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**Artful – Phase 6 Launch Activities**

**Request for Agreement to commence Artful Hold Point Phase 6 - Launch**

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## EXECUTIVE SUMMARY

### Title

Assessment of the claims, arguments and evidence provided by BAE SYSTEMS Marine Limited (BAE) to support the launch of Artful, and the continued use of Wet Dock Quay to conduct commissioning activities of the Astute Class of nuclear powered submarine.

### Permission Requested

BAE, the nuclear site licensee at the Devonshire Dock Complex in Barrow-in-Furness, is requesting ONR Agreement under Licence Condition 21(1) to commence Artful Hold Point Phase 6 – Launch.

### Background

Astute Class submarines complete construction within the Devonshire Dock Hall before being transported on to a shiplift where they are slowly lowered into the water and launched.

Following launch, Astute Class submarines are moored alongside Wet Dock Quay where further commissioning activities will take place.

Wet Dock Quay is located within the nuclear licensed site and was originally built in 1959 with a second phase in the 1980s. It is a facility used by the licensee where commissioning activities of nuclear powered submarines take place. This includes taking the reactor plant critical for the first time, which is known as Power Range Testing.

It has been recognised by the licensee for some time that the WDQ structure had shortfalls against modern standards for withstand against extreme events, namely a seismic event and rapid loss of dock water levels. Subsequent appraisals have also shown there are shortfalls against normal loading.

In February 2011, during a routine inspection at BAE, the licensee requested a meeting to give the nuclear safety regulators an update on the site strategy for Wet Dock Quay refurbishment, noting the potential long term future use of the quay. Following that meeting, copies of the justification documents to extend the Wet Dock Quay design life were requested. At that time, no potential safety concerns were evident.

In May 2012, ONR carried out a limited civil engineering assessment examining the design substantiation report for the Wet Dock Quay. It was concluded that the Wet Dock Quay structure did not appear to comply with the standards that would be expected for a facility where nuclear safety significant activities take place..

BAE divide the submarine build process into defined project phases. Prior to entering into a new phase, BAE impose 'hold points', where they carry out a review of their own readiness to move to the next phase. BAE also provide the nuclear safety regulators, within their arrangements, the opportunity to agree to the release of 'hold points'. These regulatory 'hold points' are recorded within BAE's arrangements.

ONR decided that the concerns over the Wet Dock Quay structure were serious enough that a suitable safety justification should be provided before next use. To ensure this happened, ONR decided that the most appropriate 'hold point' under BAE's own arrangements was the launch of Artful. ONR agreement for launch would only be provided after BAE had demonstrated and implemented an adequate safety case for the Wet Dock Quay.

To achieve this, in April 2013, ONR requested BAE amend their regulatory hold point control document to reflect that it will be necessary for ONR to agree to the launch of Artful.

### **Assessment and inspection work carried out by ONR in consideration of this request**

ONR has carried out a programme of assessment focussed on the adequacy of BAE's Wet Dock Quay safety justifications. These justifications were all received by ONR by February 2014.

The assessment also included an inspection of the Wet Dock Quay in December 2013 which was conducted by a team of ONR Inspectors which included civil engineering and fault studies specialists.

### **Matters arising from ONR's work**

There were a total of five ONR pre-launch recommendations from the civil engineering and fault studies assessments.

The four civil engineering assessment recommendations have been adequately addressed by BAE.

The fault studies assessment recommendation seeking nuclear safety assurance from the Defence Nuclear Safety Regulator of reactor plant withstand against impacts has been adequately addressed.

ONR has also ensured that the implementation of the revised Wet Dock Quay maintenance arrangements are suitable and sufficient to support future activities conducted at the Wet Dock Quay.

Both ONR and BAE have raised longer term actions and recommendations which will need progressing prior to Power Range Testing.

### **Conclusions**

This Project Assessment Report concludes that BAE's claims, arguments and evidence provided by BAE to support the continued use of the Wet Dock Quay forms an acceptable basis for granting BAE's request and for Agreement under Licence Condition 21(1) to commence Artful Hold Point 6 – Launch.

