The United Kingdom's Future Nuclear Deterrent: **The Submarine** Initial Gate Parliamentary Report

May 2011

For over 42 years the United Kingdom has relied upon a continuous submarine based nuclear deterrent to provide us, and our NATO allies, with the ability to deter the most destructive forms of aggression. Following the publication in December 2006 of a White Paper "The Future of the United Kingdom's Nuclear Deterrent" Parliament debated the issue and voted in favour of renewing the deterrent with a successor class of ballistic missile submarines. Since then the Ministry of Defence has undertaken a Concept Phase to assess potential submarine designs and propulsion systems and a rigorous value for money review of the programme, the results of which were announced as part of the Strategic Defence and Security Review.

We have now decided on the outline submarine design at the stage in the programme known as Initial Gate. The work to date has given us a broad design, drawing as heavily as possible on proven Astute Class technologies and on the joint US/UK programme to develop a common missile compartment which will house the Trident strategic weapon system. It will be powered by a nuclear propulsion system known as Pressurised Water Reactor 3, which will incorporate the latest safety technologies and ensure our future nuclear-armed submarines have the performance required to deliver our minimum credible nuclear deterrent out until the 2060s. More detailed costs are set out in the report but we expect the overall successor programme to remain within the White Paper cost envelope of £15-20 Billion at 2006/7 prices.

We now move forward into the Assessment Phase where we will finalise the design and start to prepare for the main build. The Assessment Phase will culminate in the Main Gate investment point in 2016, where we will sign the main construction contracts and also decide whether continuous at sea deterrence can be delivered by three or four boats. Whilst undertaking this work, we must always remember that we are taking decisions that impact directly on the safety and effectiveness of our submariners, and the people who support them, in the remarkable work they do protecting our country and our freedoms. Remaining submerged for up to three months at a time, cut off from family and friends, their vital work remains unsung and necessarily secretive. Whilst they are out of sight they are not out of my mind or the minds of my fellow Ministers.

The Rt Hon Dr Liam Fox MP
Secretary of State for Defence

1. Aim of the Report

The aim of this report is to outline:

- The work that has taken place since the Parliamentary vote of March 2007;
- The decisions taken at Initial Gate; and,
- The next steps that will be taken in the coming months and years to ensure the successful delivery of a successor nuclear deterrent.

2. Background

2.1 The 2006 White Paper

In December 2006, the Ministry of Defence (MOD) published a White Paper[1] "The Future of the United Kingdom's Nuclear Deterrent", which set out the conclusions of studies into whether the United Kingdom still required a nuclear deterrent and, if so, how that nuclear deterrent might best be delivered. The White Paper concluded that, whilst at the time there was no nation with both the capability and intent to threaten the independence or integrity of the UK, we could not dismiss the possibility that a major direct nuclear threat to the UK might re-emerge despite our work to counter proliferation. The White Paper also concluded that, of the potential ways of delivering a nuclear deterrent capability, the most effective system was a further class of submarines carrying ballistic missiles. In March 2007 a Parliamentary vote endorsed the conclusions of the White Paper.

Since the 2007 Parliamentary debate the MOD has undertaken design work with the aim of allowing a down-selection to a single submarine design at Initial Gate – the first key decision point in the MOD's procurement process. The White Paper identified three main investment strands: the submarine, the warhead and supporting infrastructure. At the present time the replacement submarine is the main focus of work and this report concentrates on the progress of that aspect of the programme.

2.2 Strategic Defence and Security Review and Value for Money Review

Whilst the Coalition remains committed to maintaining and replacing the UK's nuclear deterrent, one of the first decisions was to instigate a value for money review of the nuclear deterrent programme. The review was wide ranging, scrutinising the arrangements for the current nuclear deterrent as well as plans for the successor system. The review covered: the replacement programme timetable, the number of missiles, missile tubes and warheads required to deliver a minimum credible deterrent; the associated infrastructure and other support costs; and the industrial supply chain and commercial arrangements.

The full outcomes of the review, which saved or deferred over £3 Billion of expenditure over the next ten years, were published in Chapter 3 of the Strategic Defence and Security Review[2]. The outcomes most relevant to the next generation submarine were:

- A deferral of the delivery of the first submarine from 2024 until 2028 and a deferral of the Main Gate decision point (which is also the most suitable time to decide on the number of submarines required) to 2016.
- A reduction in the number of operational missiles carried to eight, which in total would carry no more than 40 operational warheads.
- Agreement with the United States on the major parameters of the jointly-developed common missile compartment design that will be capable of carrying the current Trident D5 missiles and any replacement missile once the D5 reaches the end of its expected life in the 2040s.
- The instigation of a programme (known as the Submarine Enterprise Performance Programme) to reduce costs, improve performance and ensure the sustainability of the UK's submarine industrial enterprise.

