Ministry of Defence

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STATEMENT OF WORK

SCHEDULE B TO CONTRACT 700008549

Bluefin 9 Sonar Trial

MHC/02/04/502

11 July 2019

MINE COUNTERMEASURES AND HYDROGRAPHIC CAPABILITY (MHC) PROGRAMME, BLUEFIN 9 TRIAL, STATEMENT OF WORK (SOW)

1. MHC BACKGROUND

Mine countermeasures and Hydrographic Capability (MHC) is a Cat A programme currently in Assessment Phase (AP) of the CADMID cycle. The programme is seeking to replace the Royal Navy's Mine Counter Measures (MCM) and Survey Vessel Hydrographic Oceanographic (SVHO) capabilities and exploit maritime autonomous systems with the aim of delivering this transformational change in an incremental transition programme. At the completion of the Concept Phase, MHC initial gate business case presented a number of programme options and explained that the solution space options would be explored in more detail during AP with some notable caveats including the need to de-risk off-board systems (OBS) within the early assessment work and the exclusion of any ship design work until post a review note in 2019. The solution space options that are being explored within AP can be seen in Figure 1.

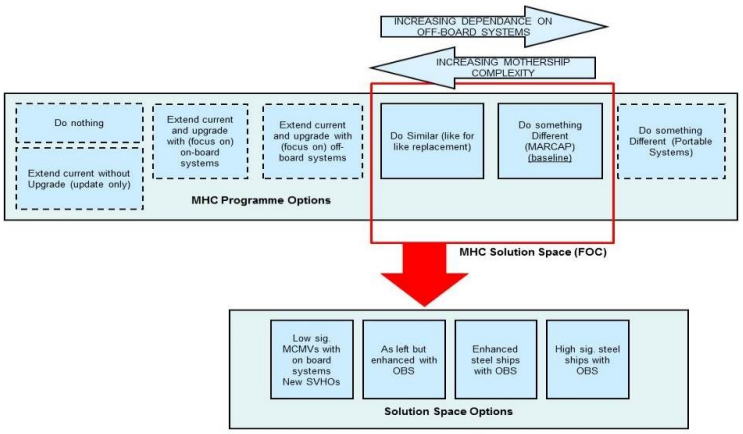

Figure 1 – MHC Solution Space Options

The MHC AP is broken down into two strands, Engineering and Programme Management, both of which have been developed to assist in the development and analysis of the solution space options.

The aim of the engineering strand is to support the MHC programme by exploring, proving or de-risking an area of the MHC programme and using the output to develop and analyse the solution space options.

The engineering strand consists of:

- Technical Studies and Analysis. These shall examine aspects of the solution space options.
- Demonstrators. There are a number of on-going (or planned) demonstrators taking place to explore the use of various technologies or demonstrate/ examine concepts.
- Trials. The trials shall examine the utility, ability and Defence Lines Of Development issues of using various equipment. This is where the work outlined within this SoW shall be used.

This Statement of Work (SoW) outlines the requirements for a trial to be conducted by General Dynamics with BLUEFIN 9 Unmanned Underwater Vehicle on behalf of MHC.

2. INTRODUCTION

This SoW details the Authority's requirements which the Contractor shall undertake to provide a Bluefin 9 underwater unmanned vehicle (UUV) plus necessary supporting equipment with operation by qualified GDMS staff for up to 5 days including management support.
The Contractor shall undertake the work outlined within this document in order to produce the outputs stated within Table 1.

3. AIMS & OBJECTIVES

The aim of the work outlined within this SoW is for the Contractor to conduct a sonar evaluation trial with a Bluefin 9 on behalf of MHC, in accordance with the Trial Order MHC 12/19 (Annex A).

4. DELIVERABLES

The Contractor shall produce the deliverables outlined in Table 1 to the specification outlined within this document and delivered to the locations and dates outlined below.