### **Recommendation**

The Superintending Inspector for the ONR Propulsion Sub-Programme is requested to:

- Accept this Project Assessment Report.
- If the Project Assessment Report is acceptable, issue Licence Instrument No. 513 under arrangements made under Condition 21(1) of Schedule 2 attached to Nuclear Site Licence No. 42B for agreement to commence Artful Hold Point Phase 6 – Launch.

## LIST OF ABBREVIATIONS

ALARP	As low as reasonably practicable
BAE	BAE SYSTEMS Marine Limited
BSL	Basic Safety level (in SAPs)
BSO	Basic Safety Objective (in SAPs)
CNS	Civil Nuclear Security (ONR)
DNSR	Defence Nuclear Safety Regulator
FFP	Fitness for Purpose
HOW2	(Office for Nuclear Regulation) Business Management System
HPCD	Hold Point Control Document
HSE	The Health and Safety Executive
IAEA	The International Atomic Energy Agency
NDA	Nuclear Decommissioning Authority
NII	HM Nuclear Installations Inspectorate
ONR	Office for Nuclear Regulation
PAR	Project Assessment Report
PCER	Pre-construction Environment Report
PCSR	Pre-construction Safety Report
PRT	Power Range Testing
PSA	Probabilistic Safety Assessment
PSR	Preliminary Safety Report
RGP	Relevant Good Practice
SAP	Safety Assessment Principle(s) (HSE)
SFAIRP	So far as is reasonably practicable
SSC	System, Structure and Component
TAG	(ONR) Technical Assessment Guide
WDQ	Wet Dock Quay

## TABLE OF CONTENTS

1. PERMISSION REQUESTED.....	9
2. BACKGROUND.....	9
3. ASSESSMENT AND INSPECTION WORK CARRIED OUT BY ONR IN CONSIDERATION OF THIS REQUEST .....	9
4. MATTERS ARISING FROM ONR'S WORK.....	14
5. CONCLUSIONS .....	14
6. RECOMMENDATIONS .....	15
7. REFERENCES .....	16



## 1 PERMISSION REQUESTED

1. BAE SYSTEMS Marine Limited wrote to ONR on 1 May 2014 (Ref. 1) requesting ONR's Agreement under Licence Condition 21(1) to commence Artful Hold Point 6 – Launch, described in their arrangements in:
  - Astute Class Regulatory Hold Point Control Document Issue 33, dated 26 November 2013 (Ref. 2)

## 2. BACKGROUND

### The Nuclear Licensed Site at Barrow-in-Furness

- 2 Nuclear site licence No. 42B for the Devonshire Dock Complex at Barrow-in-Furness was issued to Vickers Shipbuilding and Engineering Limited on 29 October 1990 and came into force on 1 November 1990. Since then, the registered name of the licensee has changed as follows:

1 August 1997 Vickers Shipbuilding & Engineering Limited (change of “and” to “&”)

16 October 1998 Marconi Marine (VSEL) Limited

23 February 2000 BAE SYSTEMS Marine Limited

- 3 Furthermore, following a reorganisation in 2003, the trading entity at Barrow-in-Furness was renamed as BAE SYSTEMS Submarine Solutions, which changed again in 2012 to BAE Systems Maritime – Submarines. In both instances BAE SYSTEMS Marine Limited remained the licensee. For ease of reference, BAE will be used in this Project Assessment Report (PAR) to denote both the licensee and the trading entity.
- 4 The BAE site in Barrow-in-Furness is also regulated by the Ministry of Defence (MoD) through the Defence Nuclear Safety Regulator (DNSR) and by the Environment Agency. DNSR authorises operations on the site through a similar and complementary process to the ONR Licensing process and the EA regulates the site under the Environmental Permitting Regulations 2010.
- 5 The UK Naval Nuclear Propulsion Programme was conceived in 1954 and born when the first nuclear powered submarine, HMS Dreadnought, was commissioned in 1963. All but three nuclear powered submarines have been built and commissioned at the Barrow-in-Furness shipyard. BAE is currently building and commissioning the remainder of the Astute Class of nuclear submarines, the third of which is named Artful, the launch of which is the subject of this report.