[1] The Future of the United Kingdom's Nuclear Deterrent (Cm6994) http://www.mod.uk/nr/rdonlyres/ac00dd79-76d6-4fe3-91a1-6a56b03c092f/0/defencewhitepaper2006_cm6994.pdf

[2] Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review (Cm7948) http://www.direct.gov.uk/prod_consum_dg/groups/dg_digitalassets/@dg/@en/documents/digitalasset/dg_191634.pdf

3. Progress on the Submarine Programme

3.1 Initial Gate Decisions

The programme to replace the nuclear deterrent is one of the largest and most complex the MOD has undertaken. The Department has completed the initial phase of concept analysis, which addressed the technical issues associated with potential designs and set out the work that will be required in the next phase, known as the Assessment Phase. The key areas covered were:

- **The Submarine Design.** A nuclear-powered attack submarine (SSN) such as the Astute Class is designed to be manoeuvrable and fast. In comparison, nuclear-powered ballistic missile submarines (known as SSBNs) housing missiles over 13 metres in length have historically been around twice the size of attack submarines. Nonetheless there are similarities between the different classes of submarine and a number of systems from the Astute Class design have been incorporated within the design of the successor submarine. This 'pull through' of proven technology reduces costs as well as design and delivery risk for the successor deterrent submarine and ensures commonality in training and maintenance.

  However, we must also be mindful of the opportunities presented by technological developments since the design of Astute and the requirement to sustain the capability throughout the life of the submarine out until the 2060s in order to deliver a design optimised to the unique role of a nuclear-armed submarine. Therefore, we are taking the opportunity to incorporate a new nuclear propulsion design as well as ensuring there is sufficient flexibility and accommodation in the design to deliver through-life upgrades.

- **The Propulsion System.** The Pressurised Water Reactors (PWR) used in submarines work by using nuclear fission to generate heat, which is then used to turn water into steam to turn the main turbines that propel the submarine through the water. There were three PWR options:

  - PWR2 is used in the Vanguard and Astute submarine Classes. It is a safe and reliable design that has served, and will continue to serve, the Royal Navy well but it is based on design features and technology that can now be improved upon;
  - PWR2b is a development of PWR2 seeking to increase PWR2's performance further. However the cost of these improvements is roughly the same as the cost of developing a new design, PWR3; and,
  - PWR3 is a new design that exploits technology that was not available when the Astute design was finalised. Through simpler design it is easier to operate, has a longer in-service life and lower through-life maintenance costs. In addition the introduction of the new design means that it is practicable to implement further improvements to safety.

When considering options a number of factors were taken into account including:

- Capability: The ability of the options to meet the required capability (a 25 year life with the option of at least a five year extension and suitably low detectability);
- Availability: The complexity and maintainability of the propulsion plant (and therefore the submarine);
- Safety: The Health and Safety at Work Act places a legal obligation on MOD Duty Holders and Industry Suppliers to ensure that the risk to the public and employees is reduced As Low As Reasonably Practicable (ALARP);
- Cost: Both in procurement and through-life costs; and,
- Schedule: The confidence of delivering the option to the required timeline.

After careful consideration PWR3 was chosen. PWR3 provides superior performance over PWR2. In availability terms the simplicity of PWR3 and the application of modern design practices and newly matured technology will significantly reduce periods in upkeep and maintenance. A particularly important issue was safety. Nuclear propulsion plants are extremely safe and our nuclear systems are assessed by the Defence Nuclear Safety Regulator to ensure this remains the case. However, this is a new design of submarine and under Health and Safety legislation we are required to look at whether performance can be improved even further. In this case PWR3 offers improvements over PWR2. That does not mean that current systems are unsafe. All our propulsion plants meet the stringent safety standards that have been set by the Defence Nuclear Safety Regulator, but as we move to a new class of submarine the requirement to continually improve our performance and to meet 'ALARP' is only met through PWR3.

In terms of cost, submarines with PWR3 are around £50 Million per boat more expensive to buy and operate over designs incorporating PWR2 over a 25 year life but would be cheaper if we were to operate the deterrent submarines for longer because of PWR3's longer life. We judge that this investment is worth making given the performance and wider benefits offered by PWR3.

