectorate, Health and Safety Executive

Atomic Weapons Establishment Management Limited

BAE Systems plc

Rolls Royce plc

GLOSSARY

Approval	The formal decision that a project should proceed to the next stage in the acquisition cycle, taken by an authorised approvals authority. For major projects, this is usually the Investment Approvals Board. At Main Gate the approval sets parameters for the project's cost, time and performance. The project cannot exceed these parameters without returning to the Investment Approvals Board for further approval.
Assessment Phase	The second phase in the acquisition cycle after the concept phase, beginning with Initial Gate. The aim of the Assessment Phase is to develop an understanding of options for meeting the requirement that is sufficiently mature to enable selection of a preferred solution and identification, quantification and mitigation of the risks associated with that solution. At the end of the Assessment Phase a Business Case is submitted to the Investment Approvals Board for Main Gate Approval.
Business Case	The documentation submitted to the Investment Approvals Board at Initial Gate or Main Gate, making the case for proposed expenditure on the next phases of the project.
Concept Phase	The first phase in the acquisition cycle, in which the aim is to produce a statement of the user's required outputs, form a delivery team, initiate industry involvement and start to identify the cost, time and performance boundaries.
Continuous at sea deterrence	The policy of ensuring that at least one nuclear-armed submarine is on patrol at any one time.
Defence Equipment and Support	Officially formed on 1 April 2007 from the merger of the Defence Procurement Agency and the Defence Logistics Organisation. It equips and supports the United Kingdom's armed forces for current and future operations, including equipment and services ranging from ships, aircraft, vehicles and weapons, to electronic systems and information systems.
Defence Industrial Strategy	The United Kingdom Defence Industrial Strategy was announced on 15 December 2005 and is aimed at ensuring that the Armed Forces are provided with the equipment that they require, on time, and at best value for money. Part of this is the requirement to procure from a sustainable industrial base that retains within the United Kingdom those industrial capabilities that are required from a national security perspective, to ensure the appropriate sovereignty.
Design Authority	An organisation appointed to be responsible for a design or modification of a design to approved specifications, and for signing the Certificate of Design.

Initial Gate	The approval point preceding the Assessment Phase. At Initial Gate, a Business Case is put to the Investment Approvals Board to confirm that there is a well constructed plan for the Assessment Phase that gives reasonable confidence that there are flexible solutions within the time, cost and performance envelope the Equipment Capability Customer has proposed.
In-Service Date	The definition varies between defence projects. The planned In-Service Date for the future submarine class is 2024 and represents the successful conclusion of sea trials for the first of the four submarines.
Integrated Project Team (IPT)	A team of civilian and military personnel responsible for managing any element of defence equipment from concept to disposal. All Integrated Project Teams are part of the Defence Equipment and Support organisation.
Investment Approvals Board	The Departmental body responsible for the approval of investment in major projects at Initial Gate and Main Gate. The Investment Approvals Board comprises the Vice Chief of Defence Staff, the second Permanent Under Secretary, the Chief of Defence Materiel and the Defence Commercial Director and is chaired by the Chief Scientific Adviser. Projects below specified values (£400 million in the case of equipment projects) may be approved by subordinate approvals authorities.
Key User Requirements	These outline the requirements which are considered to be critical to the achievement of the mission and are used to measure project performance. The Department recommends up to ten be defined for each project.
Lines of Development	Lines of Development provide a mechanism for coordinating the parallel development of different aspects of capability that need to be brought together to create a real military capability. These aspects are: training, equipment, personnel, information, concepts and doctrine, organisation, infrastructure and logistics.
Main Gate	The point at the end of the Assessment Phase when the decision to proceed with the project is made. At Main Gate the Business Case presented to the Investment Approvals Board recommends a single technical and procurement option. By Main Gate, risk should have been reduced to the extent that the Equipment Capability Customer and Integrated Project Team can, with a high degree of confidence, undertake to deliver the project to narrowly defined time, cost (procurement and whole-life) and performance parameters.
Programme Support Office	An office established on 31 March 2008 to provide support to the Senior Responsible Owner and Strategic Deterrent Programme Board.
Senior Responsible Owner	The Senior Responsible Owner (SRO) is accountable to the Defence Management Board for the integration of the total capability within a programme; for fully exploiting the potential of the business or capability change; and for the benefits delivered through life.

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The United Kingdom's Future Nuclear Deterrent Capability

A report by the Comptroller and Auditor General

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