

MINE COUNTERMEASURES AND HYDROGRAPHIC CAPABILITY (MHC)
LOA OTH SOW V6 IN MARITIME AUTONOMOUS SYSTEMS (MAS) AND OPERATING OVER
THE HORIZON (OTH), STATEMENT OF WORK

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1. MHC BACKGROUND

Mine countermeasures and Hydrographic Capability (MHC) is seeking to replace the Royal Navy's Mine Counter Measures (MCM) and Hydrographic (H) capability with Off-Board Systems (OBS), exploiting Maritime Autonomous Systems (MAS) with the aim of delivering this transformational change in an incremental transition programme. A number of solution space options are being explored within the Assessment Phase (AP) that need to be investigated in more detail and de-risked, specifically those in relation to using OBS. Due to the pioneering nature of the project new standards, legislations and laws will also have to be considered.

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 engineering strand consists of:

- Technical Studies and Analysis. Examining aspects of the solution space options. The work covered under this Statement of Work (SoW) shall form part of this.
- Demonstrators. There are a number of on-going (or planned) demonstrators taking place to explore the use of various technologies.
- Trials. Conducted through the Navy Maritime Autonomous Systems Trials Team (MASTT), the trials shall examine the utility, ability and DLOD issues of using various equipment.

2. INTRODUCTION

This SoW details the Authority's requirements which the Contractor shall undertake to provide technical studies input to Autonomy and operating Over the Horizon (OTH). The Contractor shall undertake the work outlined within this document in order to produce the outputs stated in Table 1, and potentially Table 2 if the Authority decides to take up the Optional Deliverables.

3. AIMS & OBJECTIVES

The aim of the work outlined within this SoW is for the Contractor to provide technical advice into Autonomy and operating OTH. The MHC wish to fully comprehend all aspects of Autonomy that may be used in MCM and H Functions. Autonomy levels will specify the level of freedom from external control a system or function has, and shall be aligned with autonomous functions to aide categorisation. OTH will extend the range that the OBS will be able to operate and fully exploit MAS capability.

This SoW will aim to answers questions; 016, 018, 022, 084, 085, 118, 353, 368, 410 474 and 475 from the MHC question set (see Annex K).

4. DELIVERABLES

The Contractor shall produce the deliverables outlined in Table 1 (and Table 2 if the Authority decides to take up the Optional Deliverables) to the specification outlined within this document and delivered to the locations and dates outlined below. Note Table 2 is Optional Deliverables and the Authority shall decide if they are to be undertaken once the Core Deliverables have been delivered.




Table 1 – Core Deliverables

Serial	Description	Quantity	Date	Output	Reference
A	Autonomous MCM and H Functions	1	04/06/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Annex A Paragraph 3
B	Benefits of Autonomy	1	04/06/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Annex B Paragraph 3
C	Levels of Autonomy Definition	1	13/08/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Annex C Paragraph 3
D	Autonomous MCM and H Functions Alignment with UK LoA	1	13/08/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Annex D Paragraph 3

Table 2 – Optional Deliverables

Serial	Description	Quantity	Date	Output	Reference
E	Autonomous MCM and H Functions Alignment with Technology Readiness Levels	1	10/09/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Annex E Paragraph 3
F	Legal Constraints on Autonomy	1	21/01/2019	Report in Microsoft Word Format, pdf & Printed Hard Copy	Annex F Paragraph 3
G	Legal aspect of operating Unmanned Vessel operation	1	21/01/2019	Report in Microsoft Word Format, pdf & Printed Hard Copy	Annex G Paragraph 3
H	Divers Operation Over The Horizon	1	05/11/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Annex H Paragraph 3
I	Operating UxVs Over the Horizon	1	05/11/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Annex I Paragraph 3
J	Standoff Distance	1	03/12/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Annex J Paragraph 3

Serials shall be delivered to the following address:




 MOD Abbey Wood South
 Bristol
 BS34 8JH

Email: 

Tel: 

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. FINAL OUTPUT REVIEW AND DELIVERY

6.1. DRAFT DELIVERABLE REVIEW

Although not specifically stated in the deliverables, it is assumed that the inclusion of comments from one review of the draft documentation is included within all work packages. The Contractor shall provide a draft report, in soft and hard copy, for review by the Authority. The Authority shall review the draft document and provide comments back no later than ten (10) working days after receiving the document. The Contractor shall then amend the draft documentation at no further cost to the Authority.

6.2. FINAL DELIVERABLE DELIVERY

The final version of all outputs shall be provided in soft and hard copy to the Authority. The output shall be accompanied by a presentation outlining the deliverable, at either MoD Abbey Wood or the Contractor's premises, to the MHC Project Team and where appropriate other stakeholders.

