THE DELIVERY OF THE SUCCESSOR DETERRENT SUBMARINE CONCEPT DESIGN - A COLLABORATIVE APPROACH

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Summary

Following the decision by the Government and the subsequent vote in Parliament to continue the UK's Independent Nuclear Deterrent, the Future Submarines IPT was formed to put in place the programme to deliver this vital capability. This will be the largest engineering programme in the UK in recent times, with a budget approximately double that of the Olympic Games. An innovative approach is being taken by both MoD and Industry to deliver the programme, with a truly Integrated Project team being formed utilising the best available resources from both the MoD and Industry. This paper will describe the approach being taken to the collaborative delivery of the Concept Design for the Successor Deterrent Submarine and will reflect on the lessons learned in this area during the first six months of this programme.

1. INTRODUCTION

The Government's reasoning for continuation of the UK Independent Nuclear Deterrent was clearly set out in the 2006 White Paper, "The Future of the United Kingdom's Nuclear Deterrent" [1], and following Parliament's approval in March 2007, the Future Submarines Integrated Project Team (FSMIPT) was established in April 2007. The Team was charged with the renewal or replacement of those elements of infrastructure and the UK submarine fleet necessary to deliver the will of Parliament.

In October 2007, as part of this overall programme of work, the Concept Phase for the UK Successor Deterrent Submarine began. This is a two year programme, designed to deliver the key high-level decisions, design policies and concept design definition necessary if the successor to the in-service Vanguard Class submarine is to enter service in 2024.

The Successor Deterrent is one of the first major defence programmes to adopt the collaborative approach between the MoD and Industry signalled in the Defence Industrial Strategy [2] published in 2006. The Future Submarines Integrated Project Team is staffed by personnel from Defence Equipment and Support (DE&S) and staff from the three primary companies in the 'Submarine Enterprise' – BAE Systems Submarine Solutions, Rolls-Royce Submarines and Babcock Marine.

This paper will discuss, and draw interim conclusions on the following aspects:

- The issues and challenges in setting up a collaborative team from across the submarine enterprise
- The role, structure and method of working of the IPT
- The development and management of the User and System requirement
- The planning and the delivery of a viable Submarine Concept Design
- The delivery of affordable and available submarine platforms

2. THE ISSUES AND CHALLENGES IN SETTING UP A COLLABORATIVE TEAM

The Submarine 'market' in the UK is effectively shrinking. While the United Kingdom's submarines have become more effective over the past two decades, reduced requirements and increasing costs have resulted in the reduction of the submarine flotilla. With the introduction of the Astute Class submarine over the next decade, this will result in a flotilla of up to 11 nuclear submarines – four ballistic missile submarines and seven hunter-killer submarines.

The natural corporate response to a shrinking market is to seek to increase market share at the expense of the other participants in the market. Where a market has reduced to a minimum level, this form of competition tends to dominate the senior management attention in each company as each are focussed on survival, and any success simply transfers activity between virtual monopolies of expertise and can lead to the loss of key expertise to the nation.

This situation was recognised by the Defence Industrial Strategy. This sought to ensure that the UK's strategic capability to design, build and support a submarine flotilla could be sustained while ensuring that the cost of the submarine programme in the UK represented value for money. It recognised that this was only achievable by increased collaboration within the Submarine Enterprise, both between the industry participants and between MoD and Industry.

This transition from competitive to collaborative behaviours represents the first challenge faced in establishing the FSMIPT. The culture of an organisation sets the behaviour of its staff, and such cultures are notoriously difficult to change. This organisational culture is reflected in policies and processes of each company and in the MoD and is also embedded in the

behaviour of its staff. The challenge posed by the UK Successor Deterrent Programme is not to change the culture in a single company, but to change it in four organisations – all at the same time.

The challenge is, in itself, multi-facetted, presenting significant issues in terms of policy, process, systems and behaviours.

The very concept of collaboration, rather than competition, to deliver reduced costs lies somewhat uncomfortably against a long-standing position within the MoD that competition was the primary mechanism of ensuring value for money in defence procurement. This 'position' is reflected in a vast array of formal policies and ways of conducting business within the MoD and is also enshrined in law. Equally, within industry, corporate governance requirements generally reflect the need to protect a company's competitive advantage and assume a 'traditional' commercial position where the protection of information is important.