- **The Common Missile Compartment (CMC).** We use the same Trident D5 ballistic missile as the US and there is commonality between systems used in our current Vanguard Class and the US Ohio Class submarines for the storage and firing of those missiles. In 2007, with the UK and the US both in the process of replacing our existing nuclear-armed submarines, it was agreed to develop a CMC that could be fitted to both our replacement submarines. By working collaboratively with the US, the UK is able to share the costs of designing, building and integrating a missile compartment and ensure both commonality with the current Trident D5 ballistic missile and any potential replacement missile.

  Our successor submarines will have only eight operational missiles but it is clear from work to date that the cost of the missile compartment will be minimised by keeping as much of the design as possible common with the US. The baseline design for the CMC is a 12 tube unit and work is ongoing with the US to look at how best to include our requirement for eight operational missiles into this design.

4. Future Work

4.1 The Forward Work Plan

During the Assessment Phase a considerable amount of work is required to mature the submarine design and prepare for the building of the submarines. Work is split into the following strands:

- Design and engineering: In line with best practice a design level of around 70% maturity will be reached across the overall submarine design so that build can commence after Main Gate without the expectation of having to redesign, which then adds delay and cost.
- Long lead items: As with almost all large-scale complex programmes it will be necessary to procure some parts in advance to ensure their availability for when the submarine build is commenced so the boats can be delivered to schedule. Spend on long lead items has been minimised and we expect to spend:
  - £380M for the first boat split between the propulsion, main boat systems and steel;
  - £145M for the second boat for propulsion systems; and,
  - £6M for the third boat also for propulsion systems.

  No long lead parts will be procured for the fourth boat as a decision will not be required for this boat until Main Gate in 2016.
- Production preparation: The replacement submarines are considerably larger than the Astute Class submarines currently being built. Some increases will be required in the shipyard's workforce, facilities and equipment.
- Technology development: There are some areas where new or emerging technology is planned including communications, tactical weapons systems, batteries and structural materials. Work will start to develop these components so that they can be incorporated into the design at an acceptable level of risk.
- Information and knowledge management: Improvements in design software and shared working environments will enable secure exchange of data between all parties, many of whom are located in diverse geographical locations, including our missile compartment team which is based in the US.
- Project management: An Integrated Programme Management Team (IPMT) will be established to oversee the work schedule, costs and risks and to manage relationships between MOD and the main industry partners. We will also look to develop improved collaborative arrangements with the three Tier 1 industrial partners (BAE Systems, Babcock and Rolls-Royce).

The ability to work coherently and collectively across all elements of the delivery team and industry will be key to successful delivery of the programme. The future programme control arrangements are therefore centred on the IPMT which will combine the key technical and programme decision makers from MOD and our industry partners. The IPMT will align cost and schedule processes across the MOD and our industry partners, and will:

- Deliver the successor submarine to a single Integrated Master Schedule;
- Take the agreed concept through design, manufacture and into service;
- Control the cost and certainty of delivery; and,
- Incentivise joint working.

4.2 Working with Industry

Whilst the replacement submarine programme is significant in its own right it is important to place it in the wider context of the overall submarine industrial enterprise.

Working with our industry partners will be key to delivering the successor deterrent programme to the agreed performance, cost and time. Under the Submarine Enterprise Performance Programme (SEPP) initiative the three Tier 1 industrial suppliers will work collaboratively with the MOD to transform the submarine enterprise's ability to deliver effectively. Our key objectives are:

- Sustainability Secured: We must retain the capability to design, build and support nuclear submarines and meet the commitment for a successor to the Vanguard Class submarines;
- Cost Down: We must realise significant savings through rationalisation of facilities and an inclusive approach to design, build and support through improved contracting; and,
- Performance Up: We must work together to improve delivery in terms of performance, cost and time.

Industry will be incentivised to share project risk through new collaborative commercial arrangements for the design, build and through-life support of nuclear submarines and associated nuclear reactor plants. It is estimated that successful implementation of SEPP across the submarine enterprise will deliver at least £900M in savings over the next ten years.

4.3 Cost of the Next Phase

Since Parliamentary approval to replace our nuclear deterrent in 2007 the MOD has spent around £900M (at outturn prices) on the Concept Phase of initial submarine design work, the progression of the CMC work with the US and the investment in design, programme management and construction skills that will allow us to build the submarines effectively.