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

All documents should contain a MHC file reference number, which can be provided at the time of drafting.

All documents should be saved with names that follow the file naming convention as follows: Date (YYMMDD)_Title_Marking.

Example: 20181123_ Autonomy Study in MAS and OTH_OS

7. PROJECT MANAGEMENT / PROGRESS REPORTING

A kick-off meeting shall be held within the first two (2) weeks of contract award.

A monthly progress report shall be submitted summarising progress of the MHC Project Support tasks against the deliverables and their planned delivery dates. This shall be submitted via email, with a complementary meeting or teleconference between the Authority and Contractor if requested by the Authority.

Agenda, minutes and progress reports shall be delivered via email in word format to:

[REDACTED]
[REDACTED]
[REDACTED]
MOD Abbey Wood South
Bristol
BS34 8JH

Email: [REDACTED]

[REDACTED]

Location of meetings shall be decided between parties at least five (5) working days before the meeting is due to take place. Where telephone or video conferencing is to take place, the appropriate number to use shall be distributed to the above contact at least three (3) working days before the meeting.

**ANNEX A TO
MINE COUNTERMEASURES AND
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STATEMENT OF WORK
DATED 09/05/2018**

CORE DELIVERABLE - AUTONOMOUS MCM AND H FUNCTIONS

1. INTRODUCTION

MHC will deliver a range of equipment to deliver the expected capability for MCM and H, many of these are hoped to be accomplished via MAS. Various MCM and H scenarios have been analysed through the MHC team, if the functions performed by OBS in scenarios are achieved autonomously or via remote operation has not yet been recognised. With Autonomous technology continually developing, the applications for MCM and H will have simultaneously developed. The contractor is tasked to list all MCM and H functions that an OBS could do in operation and highlight with which could be done autonomously. The amount of autonomy in the OBS whilst conducting MMCM and H operations will have great implications to the MHC Team so to have an awareness of all the developments is vital to the progression of the programme.

2. DELIVERABLES

The Contractor shall produce the deliverables to the specification, locations and dates outlined previously in this SoW and in Table A.

Table A – Deliverables

Serial	Description	Quantity	Date	Output	Reference
A	Autonomous MCM and H Functions	1	04/06/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Paragraph 3

3. AUTONOMOUS MCM AND H FUNCTIONS

In order to fully comprehend MAS, the MHC programme wish to know what MCM and H mission functions are be carried out (i.e. detect, classify, identify, dispose, neutralise) and of these, which could be carried out autonomously and what are the implications.

Questions that should be considered, but not limited to, include:

- What MCM and H mission functions are be carried out by OBS?
- What functions would benefit from being completed autonomously?
- What effect will this have on time taken to perform the function?
- What are the safety implications of each function being done autonomously?
- What are the HFI influences of each function can be achieved autonomously?
- Are there any environmental influences that will determine if a function can be achieved autonomously?

**ANNEX B TO
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CORE DELIVERABLE - BENEFITS OF AUTONOMY

1. INTRODUCTION

It is known that autonomous technology can adapt to changing patterns and preferences, remain vigilant at all times, increase the situational awareness of human operators and react quickly to avoid critical situations such as a collision. The MHC Team need to know the benefits of the usage of MAS in MCM and H operations. The usage of autonomy in OBS will have a greatly impact the progression of the MHC programme and it will influence what technologies are evaluated.

2. DELIVERABLES

The Contractor shall produce the deliverables to the specification, locations and dates outlined previously in this SoW and in Table B.

Table B – Deliverables

Serial	Description	Quantity	Date	Output	Reference
B	Benefits of Autonomy	1	04/06/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Paragraph 3

3. BENEFITS OF AUTONOMY

In order to fully comprehend MAS, the MHC programme wish to understand the Benefits of Autonomy. The contractor is asked to specifically outline the benefit of using autonomy for each function used in a MCM or H mission. This is a continuation of the study in Annex A.

Questions that should be considered, but not limited to, include:

- What are the cost benefits?
- What are the safety benefits?
- What are the time benefits?
- What are other opportunities?
- How does this compare to a non-autonomous approach?
- How much human interaction is necessary in each function?
- What functions are currently only operated manually that could be done autonomously?

CORE DELIVERABLE - LEVELS OF AUTONOMY DEFINITION

1. INTRODUCTION

Autonomy is referenced in various documentations across numerous project and domains each with a unique interpretation of the definition. Validity is needed when the subject is discussed to ensure clarity in communication and an increase level of understanding. The MHC Team wish to define generic UK Levels of Autonomy (LoA) so that all subsequent technical documentation will have a reference and a standard to adhere to. This common lexicon and structure would help better communications about autonomy, particularly as there is a vacuum at the moment at the doctrine and concepts level relating to taxonomy.