Each partner within the collaborative construct delivering the Concept Phase of the Successor Deterrent Submarine has found that this collaborative approach has 'clashed' in one way or another with established policies. For example, corporate governance policies for the release of a proposal would generally ask the question 'are the customer's requirements clearly and unambiguously defined'. The provision of a response of the form 'No, we have agreed to develop the requirements collaboratively alongside the Concept Design so that we can together trade requirements against whole life cost and agree an outcome that represents the minimum whole life cost' is likely to be unexpected, and potentially might normally be considered to be unacceptable.

In terms of process, the collaborative approach presents both issues and opportunities. Consider a simple concept such as the review of the Concept Design as it emerges. All of the industrial partners have 'design review' processes, and each is, to some extent, different. What may well be missed is that each company has a different definition of the term 'Concept Design' while using identical terminology. Patently, a common understanding of both the subject matter and the conduct of the review is essential, and this is addressed by the development of specific processes supporting the collaborative delivery of the Concept Design. The fact that a number of the participants have extant processes presents the opportunity of 'benchmarking' these to identify good practice, incorporating this into the new process. The approach taken to the development of all processes for the Successor Deterrent Concept Phase ensures that good practice is sought and that the appropriate stakeholders from any of the participants are engaged in the development and approval of the process.

Each of the participants recognises that effective 'business systems' are an essential feature of an efficient organisation. However, each has to date pursued its own strategy for the selection and deployment of these key elements of the organisation's infrastructure. Unsurprisingly this has not resulted in significant commonality across the collaborative landscape, other than in the ubiquitous email and standard PC desktop tools. Even simple tools such as email can initially present issues, with differing firewall and spam detection settings. Significant efforts will be required to provide an effective collaborative environment for the delivery of The Concept Design and enable the development of the detailed submarine design in the future.

Finally, the most difficult challenge is likely to be ensuring that the people who will together deliver the Concept Design (and the larger number who will deliver the detailed design of the submarine) exhibit constructive behaviours. Our behaviours are the unconscious result of experience, and until recently this experience has been competitive.

Each individual responds differently to a new situation – we all know individuals who are 'stuck in their ways' or who 'relish a new challenge'. A key success factor in changing the behaviour of both individuals and a team is to ensure that the basis for the behaviours exhibited is consciously understood. At a high level, this can be achieved by including measures and incentives in contracts to reward the right, collaborative behaviours, thus ensuring that the senior management in each participant is appropriately (and consciously) focussed.

At a team and individual level, the experience of a number of the participants has demonstrated the value of the deployment of structured development programmes that equip staff with a basic understanding of the drivers that result in effective and ineffective behaviours within the team. This provides a conscious understanding at an individual level, and although not a 'quick fix' has been shown to reap rewards in the medium to long term.

3. THE ROLE, STRUCTURE AND METHOD OF WORKING OF THE IPT

The Future Submarines IPT must essentially work, and organise itself, in two levels to deliver the continuation of the UK's independent nuclear deterrent. The delivery of the complete 'deterrent capability' requires the co-ordination of a large and complex set of organisations, each of whom contribute one or more elements of the 'capability. At this level, the Defence Lines of Development - Training, Equipment, Personnel, Information, Concepts and Doctrine, Organisation, Infrastructure and Logistics - must all be delivered in a co-ordinated manner, and the senior stakeholders within the Ministry of Defence and wider Government must be engaged. A Programme Support Office has been

established to assist the Senior Responsible Owner, the MoD's Director General of Equipment.

Within this broad co-ordinated programme, significant elements such as the design and delivery of a new class of submarine must also be managed. It is this latter aspect that is the subject of this paper. This is the primary responsibility of the IPT, and - while the capability level is vital - we shall concentrate today on the delivery of the submarine Concept Design.

We have formed a single team comprising staff from each participating organisation and the wider Submarine Enterprise, designed to deliver the submarine Concept Design effectively. The team has elements at three levels.

At the highest level, a MoD/Industry Steering Group provides strategic direction and collaborative governance for the submarine platform programme. Each participant is represented at Director (board) level, with the Terms of Reference for the Steering Group encouraging consideration of the best interests of the programme as a whole and the building of consensus.

The senior 'working' level of the collaborative organisation is the Operations Board. Again, each participant is represented at Director level, but in this instance the representatives are closely engaged in the delivery of the programme. The Operations Board also includes other senior members of the IPT with other managers joining as appropriate.