### Permissioning Process

- 6 In accordance with the requirements of condition 21(1) of its nuclear site licence, BAE has made and implemented arrangements to control the commissioning of any plant or process which may affect safety. These arrangements allow BAE to produce, approve, issue and control a Hold Point Control Document (HPCD) that:
  - specifies the principal internal hold points associated with design, construction, modification, commissioning and operation of all activities and facilities on the nuclear licensed / authorised site;
  - defines the activities associated with each hold point; and

- defines the key deliverables and release criteria associated with each hold point.
- 7 The arrangements also enable ONR and/or DNSR to set regulatory hold points that will require the Agreement of the regulators before they can be passed, and which will normally be coincident with specified internal hold points. The granting of an Agreement by ONR and/or DNSR for BAE to carry out activities beyond hold points is decided on two essentials:
- confirmation that BAE has adequate documentation that demonstrates the safety of all relevant activities and facilities, and that all associated risks are as low as reasonably practicable; and
  - confirmation that BAE has in place adequate management arrangements to comply with the requirements of the relevant conditions attached to the nuclear site licence and nuclear site authorisation, and other relevant legislation such as the Ionising Radiations Regulations 1999 (IRRs) and Radiation (Emergency Preparedness and Public Information) Regulations 2001, and to carry out all relevant activities safely.
- 8 This is achieved by:
- an assessment by ONR and DNSR of the adequacy of the BAE's safety cases for the relevant activities and facilities, and their supporting documents;
  - inspections of the adequacy of BAE's management arrangements for the relevant activities and facilities; and
  - joint ONR and DNSR meetings with BAE to ensure that any issues raised during the regulatory interventions above, and relevant to the activities for which regulatory permission has been requested, have been adequately addressed prior to commencement of the activities.

### **Wet Dock Quay**

- 9 The Wet Dock Quay (WDQ), located on the nuclear licensed site, was originally built in 1959 with a second phase in the 1980s. It is a facility used by the licensee where, following launch, commissioning activities of nuclear powered submarines take place. This includes taking the reactor plant critical for the first time, which is known as Power Range Testing (PRT).
- 10 It has been recognised by the licensee for some time that these structures forming the WDQ had shortfalls against modern standards for withstand to extreme events, namely seismic events and rapid draw down (loss) of the dock water levels. Subsequent appraisals carried out by ONR have shown there are also shortfalls against normal loading.
- 11 In February 2011, during a routine inspection at BAE, the licensee requested a meeting to give ONR's predecessor, the NII, and DNSR an update on the site strategy for Wet Dock Quay refurbishment noting the potential long term future use of the quay. The key points from this meeting are recorded (Ref. 3). Following that meeting, a copy of the justification documents to extend the WDQ design life were requested by NII. At that time, no potential safety concerns were evident.
- 12 In May 2012, ONR carried out a limited civil engineering assessment (Ref. 4) examining the design substantiation report of the WDQ. It was concluded that the

WDQ structure did not appear to comply with the standards that would be expected for a facility where nuclear safety significant activities take place.

13 Following launch, Astute Class submarines are moored alongside WDQ where further commissioning activities take place. ONR decided that the concerns over the WDQ structure were serious enough that a suitable safety justification should be provided before next use. To ensure this happened, ONR decided that the most appropriate 'hold point' under BAE's own arrangements was the launch of Artful. ONR agreement for launch would only be provided after BAE had demonstrated and implemented an adequate safety case for the WDQ.

14 To achieve this, in April 2013, ONR requested BAE amend their regulatory hold point control document to reflect that it will be necessary for ONR to agree to the launch of Artful (Ref. 5).

### 3. ASSESSMENT AND INSPECTION WORK CARRIED OUT BY ONR IN CONSIDERATION OF THIS REQUEST

15 ONR specialist civil engineering and fault studies inspectors visited the site on a number of occasions during 2013 and held technical meetings where regulatory expectations were explained. These meetings were also beneficial to understand the progress BAE were making with the production of WDQ safety justifications. In addition a system based inspection of the WDQ was completed in December 2013 (Ref. 6).