2. DELIVERABLES

The Contractor shall produce the deliverables to the specification, locations and dates outlined previously in this SoW and in Table C.

Table C – Deliverables

Serial	Description	Quantity	Date	Output	Reference
C	Levels of Autonomy Definition	1	13/08/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Paragraph 3

3. LEVELS OF AUTONOMY DEFINITION

In order to fully comprehend autonomy and what it means for MHC, the MHC programme wish to categorise autonomous functions into defined, generic LoA. These autonomy levels will specify the level of freedom from external control a function has. Recognising that there are previous definitions, the contractor should consider these to create affinity but ultimately produce unique, precise, hierarchical levels.

Questions that should be considered, but not limited to, include:

- How/what much human interaction is necessary?
- What is the response time of the system or function?
- How long can a system or function be in isolation?
- Is the system or function reactive or proactive?
- Does the system or function react to environment?
- Is system or function able to learn/adapt?

**ANNEX D TO
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**CORE DELIVERABLE - AUTONOMOUS MCM AND H FUNCTIONS ALIGNMENT WITH UK
LEVELS OF AUTONOMY**

1. INTRODUCTION

It is imperative that the MHC Team knows the LoA of current, required and desired autonomous MCM and H mission functions. The usage and LoA in OBS will greatly impact the MHC programme, it will influence what technologies are evaluated and may impact fundamental designs of the project. This study is a continuation of the studies in Annex A and C.

2. DELIVERABLES

The Contractor shall produce the deliverables to the specification, locations and dates outlined previously in this SoW and in Table D.

Table D – Deliverables

Serial	Description	Quantity	Date	Output	Reference
D	Autonomous MCM and H Functions Alignment with UK LoA	1	13/08/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Paragraph 3

3. MCM AND H FUNCTIONS ALIGNMENT WITH UK LEVELS OF AUTONOMY

In order to fully comprehend autonomous functions may be used in OBS, the MHC programme wish to align current, required and desired autonomous MCM and H mission functions with the defined UK LoA. A detailed explanation as to why each function has been aligned to the LoA associated will be imperative. The Contractor may consider, is but not restricted to creating a matrix layout to show this with a complementing report.

Questions that should be considered, but not limited to, include:

- What developments have been made in autonomy?
- Does a function already exist to a level of autonomy?
- What is the nature of the function?
- How much human interaction is necessary in the function?
- How complex is the function or task?
- Could complexity of a function be reduced via autonomy?
- How does safety and risk factor?
- How sensitive is the nature of the function, could autonomy be trusted?

**ANNEX E TO
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**OPTIONAL DELIVERABLE - AUTONOMOUS MCM AND H FUNCTION ALIGNMENT WITH
TECHNOLOGY READINESS LEVELS**

1. INTRODUCTION

Autonomy is ever developing technology with many aspects at varying stages. To have autonomous MCM and H functions aligned with Technology Readiness Levels (TRL) will produce an understanding as to where the technology is currently and where the technology is potentially going. The autonomous MCM and H function alignment with TRL will impact the MHC programme, it will influence what technologies are recognised and could influence fundamental decisions for the project. This study is a continuation of the study in Annex A.

2. DELIVERABLES

The Contractor shall produce the deliverables to the specification, locations and dates outlined previously in this SoW and in Table E.

Table E – Deliverables

Serial	Description	Quantity	Date	Output	Reference
E	Autonomous MCM and H Function Alignment with Technology Readiness Levels	1	10/09/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Paragraph 3

3. AUTONOMOUS MCM AND H FUNCTIONS ALIGNMENT WITH TECHNOLOGY READINESS LEVELS

In order to fully comprehend MAS, the MHC programme wish to align required and desired MCM and H mission functions with TRL. A detailed explanation as to why each Function has been aligned to the TRL associated will be needed. The Contractor is expected to use TRL developed by the Technical Management Office sent by the MHC PM. The Contractor may consider, is but not restricted to creating a matrix layout to show this with a complementing report.

Questions that should be considered, but not limited to, include:

- What is in development?
- What is currently in use?
- Is there a constraint on the function from increasing in TRL, if so what?
- Is there any external technologies that will influence the autonomous technology in the next ten years?