Finally, the Concept Design is being developed by the organisation shown in Figure 1. The organisation reflects the need to work at both the 'capability delivery and 'submarine delivery' level and to deliver the 'business aspects' of the IPT. The appointment of industry team members is managed collaboratively by all participants to ensure that the best available expertise is deployed without consideration of the individual's employer.

3.1 BUSINESS DELIVERY

The Business Delivery element of the organisation is responsible for the financial and commercial management of the programme. The transition from competitive to collaborative has presented some challenges in this area and the partners have worked together to develop a commercial construct that reflects the collaborative strategy of the programme. The contractual arrangement must also reflect that, within the collaborative framework, there remains a client - provider relationship

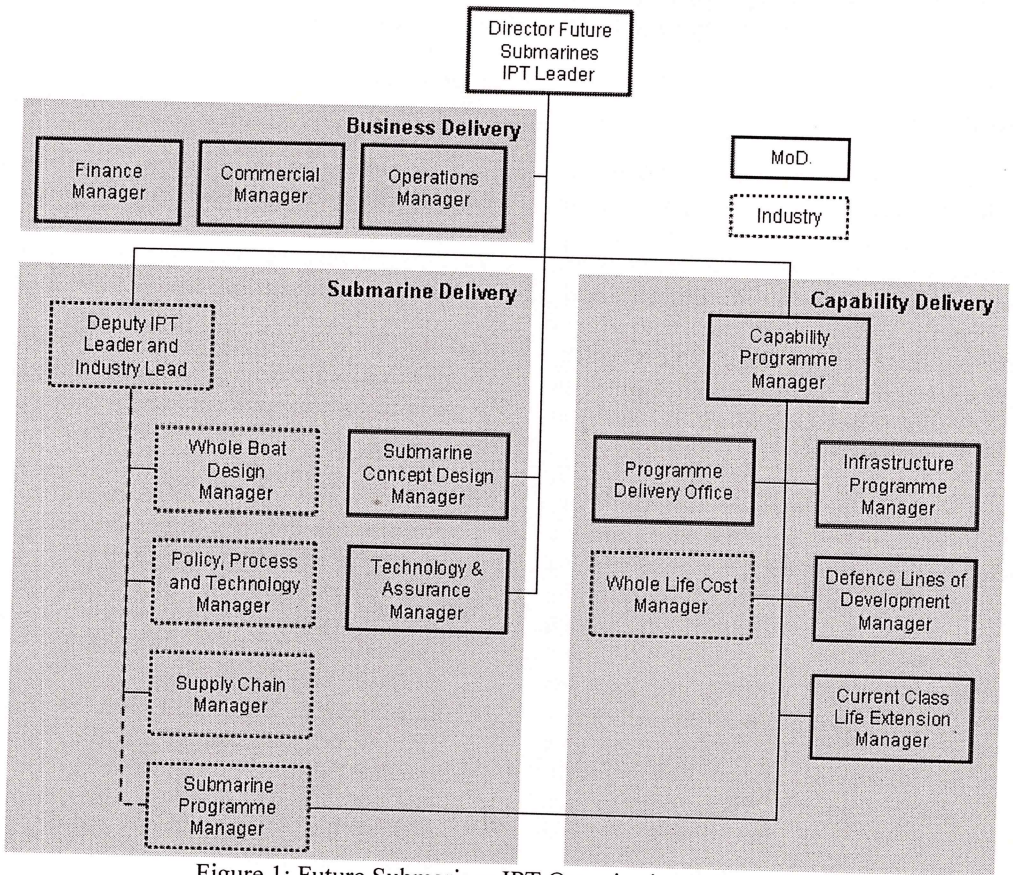

Figure 1: Future Submarines IPT Organisational Structure

The individual contractual arrangements with each of the industrial partners include a collaboration agreement and associated financial incentives that are available to all of the industry partners based on the delivery of evidence of effective collaboration.

This part of the organisation is also responsible for developing and presenting the programme's business case for scrutiny within the MoD "HQ", Defence Equipment and Support, and by wider government.

3.2 CAPABILITY DELIVERY

The Capability Delivery element of the organisation is responsible for ensuring that the necessary actions are taken across all elements of the Defence Lines of Development to ensure the continuation of the UK's independent nuclear deterrent capability. The role is primarily one of co-ordination, ensuring that the overall requirements of the programme are understood by the wide range of organisations involved and that an integrated programme capturing the necessary high-level activities is developed, maintained and delivered.