Serial	Description	Quantity	Date	Output	Reference
1	Conduct of Trial MHC 12/19 as per Trial Order (Annex A)	1		Trial Conduct	Annex A
2	Deliverables	1		Soft Copy	Paragraph 6
PPM1	Progress Meetings	2		Telecom / Meeting	Paragraph 7

Table 1 – Deliverables

Serial 1 shall be delivered to trials locations as per Annex A

Serial 2 shall be delivered to the following address:

[redacted]
Birch 2b, #3229
MOD Abbey Wood South
Bristol
BS34 8JH

Email [redacted]

Tel: [redacted]

Serial PPM1 shall be delivered in accordance with Paragraph 7.

5. STANDARDS

All work undertaken by the Contractor shall be in accordance with the standards, policies and publications specified in this SoW and the Contract.

6. WRITTEN DOCUMENTATION, FINAL OUTPUT REVIEW AND DELIVERY

The Contractor shall conduct a sonar evaluation trial with a Bluefin 9 on behalf of MHC, in accordance with the Trial Order MHC 12/19 (Annex A).
To this aim, the contractor shall provide a Bluefin 9 underwater unmanned vehicle (UUV) plus necessary supporting equipment with operation by qualified GDMS staff for up to 5 days including management support.

The 5 trials days dates will be selected based on weather and may not be consecutive.

The dates for the conduct of this trial shall be agreed at the kick off meeting. All efforts shall be made by all parties so that the trial is conducted in either October or November 2019.

If Trial MHC 12/19 is completed in less than 5 working days, the Authority reserves the right to task General Dynamics with the conduct of further runs to trial the Navigational Accuracy of the Bluefin 9. Guidance for the conduct of this trial shall be provided by the Authority.

The final version of all outputs shall be provided in soft copy to the Authority.

The Contractor shall ensure that the report is validated within his organisation prior to delivery in final form.

All documents should be saved with names that follow the file naming convention, Date–Title–Marking.

The deliverables shall include:

a. Provide “mug shots” for each view of every target seen during each mission in a standard graphics format (e.g. PNG).
b. Determine subjective image quality versus current magnitude and direction for each view of every target:
    i. Subjective image quality: rate each view of the target on a scale from 1 (poor) to 5 (good)
c. Provide plots of vehicle yaw, pitch, and roll for each mission.
d. Provide values of standard deviation for vehicle yaw, pitch, and roll for each mission.
e. Provide missions sonar raw data
f. Provide contact positions for each look of every target.

7. PROJECT MANAGEMENT / PROGRESS REPORTING

7.1 Kick-off meeting

A kick-off meeting shall be held, at either an MoD location or Contractors location in the UK, within the first two weeks of contract award. Telecon for overseas personnel is acceptable.

7.2 Test Exit Meeting

A test exist meeting shall be held, at either an MoD location or Contractors location in the UK, upon the completion of the trial.

7.3 Stakeholder and Communications Management

The Contractor shall work jointly with the Authority to ensure that relevant Stakeholders are identified and engaged at the appropriate level, and that communications across the project delivery team and Stakeholders is carried out effectively and in the most appropriate manner.

All formal communication between the Contractor and the military or cooperating project authorities shall be in agreement with the Authority.

7.4 Assumptions, Dependencies, Limitations and Exclusions

Any assumptions, dependencies, limitations and exclusions shall be highlighted in the contractor’s proposal, including those that require MoD involvement.

7.5 Government Furnished Assets (GFX)

GFX shall be limited to reasonable access to MASTT and MoD expertise on a reasonable endeavours basis. It is anticipated that the following GFX shall be required:

a. Workboat (11 m RHIB) with coxswain to transit to the trials area, launch and recover the BluefinTM-9 UUV and monitor the demonstration from.

It shall not be assumed by the Contractor that any further GFX will be available, although reasonable requests for GFX will be considered.