**ANNEX F TO
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OPTIONAL DELIVERABLE - LEGAL CONSTRAINTS ON AUTONOMY

1. INTRODUCTION

Autonomous OBS may reduce the risk to military personnel, keeping human out of harm's way, reduce human workloads and may accomplish the mission more effectively than a manned systems but the Legality of the use of these systems needs to be clarified if it is to be a viable solution for the MHC programme.

2. DELIVERABLES

The Contractor shall produce the deliverables to the specification, locations and dates outlined previously in this SoW and in Table F.

Table F – Deliverables

Serial	Description	Quantity	Date	Output	Reference
F	Legal Constraints on Autonomy	1	21/01/2019	Report in Microsoft Word Format, pdf & Printed Hard Copy	Paragraph 3

3. LEGAL CONSTRAINTS ON AUTONOMY

In order to fully comprehend the constraints on autonomy of MAS, the MHC programme wish to identify what are the legal constraints on the use of Autonomous OBS in the MHC programme. This should focus on the autonomous functions highlighted in Annex A.

Questions that should be considered, but not limited to, include:

- How are Autonomous functions affected by maritime law?
- Are there any existing MAS laws?
- Are there any MAS laws being developed?
- Do these laws apply to the UK only or are they international?
- Some OBS may be carrying explosives, will this categorise them as being weaponised and change what they can do autonomously?

**ANNEX G TO
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OPTIONAL DELIVERABLE - LEGAL ASPECT OF UNMANNED VESSEL OPERATION

1. INTRODUCTION

Taking the man out of the mine field is a process that is already begun but it is necessary to fully understand the legal processes associated in doing so. To have a total comprehensive knowledge of this will shape how unmanned vessel operation is carried out, give firm support to OBS operations and could potentially develop the market.

2. DELIVERABLES

The Contractor shall produce the deliverables to the specification, locations and dates outlined previously in this SoW and in Table G.

Table G – Deliverables

Serial	Description	Quantity	Date	Output	Reference
G	Legal aspect of Unmanned Vessel operation	1	21/01/2019	Report in Microsoft Word Format, pdf & Printed Hard Copy	Paragraph 3

3. LEGAL ASPECT OF UNMANNED VESSEL OPERATION

In order to fully comprehend the Legal aspect of unmanned vessel operation, the MHC programme wish to understand how operation of the mission packages would be allowed. This would require a deep knowledge the Rules of Engagement (ROE) and a legal review of the mission packages to be conducted.

Questions that should be considered, but not limited to, include:

- Are UxVs considered weapons or will they be flagged as war ships or something else?
- What are the legal consequences of them entering restricted waters?
- What are the ROE for unmanned systems, both in prosecuting the mission (i.e. in detonating explosives) and also when threatened by hostile forces?
- Will the OBS presence have to be known to others prior to its use?
- Which mission functions must be manned, from a legal, safety and ROE perspective?
- What are the liabilities on the command when autonomous functions are being used?

**ANNEX H TO
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OPTIONAL DELIVERABLE - DIVERS OPERATING OVER THE HORIZON

1. INTRODUCTION

MHC will deliver a range of equipment to deliver the expected capability. During assessment phase, the MHC project will be undertaking an evaluation of possible support strategies in order to inform the development of the capability. In order to provide an understanding of the support required, it is necessary to look at the support provided to existing Maritime procedures. The Benefits of the developments and usage of over the horizon Divers will have a great impact on the progression of the MHC programme. Divers have been and will remain a key aspect of MCM, as when an operation cannot be performed by an OBS or is failure in an OBS system a diver may be have to be used.

2. DELIVERABLES

The Contractor shall produce the deliverables to the specification, locations and dates outlined previously in this SoW and in Table H.

Table H – Deliverables

Serial	Description	Quantity	Date	Output	Reference
H	Divers Operating Over The Horizon	1	05/11/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Paragraph 3

3. DIVERS OPERATING OVER THE HORIZON

In order to fully comprehend operating Over the Horizon (OTH) and what it means for MHC, the MHC programme wish to inquire the need for Divers to operate over the horizon. It should address if divers are allowed to operate OTH away from the host platform and what is the maximum allowable distance from host platform/jetty if not OTH. Q118

Questions that should be considered, but not limited to, include:

- Are divers allowed to operate OTH away from the host platform/jetty?
- What is the maximum allowable distance from host platform/jetty if not OTH?
- What are the Requirements for divers operating OTH?
- What are the methods for divers to reach the MTA and return to host platform/jetty?
- What communications requirements are there for divers to operate OTH?

**ANNEX I TO
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OPTIONAL DELIVERABLE - OPERATING UXVS OVER THE HORIZON

1. INTRODUCTION

MHC will deliver a range of equipment to deliver the expected capability. Operating unmanned vessels over the horizon could prove to be imperative to the future of MHC, expanding the capability exponentially. To do this there must be robust knowledge of vessel behaviours, reliable sources of communications, dependable situational awareness and to be operated safely. All of this will form the basis that may lead to the operation of multiple OBS OTH.