Between now and Main Gate in 2016 (the decision point at which contracts for building the submarines will be placed) we expect to spend a further £3Bn at outturn prices on the work plan set out in section 4.1 (including the long lead items previously highlighted). We therefore expect to have spent some £3.9Bn on reaching Main Gate, or around 15% of the outturn cost of the submarines (based on a four boat fleet). This is in line with the MOD's approvals guidance, which advises that programmes should expect to spend 15% of their budget in reaching Main Gate. This ensures that programme risks are understood and managed, build contracts are based on suitably mature designs, and there is confidence that sufficient preparation has been made to deliver to time and cost.

BAE Systems Barrow

DE&S Abbey Wood

Devonport Naval Base

Rolls-Royce Raynesway

5. The Wider Deterrent Programme

The submarine is only one aspect of the replacement plans set out in the 2006 White Paper. There are two other areas that are outside the scope of the Initial Gate decision on submarine design but are crucial to the wider programme to replace our nuclear deterrent:

- Warhead: The value for money review concluded that a decision on whether to replace our current warhead design could be deferred until the next Parliament as we are able to maintain our current warhead design in-service for longer than previously assessed. The current warhead design is now planned to continue in service until the 2030s.

  The SDSR reviewed the UK's deterrence criteria and concluded we could reduce warheads carried on deterrent patrols from 48 to 40, carried on eight operational missiles. Consequently the UK will also reduce its stockpile of operationally available warheads from fewer than 160 to not more than 120 and our overall stockpile from not more than 225 warheads to not more than 180.

  The 2006 White Paper also noted that investment in a replacement ballistic missile would eventually be needed and that investment at the Atomic Weapons Establishment would need to continue. We currently expect the Trident D5 missile to remain in service until the 2040s and no work is currently being undertaken on a replacement. Work at Aldermaston was reviewed during the value for money review with the aim of ensuring that we have the appropriate facilities and programmes in place to support the current warhead and eventually, the information required for a decision in the next Parliament on a replacement warhead. We also announced in the SDSR that we could minimise costs by cooperating with the French on our research programmes and would develop a joint test facility.

- Infrastructure: The value for money review also examined the infrastructure and command and control facilities that support our deterrent and concluded that no significant investment was needed in the immediate future. The successor submarines are being designed for maximum compatibility with existing infrastructure much of which has been recapitalised during the last 20 years. We will spend around £8M over the next three years to study in detail the requirement for investment in our infrastructure and will continue to look for opportunities to drive down running costs and any new investment.

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6. Cost Estimates

6.1 Submarine Costs

The 2006 White Paper estimated that the cost of the successor deterrent system would be £15-20Bn (at 2006/7 prices) of which £11-14Bn would be attributed to the cost of the replacement platform. These estimates were stated at 2006/7 prices to provide an understandable way of explaining the cost of the replacement deterrent at a constant price base. MOD investment approval is normally made at outturn prices i.e. the sum of the expected spend in each year including inflation and the figures provided earlier in the report are made on that basis. However, expressing costs at 2006/7 prices remains an important way of demonstrating how we are performing and we will continue to provide comparisons against the White Paper estimate. This equates to £25Bn at outturn prices for the successor submarines.

Our assessment is that, assuming a four boat fleet, the replacement submarines will remain within the £11-14Bn estimate. Further work needs to be done between now and Main Gate to refine this estimate, particularly on the benefits to be achieved through SEPP.

This estimate includes programme risk. The MOD and industry operate a joint risk management approach and have developed comprehensive risk registers using the combined experience of Government and industry. This has drawn on the experience from other similar programmes such as Astute and has ensured that lessons identified in those programmes are incorporated into the Successor Programme.

6.2 Wider Programme Costs

Work on the Trident replacement programme has so far concentrated on the submarine. The SDSR concluded that it would be possible to defer decisions on the replacement of both the warhead and infrastructure elements of the programme with a consequential deferral of spend over the next ten years. Over the next few years concept studies will begin to refine potential programmes and costs. In particular we expect that it may be possible to reduce the cost of supporting infrastructure but at this stage the estimates given in the 2006 White Paper of £2-3Bn for each of the two elements stand.

Glossary

ALARP	As Low as Reasonably Practicable
CMC	Common Missile Compartment
IPMT	Integrated Programme Management Team – a joint MOD and industry team
MOD	Ministry of Defence
PWR	Pressurised Water Reactor
SDSR	Strategic Defence and Security Review
SEPP	Submarine Enterprise Performance Programme

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