16 By February 2014, BAE had provided the following submissions to ONR for assessment. These were:

- Wet Dock Quay Summary Report (Ref. 7);
- Fitness for Purpose and Maintenance Strategy for the Wet Dock Quay (Ref. 8);
- Wet Dock Quay Independent Technical Assessment (Ref. 9);
- Wet Dock Quay Stand-Alone Safety Statement (Ref. 10).

17 ONR have completed the following assessments of the submissions:

- Wet Dock Quay – Civil Engineering Assessment of the Fitness for Purpose Safety Case (Ref. 11);
- Fault Studies Assessment for Berthing of Astute Class Submarines Alongside the Wet Dock Quay at the Barrow-in-Furness Licensed Site (Ref. 12).

#### Civil Engineering Assessment

18 The ONR civil engineering assessment report (Ref. 11) described the ONR civil engineering interventions conducted during 2013 and ONR's assessment of the BAE safety submissions (Ref. 8 & 9). The report also examined whether the shortfalls identified in ONR's earlier 2012 assessment (Ref. 4), had been addressed by BAE, namely that BAE should:

- Confirm the shortfalls in the structure against normal and extreme loadings;
- Confirm the safety functional requirements for the structure and its required withstand for extreme loadings;
- Confirm the remedial works required to the structure to bring it up to an adequate standard to resist the stated loading expectation; and

- Assess whether sudden dock drawdown is significant for nuclear safety so that this can be related to the significance of failure of the sheet piled wall.
- 19 ONR noted that the Fitness for Purpose (FFP) document (Ref. 8) set out to:
- assess the fitness for purpose of WDQ to provide berthing facilities and establish the safety functional requirements;
  - examine the current limitations of the WDQ structure with regard to its assessed capability;
  - summarise the current condition of the WDQ and mechanism for ageing; and
  - provide an overall maintenance plan up to 2025
- 20 In addition, two new safety functional requirements were identified by BAE to capture the required performance of the structure. The WDQ design substantiation reports (Ref. 13) were revised to include the following safety functional requirements:
- The WDQ structure is to remain serviceable and stable, and provide structural support for the mobile cranes and submarine support services, under normal operational loadings and environmental conditions up to the 50 year return period level; and
  - The WDQ structure is to remain stable and not threaten the safety of the submarine in the event of credible design basis faults (including rapid draw-down) and/or external environmental hazards, up to a level corresponding to a return frequency of  $10^{-3}$ /year.
- 21 The civil engineering assessment concluded that the Fitness for Purpose (FFP) document and supporting work presented an adequate engineering case for the resilience of the WDQ structures.
- 22 Parts of the structures cannot be shown to be code compliant for normal load cases, and the overall structural system will not provide modern standards resilience to extreme events ( $10^{-4}$ ). The competence of the structural system relies on the upper deck structure to remain intact thus preventing collapse of the other structures towards the submarine. Substantiation has been given for  $6.8 \times 10^{-4}$  which meets the target of  $10^{-3}$  resilience.
- 23 The FFP document has used engineering judgement, based on deterministic methods, to show that the performance of the structure under normal loads has been appraised, is understood and can be carefully monitored. It has been shown that potential collapse under normal loads would be progressive, thus allowing emergency egress of staff and avoiding the conventional health and safety risk.
- 24 For extreme loads, the licensee claims that the boat standalone safety case is suitable and sufficient to provide the necessary nuclear safety assurance and this is addressed separately by ONR gaining the necessary nuclear safety assurance from DNSR. Therefore, the civil engineering assessment has been limited to whether the collapse scenarios and withstands quoted are reasonable.
- 25 The ONR civil engineering assessment confirmed that ONR were satisfied with the engineering data on withstands presented in the FFP document and that it has undergone suitable independent technical assessment.

- 26 The assessment generated four pre-launch recommendations. BAE responded to these recommendations (Ref. 14) and ONR concluded that the pre-launch responses were adequate (Ref. 15).
- 27 The ONR civil engineering assessment concluded that, following satisfactory closure of the pre-launch recommendations, that adequate safety justifications for the continued use of WDQ had been provided by BAE to support the launch of Artful.