2. DELIVERABLES

The Contractor shall produce the deliverables to the specification, locations and dates outlined previously in this SoW and in Table I.

Table I – Deliverables

Serial	Description	Quantity	Date	Output	Reference
I	Operating UxVs Over the Horizon	1	05/11/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Paragraph 3

3. OPERATING UXVS OVER THE HORIZON

In order to fully comprehend operating UxVs Over the Horizon (OTH) and what it means for MHC, the MHC programme wish to investigate how to manage single and multiple UxVs OTH from a Mothership. Including the variety methods that OBS can be operated from a Mothership or other control centre and what would be necessary to allow this.

Questions that should be considered, but not limited to, include:

- How can multiple unmanned systems be managed over the horizon?
- What autonomy will be needed to successfully compete workload OTH?
- What are the known limitations of working OTH?
- How will communications be made between a Mothership or control centre and an UxV?
- How will an OBS reach a mission area OTH and return or are there other options?

**ANNEX J TO
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OPTIONAL DELIVERABLE - STANDOFF DISTANCE

1. INTRODUCTION

The safety of a Mothership and the crew is vital to any mission, this has lead the MHC Team to consider the use of OBS, to take the man out of the minefield. A study is needed to know the minimum and recommended safe distance or standoff distance that a mothership should be from a mine treat area and how it will affect the operations.

2. DELIVERABLES

The Contractor shall produce the deliverables to the specification, locations and dates outlined previously in this SoW and in Table J.

Table J – Deliverables

Serial	Description	Quantity	Date	Output	Reference
J	Standoff Distance	1	03/12/2018	Report in Microsoft Word Format, pdf & Printed Hard Copy	Paragraph 3

3. STANDOFF DISTANCE

In order to fully comprehend operating OBS from a Mothership and what it means for MHC, the MHC programme wish to investigate the standoff distance for Mothership from Mine Treat Area (MTA).

Questions that should be considered, but not limited to, include:

- What is current RN doctrine and Standard Operating Procedures concerning stand-off distances for various RN, RFA and chartered civilian vessels?
- What is current RN doctrine and Standard Operating Procedures concerning stand-off distances for ID/disposal parent vehicle against various mine threats?
- What is the safe stand-off range for the host platform?
- What is the safe stand-off distance from the host of the ID/disposal vehicle?

**ANNEX K TO
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APPLICABLE QUESTION SET QUESTIONS

Table 2 – Question Set

Question	Title	Main Text
Q016	Autonomous MCM & H activities	What MCM and H mission activities need to be carried out autonomously (i.e. detect, classify, identify, dispose, neutralise) and of these, which could be carried out autonomously?
Q018	Human-in-the-loop, including Legality, Safety & ROE	Which mission activities must have human control, from a legal, safety and Rules of Engagement (RoE) perspective? (E.g. when detonating explosives, when threatened by hostile forces, etc.) What are the liabilities on the Command when autonomous functions are being used?
Q022	Tech, Legal constraints on UXV Autonomy	What are the current technology constraints on UxV autonomy?
Q084	Legality from a weapons perspective	Is the system legal from a weapons perspective?
Q085	Legality w.r.t. maritime navigation rules	Can the system be operated legally with respect to maritime navigational rules?
Q118	Divers operating over the horizon	Are divers allowed to operate OTH away from the host platform/jetty? What is the maximum allowable distance from host platform/jetty if not OTH? What are the Requirements for divers operating OTH? What are the methods for divers to reach the MTA and return to host platform/jetty?
Q353	UxV rules of engagement	What are the rules of engagement for unmanned systems, both in prosecuting the mission (i.e. in detonating explosives) and also when threatened by hostile forces.
Q368	Over the horizon management of multiple unmanned systems	How can multiple unmanned systems be managed over the horizon?

Q410	Safe stand-off ranges	<p>What is the safe stand-off range for the host platform?</p> <p>How far from the mother ship can OBS operate in order to conduct a mission in the time required?</p> <p>What is the optimum range from which to conduct MCM and H operational tasks using UxVs? What is the effect of conducting tasks from a different range?</p> <p>(d) What is the safe stand-off distance from the host of the ID/disposal vehicle?</p>
Q474	Autonomy Level Definitions	What are practical definitions of levels of autonomy?
Q475	Benefits of Autonomy	What are the benefits of using autonomy, at each stage of the mission activity for MCM & H?