In addition, this part of the organisation is charged with developing an adequate understanding of the Whole Life Costs of the overall programme to enable the primary cost drivers to be identified and managed. This element is also highly collaborative, with each partner actively involved.

3.3 SUBMARINE DELIVERY

The Submarine Delivery element of the organisation is charged with the delivery of the Submarine Concept Design. At a high level, this comprises a record of the key decisions made during the Concept Phase (together with a capture rationale for the decision and all supporting evidence), a Submarine Concept Design Definition capturing the emergent design and reflecting the decisions made, and a set of Design Policies that set the 'design direction' for the completion of the functional and detailed design of the submarine.

The organisation has been designed to avoid any unnecessary 'man marking' between the MoD and the industry participants. Conscious efforts have been made to foster close working relationships throughout the team. MoD and Industry team members are located together in two main offices in Abbey Wood and Barrow-in-Furness and frequent working level meetings are held. The organisation also ensures that the Submarine Concept Design Manager (who is responsible for the submarine's User and System Requirements) works closely together with the Whole Boat Design Manager, promoting effective and timely decision making and enabling requirement/performance trades.

In a similar way, collaborative teams have been formed to address the adoption of innovative technologies into the submarine design, the development of the commercial arrangements, the development of a co-ordinated Supply Chain strategy, and the development of Whole Life Cost models.

4. THE DEVELOPMENT AND MANAGEMENT OF THE USER AND SYSTEM REQUIREMENT

In general, recent major defence programmes have been 'requirement-based', this is the customer defined the requirement for the system and industry provided a product the demonstrably met these requirements.

While this has some obvious advantages, there a number of significant issues that can arise as the result of this approach. The definition of a complete, consistent and correct requirement for a complex system such as a submarine is notoriously difficult. The process inevitably involved a large number of people each experts in their own field, and is developed as a textual document with the inevitable ambiguities that this entails. The old joke about a camel being a horse that has been designed by a committee rings particularly true here.

In addition, careful commercial management of such as contract and the long design and production timescales associated with such a complex and large product results in the customer receiving precisely the product that he has asked for more than a decade ago, but potentially not the product that the Government needs at the time. The imprecise nature of any such requirement specification coupled with a limited understanding (in both the MoD and Industry) of the capability/cost equation is also a crucial factor contributing to cost overruns in these large, complex programmes.

The Successor Deterrent programme has consciously decided to take a different approach. There are a number of overarching principles that can be summarised as:

- Cost is king in the capability/cost/time equation – there are some crucial aspects to the requirements for a nuclear deterrent submarine (safety, continuous at-sea deterrence, stealth, etc.) but in principle, all requirements can be considered for trading against whole life cost. The Government have asked for a submarine in the water by 2024 at a cost between £11bn and £14bn
- Requirements can, and should, be challenged – a requirement must have a valid rationale – the rational 'because a previous design was like that' is not acceptable. Proposal for slightly reduced performance for significantly reduced cost will be considered, and this is actively happening within the Submarine Delivery team
- The requirement set will reflect the factors that are crucial for the submarine to be able to perform its

defined role. This will include constraints such as the maximum limits of the current supporting shore infrastructure

The intention is that the User Requirement will remain 'fluid' during the Concept Phase, enable capability / requirement / cost trades to take place. Towards the end of the Concept Phase the User Requirements will be baselined. At this stage, the System Requirement for the submarine will be drafted, together with a Submarine Design Specification that will capture the high-level design decisions made during the phase.

All requirements are being managed and developed using the DOORS toolset. Functional Analysis is being undertaken using System Architect and the MODAF method. Textual requirement documents will be generated from the DOORS toolsets.

5. THE PLANNING AND THE DELIVERY OF A VIABLE SUBMARINE CONCEPT DESIGN

The development of a submarine Concept Design does not happen very often, and such an opportunity is available perhaps only once or twice in a career. In addition, the circumstances prevalent at the inception of each submarine programme are likely to be different, presenting different design drivers and constraints. Both of these factors mean that there is no reference 'body of knowledge' on which to base these early phases.