### **Fault Studies Assessment**

- 28 The safety case applicable to activities conducted at WDQ termed OSC4.1 (Ref. 16) was initially reviewed in March 2013 (Ref.17). The following summary of regulatory concerns were identified (Ref. 12):
- The current safety case does not fully reflect the behaviour of the WDQ during seismic events, given the recently developed understanding of shortfalls in the WDQ structure when compared against a modern standards withstand of  $10^{-4}$ /year. It was concluded that the revised safety case should provide additional information on the design basis and beyond design basis failure modes of the WDQ.
  - BAE includes information on the dock system becoming tidal in OSC4.1, but does not fully explore the potential fault sequences and hazards presented to the submarine reactor plant. [REDACTED]
  - BAE assumes within OSC4.1 that following WDQ failure and/or the dock system becoming tidal the submarine reactor plant will operate safely in a self-sufficient and resilient manner. However, it was concluded that clarification of the challenges to the submarine and evidence of the submarine's safety performance was needed to justify this assumption. In addition, clarification of the safety measures provided and the defence-in-depth available was needed.
  - Further clarification of the ALARP justification should be presented by BAE to address the structural integrity of the WDQ, and the measures the site could take following a WDQ failure and/or the dock system becoming tidal, to support the safety of the submarine reactor plant.
- 29 The fault studies assessment examined BAE's safety submissions (Refs. 7, 8 & 10) to determine if the above concerns had been addressed. The ONR Fault Studies Inspector concluded that BAE has adequately substantiated the fault studies aspects of the two new safety functional requirements for the WDQ. BAE has also adequately identified the design basis and beyond design basis failure modes of the WDQ that can adversely affect submarine reactor safety. [REDACTED]
- 30 The safety submissions presented by BAE require adequate safety performance of the submarine safety systems and crew. This is regulated by DNSR. Assurance was requested from DNSR that this has been adequately addressed for boat launch (Ref. 18). DNSR has provided assurance of the reactor plant withstand capability to support boat launch (Ref. 19).
- 31 Following Artful launch, pre-critical inactive commissioning is undertaken alongside WDQ, followed by PRT. PRT is the phase of initial critical operations and active

commissioning of the reactor plant and supporting systems. Further DNSR assurance for PRT will be required prior to ONR granting the licence instrument for PRT.

- 32 The safety assessment presented by BAE contains a number of outstanding actions which need to be completed by BAE before initial criticality and PRT can proceed. One such engineering measure is the addition of further fendering to berth the submarine at a greater distance from the WDQ. These are being pursued by BAE and will be inspected by ONR prior to any regulatory decision to allow BAE to commence PRT activities.
- 33 The ONR fault studies assessment has not identified any nuclear safety significant areas that do not have a clear way forward and supports the issue of a licensed instrument for the launch of Artful and berthing alongside the WDQ for pre-critical commissioning activities.

### **System Inspection of the WDQ Structure**

- 34 ONR Inspectors conducted a system based inspection of the WDQ in December 2013 (Ref. 20). The main conclusion from the inspection was that the WDQ maintenance arrangements required to demonstrate compliance with licence condition 28 were significantly below standard. Although it was acknowledged that maintenance and condition surveys had been carried out by BAE, no records of maintenance conducted from 2006 had been recorded on the proprietary maintenance software. A large number of maintenance concessions had been granted for maintenance activities that, in the opinion of the ONR, could have been completed.
- 35 During a subsequent follow up site inspection in March 2014, ONR Inspectors were presented evidence that the planned maintenance schedule associated with Wet Dock Quay had been updated and implemented (Ref. 21). As a result of BAE's own assessments and surveys, additional maintenance routines had been included within the proprietary maintenance software planning system. It was also noted that the concession process had been strengthened.
- 36 ONR concluded that the implementation of the revised WDQ maintenance arrangements are suitable and sufficient to support future activities conducted at the WDQ.