7.6 Issues

All issues identified during the progress of this project or issues surrounding the delivery against proposed deadlines should be raised to:

Point of Contact (PoC):

[redacted]

Any changes to the scope of work or delivery timelines shall need to be formally raised and agreed with the PoC

Mine Countermeasures and Hydrographic Capability (MHC) Project

MHC TRIAL ORDER

MHC 12/19

Bluefin 9 - Effect of Currents on Sonar Image Quality and Vehicle Stability

ISSUE 1		
PREPARED BY	CHECKED BY	APPROVED BY
Name: Date:	Name: Date:	Name: Date:

ISSUE 2		
PREPARED BY	CHECKED BY	APPROVED BY
Name: Date:	Name: Date:	Name: Date:
Changes:		

ISSUE 3		
PREPARED BY	CHECKED BY	APPROVED BY
Name: Date:	Name: Date:	Name: Date:
Changes:		

A. Introduction

2. Previous trials using Autonomous Unmanned Vehicles (AUVs) operated by MASTT have shown that the quality of side-scan sonar imagery collected by these vehicles degrades as water currents increase due to vehicle motion. The single port and starboard beams of a conventional side-scan sonar move with the vehicle; if the amplitude of the vehicle yaw significantly exceeds the sonar beamwidth, holidays in coverage and distortions in the sonar imagery will occur. The SOLSTICE side-scan sonar has multiple port and starboard beams and corrects for vehicle motion when producing the sonar imagery; it should, therefore, allow side-scan sonar data to be collected in high currents without a degradation in image quality.

B. Aim and Objectives

3. The principal aim of the trial is to show to what extent the SOLSTICE sonar is able to mitigate the effects of vehicle motion and to produce high quality sonar imagery even in high currents. A secondary aim is to compare the vehicle motion of the BLUEFIN 9 vehicle as a function of water current with that of vehicles operated by MASTT. A tertiary aim is to assess the contact position accuracy of the BLUEFIN 9 vehicle and SOLSTICE sonar.

4. The main objective is to collect data from the SOLSTICE side-scan sonar in a variety of water currents in order to assess image quality. A secondary objective is to collect data on the motion of the BLUEFIN 9 vehicle in a variety of water currents to compare its stability with vehicles currently operated by MASTT. A tertiary objective is to assess the contact position accuracy of the BLUEFIN 9 vehicle and SOLSTICE sonar by marking the positions of each target in the survey area.

C. Assets

5. This trial should be conducted with a Bluefin 9 AUV manufactured by General Dynamics, mounting a solstice Sonar.

6. If possible, an IVER and/or Remus 100 shall be also used, by the MASTT team.

7. Pre-laid targets in the area will be used.

D. Participants/Stakeholders

8. The following Stakeholders/Participants are identified:

   a. MHC. The Mine Countermeasures and Hydrographic Capability (MHC) Project Team provide sponsorship of this trial and are the tasking authority for MASTT;

   b. MASTT. The Maritime Autonomous Systems Trials Team are a Royal Navy team located in Portsmouth Naval Base and under the administrative authority of Portsmouth Flotilla;

   c. Navy Command HQ Maritime Capability (MARCAP). MARCAP provide operational requirements and context to MHC and MASTT;

   d. Dstl Platform Systems Division. Dstl have a tasking agreement with MHC to provide scientific and technical advice and will undertake more in-depth analysis;

   e. General Dynamics will provide BluefinTM 9 underwater unmanned vehicle (UUV) plus necessary supporting equipment with operation by qualified GDMS staff

E. Location

9. Area x5050, as shown in Figure 1, is an RN trials location located just off the Isle of Wight. Both have suitable mine-like targets to assess the capability of the sonars trialled under this trial. Details of this trials site are detailed below:

	x5050
Water Depth (m)	13 – 16 A 22 m patch
Bottom Type	Fine sand, broken shingle, gravel
Transit time from Portsmouth Naval Base (min)	50
Targets	Mk1 and Mk16
Further Requirements	Boat for deployment, recovery, power supply and operation

F. Prerequisites

10. Water space and area bookings are to be made in good time and are the responsibility of OiC MASTT

11. Liaison with local harbour and other authorities should be made where appropriate by OiC MASTT

12. Pre-deployment site inspections should be made by MASTT if deemed appropriate.

G. Trial Conditions and Limits

13. It is desirable to repeat the trial in a variety of conditions of sea state and current magnitude. It may only be possible to understand a subset of these parameters in any particular trial. Sea bed gradient may need different locations to be visited in separate trials.