The value of the collaborative approach is that we have been able to collectively determine the key aspects that need to be undertaken during the Successor Deterrent Concept Phase. At a high level, these are:

- The determination of the key user requirements for the submarine
- The identification of the key decisions that must be made regarding the submarine design
- The development of Design Principles and supporting strategies and policies for significant elements of the submarine design
- The development of a common understanding of Whole Life Cost issues
- The development of the Business Case for the programme and its scrutiny at senior levels within MoD and the Government
- The development of the processes, tools and infrastructure for the future phases of the programme
- The development of a single integrated programme

5.1 KEY USER REQUIREMENTS

The determination of the key user requirements for the submarine is an obvious requirement of the early phase of the programme. It is important, however, that this is undertaken in a way that does not undermine some of the other key principles, particularly the minimisation of Whole Life Costs, and this has been discussed in an earlier section of this paper.

5.2 KEY DECISIONS

The identification of the key decisions that must be made regarding the submarine design in these early phases was not straightforward. While the need for some decisions to be made was relatively obvious, it quickly became clear that very few decisions could be taken in isolation from the others and from the emerging design concept. At a very simple level the maximum speed at which the submarine can proceed through the water is a function of propulsion power and hull diameter (among other things), so any decisions relating to the hull diameter must recognise any constraints imposed by the propulsion plant (and vice versa).

The complex nature of all of these inter-relationships mean that these is no single ideal sequence for the necessary decisions, and many must proceed in parallel with an holistic view of the design being maintained at all times. Some would say that this represents the art of Naval Architecture and perhaps they would be right, but the net of decisions extends significantly outside what might normally be considered as Naval Architecture to the edges of the 'deterrent capability'

A 'decision' is also in itself a complex thing. Such a large, complex and politically sensitive programme has many stakeholders, together with an even greater number of organisations and people that will potentially be affected by any decisions taken. A critical success factor in this area is (borrowing somewhat from 'Allo Allo') the ability to make decisions *only once*. This large and complex programme will only be able to proceed to the required programme if key decisions are not re-visited and potentially reversed over time. If this happens, then the level of re-work will be significant, with a consequent impact on both cost and programme.

A 'decisions process' has been developed encompassing all of the FSMIPT and the wider stakeholder community to ensure that all decisions made are well founded (that sufficient analysis and evidence supporting the decision made has been captured), that they are well understood (that all stakeholders have been actively engaged in making the decision) and well communicated (that all potentially impacted know that the decision ahs been made and are aware of its impact on them).

5.3 DESIGN PRINCIPLES

The development of a set of overarching Design Principles was a key deliverable of the pre-concept phase of the programme. These Design Principles set out the high-level strategic direction for the design process and cover elements such as design for minimum whole life cost, Safety, the use of commercially available equipment, and similar high-level aspects

Priority has been given in the initial three months of the programme to the development of more detailed design strategies covering significant elements of the submarine design and overarching aspects such as Information Management and Systems Engineering. These Design Strategies will be subject to appropriate scrutiny within the FSMIPT and by appropriate stakeholders and subject matter experts.

As the Concept Phase develops, these Design Strategies will be further refined and will become policies to guide the design process through to release to manufacture. The intention is that, having embodied the high-level Design Principles and validated strategies, they will provide a firm foundation for the achievement of the programme's overall goals.

5.4 COMMON UNDERSTANDING OF WHOLE LIFE COST

By definition, all of the participants in the programme contribute in some way to the Whole Life Costs of the programme, and each holds knowledge information that will be crucial to the management and minimisation of Whole Life Costs. This development then, of a *common understanding* of Whole Life Cost drivers and outcomes is crucial to the overall success of the programme.

The ability of the industrial participants to share detailed cost information is limited by UK and European competition law, and by commercial confidentiality to suppliers and other third parties. The legal aspects are currently being addressed and consultation on the granting of a 'competition waiver' is currently underway at the time of writing.

The latter aspects of commercial confidentiality are being addressed by the formation of a Cost Modelling function within the MoD element of the collaboration, and a Data Collection function within industry. This approach, with appropriate processes, checks and balances to preserve the necessary confidentiality is intended to enable the necessary common understanding to be developed with the aim of influencing the design process to 'design out' or minimise significant cost drivers.