## **4. MATTERS ARISING FROM ONR'S WORK**

- 37 There were a total of five ONR pre-launch recommendations from the civil engineering and fault studies assessments.
- 38 The four civil engineering assessment recommendations have been adequately addressed by BAE.
- 39 The fault studies assessment recommendation seeking nuclear safety assurance from DNSR of reactor plant withstands has been adequately addressed.
- 40 ONR have raised a small number recommendations that will need to be addressed prior to Power Range Testing taking place at WDQ.

## **5. CONCLUSIONS**

- 41 This report presents the findings of ONR's assessment to determine the adequacy of the safety case justifying the activities conducted at the WDQ.

- 42 The civil engineering assessment concluded that the Fitness for Purpose (FFP) document and supporting work presents an adequate engineering case for the resilience of the WDQ structures. ONR are satisfied with the engineering data on withstands presented in the FFP document and that it has undergone suitable independent technical assessment.
- 43 The fault studies assessment concluded that there were no nuclear safety significant areas that did not have a clear way forward and supported the issue of a licence instrument for the launch of Artful and subsequent berthing alongside the WDQ for pre-critical commissioning activities.
- 44 The system inspection of the WDQ identified maintenance arrangement shortfalls which were ultimately resolved and the maintenance arrangements for WDQ are now adequate to support the future activities conducted at the WDQ.
- 45 To conclude, ONR are satisfied with the claims, arguments and evidence provided by BAE to support the continued use of the WDQ and for ONR to accept BAE's request for Agreement under Licence Condition 21(1) to commence Artful Hold Point 6 – Launch.

## **6. RECOMMENDATIONS**

- 46 The Superintending Inspector for the ONR Propulsion Sub-Programme is requested to:
- Accept this Project Assessment Report.
  - If the Project Assessment Report is acceptable, issue Licence Instrument No. 513 under arrangements made under Condition 21(1) of Schedule 2 to attached Nuclear Site Licence No. 42B for agreement to commence Artful Hold Point Phase 6 - Launch.

## 47 REFERENCES

1. Letter from BAE to ONR Requesting Agreement to for BAE to commence Artful Hold Point Phase 6 – Launch, eDMS 1787109, dated 1 May 2014 (TRIM 2014/170892)
2. BAE Document – Astute Class Regulatory Hold Point Control Document - eDMS 1222904 Issue 33 dated 26 November 2013 (TRIM Ref: 2014/169300)
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4. ONR Assessment Note No. 1/2012 dated 2 May 2012 (TRIM Ref: 2012/198007)
5. ONR email to BAE dated 10 April 2013 (TRIM Ref: 2013/317087)
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7. BAE Document – Wet Dock Quay Structure Summary Report, eDMS 1775387 Issue 1, dated February 2014.
8. BAE Document – NFDA/R13-017 – Fitness for Purpose and Maintenance Strategy for the Wet Dock Quay, eDMS 1777929, Issue 8, dated January 2014.
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12. ONR Assessment Report – Fault Studies Assessment for Berthing of Astute Class Submarines Alongside the Wet Dock Quay at the Barrow-in-Furness Licensed Site, ONR-BAE-AR-13-037 Revision 0, dated May 2014 (TRIM Ref 2014/171940)
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17. ONR Document – Fault Studies comments on OSC4.1 and WDQ ESR, dated 25 March 2013 (TRIM Ref. 2013/112330)
18. BAESM – WDQ – ONR Request for DNSR Assurance for Boat 3 Launch at Barrow – Email ONR to DNSR – 2 April 2014. (TRIM Ref. 2014/134769)



19. DNSR Letter to ONR – DNSR Assurance Statement For Boat 3 Launch, Ref. DNSR/04/14/07/05[1541], dated 31 March 2014 (TRIM Ref. 2014/172523)
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23. *Safety Assessment Principles for Nuclear Facilities*. 2006 Edition Revision 1. HSE. January 2008. [www.hse.gov.uk/nuclear/SAP/SAP2006.pdf](http://www.hse.gov.uk/nuclear/SAP/SAP2006.pdf).