H. Timing

14. The trial shall be conducted in ZULU time throughout as this aligns with the time recording within the UUVs and supporting software.

15. See Annex 2 Trial Programme

I. Responsibilities

16. The MHC TL is responsible for:

    a. Ensuring that the trial is safe to conduct;

    b. Authorisation of this Trials Order;

    c. Gaining assurance that the trial is conducted within the conditions and limits of the Trials Order;

    d. Authorising any changes to the Trial Order.

17. MHC Trials Manager is responsible for:

    a. Specific preparations as identified by this Trial Order;

    b. Determination of priorities for the trial to inform MASTT OiC on the most cost effective use of the MASTT assets within the available time and under the conditions prevailing at the time of the trial;

c. Providing support and advice to the Trials Officer (OiC MASTT);

d. Liaison with Dstl.

e. Liaison with General Dynamics for the provision of a suitable Solstice-Mounted UUV and Operators.

18. Trials Officer. OiC MASTT is the Trials Officer and is responsible for:

a. The safe employment of the MASTT team,

b. Safe operation of MASTT assets in accordance with safety cases and MASTT Standard Operating Procedures;

c. Minimising risk to third parties and to the environment;

d. The conduct and recording of formal risk assessments for operating activities not previously assessed or covered by SOPs;

e. Acting on behalf of the Trials Manager in order to meet the aims of this Trials Order;

f. Specific preparations for this trial, including being responsible for identifying the location of the trials; booking appropriate water space; laying and recovering of targets if required; appropriate liaison with harbour and/or authorities; pre-deployment site inspections where appropriate; provision of maintained UUVs and any supporting resources (including equipment and personnel) required to conduct the trial safely and effectively;

g. Communicating with the MHC Trials Manager/Trial Sponsor to ensure that any changes made during the trial period for whatever reason satisfy the priorities as laid down by the Trials Sponsor;

h. Reporting to the MHC Trials Manager any concerns or suggestions for improvement in order to minimise risk and ensure successful achievement of future trials;

i. Delegating appropriate authority to other members of the MASTT team;

j. Providing advice to the Master of the host trials vessel (when not RMNB HAZARD) to facilitate the safe conduct of the vessel with respect to the satisfaction of the trial's objectives.

J. Communications

19. Telephone numbers for trial stakeholders include:

a. [redacted].

c. [redacted].

e. [redacted]

f. [redacted]

g. [redacted]

h. xxxxxxxx (General Dynamics) xxxxxxxxxxxxx

K. Safety & Environment

20. OiC MASTT will retain overall safety for personnel and equipment during the trial.

21. All equipment is to be operated within the limits laid down in the respective BRs, equipment safety cases and MASTT SOPs.

L. Trials Procedure

22. Carry out a survey using a ladder search pattern to cover the targets at a number of different angles (e.g. 0, 30, 60, 90, 120, 150 degrees) to the current and over a range of currents from zero to maximum current strength. It will not be possible to collect data for all possible combinations of current and angle, but a full range of current values should be obtained if possible for 0 degrees (relative to the current direction), since this will be the angle normally used operationally when operating in high currents. Surveys should be planned to allow legs that are long enough for the vehicle to stabilise after turning. It may be possible for a vehicle to experience different angles of current sequentially in a single planned mission within vehicle endurance. 50 m (or greater) sonar range setting to be used.

23. Repeat this process for each vehicle. Mission runs will depend on current tidal streams and sea state so not all missions will be possible and may have to be adjusted for vehicle endurance.

24. Identified mission variations:

    a. **Mission 1 – Low current magnitude; 0, 30, 60 degrees wrt. current**
    b. **Mission 2 – Low current magnitude; 90, 120, 150 degrees wrt. current**
    c. **Mission 3 – Moderate current magnitude; 0, 30, 60 degrees wrt. current**
    d. **Mission 4 – Moderate current magnitude; 90, 120, 150 degrees wrt. current**
    e. **Mission 5 – High current magnitude; 0, 30, 60 degrees wrt. current**
    f. **Mission 6 – High current magnitude; 90, 120, 150 degrees wrt. current**

25. The track spacing should alternate between 0.5 x range scale and 1.5 x range scale to obtain full coverage of the seabed.