5.5 THE BUSINESS CASE

The development of the Business Case for the programme and its scrutiny at senior levels within MoD and the Government is a vital element of the Concept Phase. The Initial Gate for the programme has been set approximately 18 month into the Concept Phase, with the intention of achieving approval for subsequent phases of the programme prior to the end of the Concept Phase, and thus enabling a smooth transition to the Functional Design phase of the programme

While the Business Case will draw upon documents and evidence produced as a result of the other elements of the Concept Phase, the programme also considers the specific evidence required to support the business case.

Again, the collaborative approach established for the programme has enabled a more 'joined up' approach between MoD and Industry with a single programme being able to utilise the same deliverable more than once – supporting the delivery of the Concept Design and the requirements of the Initial Gate review.

5.6 PROCESS, TOOLS & INFRASTRUCTURE

The development of the processes, tools and infrastructure for the future phases of the programme is also a crucial deliverable from the Concept Phase.

A set of key processes are being developed to support the collaborative development of the Concept Phase. A number of these have been mentioned in passing in this paper – the selection of industry members of the IPT, the decisions process, and the concept review process. The deployment of a single set of processes across four collaborating partners presents some challenges, but also provides an opportunity for benchmarking and the sharing of good practices across these organisations.

The delivery of the future design phases of the programme will require a significant supporting infrastructure and specialist design toolsets available to engineers based at a number of geographic sites. Again, a collaborative approach has been adopted, with all participants being actively engaged in the development of the strategies and more detailed plans to deliver the required facilities.

5.7 THE DEVELOPMENT OF A SINGLE INTEGRATED PROGRAMME

The collaborative approach taken for the delivery of the Successor Deterrent Concept Phase has enabled the development of a single integrated programme of activities to deliver the required outputs. While this might seem an obvious step, this has been difficult to achieve in the past.

It is intended that this approach also be applied to the complete programme with and integrated Master Schedule for the delivery of the deterrent capability being developed. This Master schedule will be linked with more detailed schedules for each major project

across the Defence Lines of Development that is needed to deliver the overall programme.

The key measure of success of this approach is the ability to identify and manage the key dependencies within the programme at an appropriate level.

6. THE DELIVERY OF AFFORDABLE AND AVAILABLE SUBMARINE PLATFORMS

This paper has set out the approach being taken in the early stages of the Successor Deterrent programme to ensure that those involved will be able to deliver an affordable and available capability.

The first six months of the Concept Phase programme has presented a number of challenges, some expected and others less so. In these early stages is it evident that a collaborative approach has already paid dividends, with Design Principles being adopted by all concerned and design strategies being developed collaboratively in a very short period to begin the process of embedding these principles into the submarine design.

A single common programme for the delivery of the Concept Phase by all collaborating partners has also been established, with progress meetings being attended by all participants with issues and dependencies within the programme being identified and resolved.

The programme has also been able to populate the team that will deliver the Concept Design from across industry, with all of the collaborating partners being engaged in the selection of the best person for the job. This has resulted in a number of the teams being populated from two or more companies, with consequently a wider set of knowledge and expertise being available within the team. This process has also identified where expertise from other companies can be usefully employed on the programme.

The key processes required to deliver the Concept Phase are now established and have involved all of the collaborating partners. Concentration in this area is now beginning to move to the development of the processes, tools and supporting infrastructure that will be required to deliver future phases of the programme.

You would not expect such a large and complex programme to be without its difficulties, and a number of challenges have been faced. A number of areas have found it difficult to identify and engage engineers with the experience to contribute to the programme. This is particularly the case for Systems Engineering where capable engineers with an in-depth knowledge of submarine design do not routinely attend their local Job Centre seeking work!

Similarly, expertise in the design and development of Strategic Weapon Systems are not needed for every submarine programme. The available expertise in this area (generally with experience gained from the Vanguard programme) tend to be towards the end of their careers, and an active succession management strategy will be needed to ensure that their knowledge and experience is transferred to a younger generation who will complete the work on this programme.

One of the advantages of a collaborative approach is that knowledge and expertise can be sought from other organisations. The first six months of this programme have underlined the fact that the knowledge and resources to deliver this programme successfully can only be deployed collaboratively, since no one company or the MoD has the full range of expertise and resources necessary.

Finally, the delivery of this programme within cost and programme constraints presents a very real challenge. On a personal note, I feel very privileged to be contributing to this programme in these early stages. Working together we can set the programme of 'in the right direction' to achieve a successful outcome.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

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2. Defence Industrial Strategy, *HMSO*, December 2005

9. AUTHORS BIOGRAPHY

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