M. Records

26. Standard records

i. OPDEFS
ii. ACOMMS failures
iii. Location
iv. Operating boxes
v. Target lay positions and target types
vi. Equipment used (vehicle IDs etc)
vii. Vehicle settings
viii. Operating altitude/depth
ix. Speed
x. Sonar range scale
xi. Vehicle configuration including additional sensors fitted (e.g. camera)
xii. Trials log including times for: mission planning; transit; vehicle preparation; deployment; on-mission; recovery; transit; data transfer; PMA; battery charging
xiii. Environmental information including: wind speed; sea state; current (speed and direction); other (e.g. turbidity, bottom type, etc)
xiv. Vehicle status following mission (energy used/remaining, faults, damage, etc)
xv. Results
xvi. Evidence gathered against questions in the question set
xvii. Lessons Identified
xviii. Observations

xix. File locations and names (mission, logs, data)
xx. Results from post mission analysis

27. **Records specific to the trial**

For current surveys:

i. Mission ID
ii. Filename
iii. Current Magnitude (estimate)
iv. Direction w.r.t Current (estimate)

N. Analysis

28. **General Dynamics analysis**

a. Provide “mug shots” for each view of every target seen during each mission in a standard graphics format (e.g. PNG).
b. Determine subjective image quality and objective image resolution versus current magnitude and direction for each view of every target:
    i. Subjective image quality: rate each view of every target on a scale from 1 (poor) to 5 (good)
c. Provide plots of vehicle yaw, pitch, and roll for each mission.
d. Provide values of standard deviation for vehicle yaw, pitch, and roll for each mission.
e. Provide contact positions for each view of every target.

29. **DSTL analysis**

a. Dstl to Investigate image quality for different currents. Utilise the results of this and estimates of image quality to produce polar plots giving image quality versus current speed and direction. Carry out a similar analysis to show the effect of currents on vehicle motion (pitch, roll, and yaw). Show the correlation between vehicle motion and image quality.
b. Dstl to assess the navigation accuracy of the BLUEFIN 9 vehicle.

O. Security

30. The classification of the sea trial, its aims and objectives, conduct and post mission analysis is Official Sensitive; results of trials may have additional sensitivities that must be appropriately protected (e.g. if there are ITAR issues).

31. The results of the subsequent scientific analysis shall be classified appropriately at the time of analysis, depending on the assessment, findings, conclusions and recommendations.

PLANNED AREA

Programme

A detailed programme for the trial is shown below after a summary of the trials to be conducted

Summary of Trials

Location	Activity	Comment
Box X	Mission 1a – Survey Box X with Bluefin 9	Low Current; 0, 30, 60 degrees wrt current
Box X	Mission 1b – Survey Box X with R100/IVER	Low Current; 0, 30, 60 degrees wrt current
Box X	Mission 2a – Survey Box X with Bluefin 9	Low Current; 90, 120, 150 degrees wrt current
Box X	Mission 2b – Survey Box X with R100/IVER	Low Current; 90, 120, 150 degrees wrt current
Box X	Mission 3a – Survey Box X with Bluefin 9	Moderate Current; 0, 30, 60 degrees wrt current
Box X	Mission 3b – Survey Box X with R100/IVER	Moderate Current; 0, 30, 60 degrees wrt current
Box X	Mission 4a – Survey Box X with Bluefin 9	Moderate Current; 90, 120, 150 degrees wrt current
Box X	Mission 4b – Survey Box X with R100/IVER	Moderate Current; 90, 120, 150 degrees wrt current
Box X	Mission 4a – Survey Box X with Bluefin 9	High Current; 0, 30, 60 degrees wrt current
Box X	Mission 5b – Survey Box X with R100/IVER	High Current; 0, 30, 60 degrees wrt current
Box X	Mission 6a – Survey Box X with Bluefin 9	High Current; 90, 120, 150 degrees wrt current
Box X	Mission 6b – Survey Box X with R100/IVER	High Current; 90, 120, 150 degrees wrt current