United Kingdom
Hydrographic Office

HYDROGRAPHIC SURVEY SPECIFICATION (LIDAR)

Version 4.1|June 2020

Contents

Part A – Introduction

A1 The UK Hydrographic Office

The United Kingdom Hydrographic Office ("the Authority") is part of the Ministry of Defence and operates as a Trading Fund. It is responsible for satisfying the UK's Safety of Life at Sea (SOLAS) obligations with regards to the publishing and updating of nautical charts and publications. The Authority also provides other services for Mariners and the Royal Navy.

In accordance with the Equality Act 2010, in our capacity as a public body we have a statutory duty to eliminate unlawful discrimination, promote equality of opportunity and promote good relations between people from different groups.

Participating Survey Companies (and their sub-contractors) ("the Contractor") will be expected to ensure that the service they provide promotes Equality between the Authority and its customers and does not directly or indirectly discriminate on the grounds of Equality in accordance with both the Act and the Duty.

A2 Scope

This specification is the main document for all lidar surveys conducted on behalf of the Authority. It will be supplemented by the Hydrographic Instruction for each specific project which will contain further instructions and requirements. Where a project includes an element of boat work the UKHO Hydrographic Survey Specification (Acoustic) v3.0 dated July 2018 is to be used for all elements of the project conducted from the boat.

A3 Assurance

This specification builds on the IHO S44 standard and forms the foundation of a total quality management system for hydrographic surveys that allows for the enhanced use of the resultant data in safety of navigation and other maritime geospatial products. Used alongside other quality assurance measures such as client representative visits, standardised reporting and data validation, it can assist in providing confidence to the contracting authority in the quality of the data provided.

A4 Symbols & Abbreviated Terms

Abbreviation	Term
AAR	After Action Review
ALARP	As Low as Reasonably Practicable
ASPRS	American Society for Photogrammetry and Remote Sensing

ATC	Air Traffic Control
BM	Bench Mark
CAA	Civil Aviation Authority
CD	Chart Datum
ConOps	Concept of Operations
DPR	Daily Progress Report
EAP	Employee Assistance Program
ERP	Emergency Response Plan
GNSS	Global Navigation Satellite System
HAZID	Hazard Identification
HI	Hydrographic Instruction
HSEMP	Health, Safety & Environment Management Plan
iaw	In accordance with
ICAO	International Civil Aviation Organisation
IHO	International Hydrographic Organisation
ITP	Inspection and Test Plan
JSA/JHA	Job Safety Analysis/Job Hazard Analysis

		PEP	Project Execution Plan
		QHSE	Quality, Health, Safety and Environment
		RPA	Remotely Piloted Aircraft
		RPAS	Remotely Piloted Aircraft System
		RPAS SOC	Remotely Piloted Aircraft System Safety Operating Case
		RPS	Remote Pilot Station
		S44	Special Publication No.44 – Standards for Hydrographic Surveys, edition 5 February 2008.
		SWA	Stop Work Authority
		UK CAA	The UK Civil Aviation Authority
		UKHO	UK Hydrographic Office
		WPR	Weekly Progress Report
A5	**Major Amends from Version 3**	**Section**	**Description of Amend**
		C63	Additional requirement to estimate carbon footprint of the project.
		E4	Continuously Operating Tide Gauge requirements added.
		F13	Change to the editing of vertical features from suppressed to rejected.
		H8	Amend to orthorectification requirements to select seamlines between buildings.
		I	Addition of Vegetation Mapping from Imagery

	K5	Clarification of contractual terms regarding extended scope of project.
	Annex A5	Amend from Point Record 6 to Point Record 9 to include wave packet information.

Part B – Personnel

B1	**Field Manager**	The Offshore Manager performs the role of the Project Manager, but locally from the field offices, (afloat or ashore) as opposed to remotely from the Contractor's main offices.
B2	**Party Chief**	The Party Chief is in overall charge of the conduct of survey operations. He is responsible for: • Liaison with the Authority Client Representative or Project Manager; • The welfare of all project personnel including sub-contractors; • QHSE; • Logistics; • Running the daily routine; • Direction and completion of the work scope in accordance with the HI and Framework; • Adherence to Contractor policy and procedures; • The creation of field deliverables including the Mobilisation and Calibration Report and DPRs; • Completion of all QHSE related documentation and returns. The Party Chief may be from a hydrographic survey background and may also meet the requirements and fulfil the role of Charge Surveyor described below. Appropriately experienced individuals from other offshore backgrounds may however be appropriate, including but not limited to Survey Engineers and Geophysicists. If this is to be the case, there must also be a designated Charge Surveyor present who meets the specific requirements stated below. The Party Chief shall be on site during all survey operations.

B3	**Charge Surveyor**	The Charge Surveyor shall have completed an IHO/FIG Category A[1] accredited hydrographic survey course (or have equivalent training and/or experience as agreed by the Authority) and have a minimum of 5 years' hydrographic surveying experience including at least 2 years working specifically with lidar. The Charge Surveyor shall have the authority and experience to make and implement operational decisions and will be available for the Authority to contact regularly to assess progress and modify the survey plan if necessary. The Charge Surveyor's other duties and responsibilities shall be arranged such that they do not interfere with the management of the contract and his/her primary Quality Control (QC), Leadership and Management responsibilities as Charge Surveyor (See also B11 & C8). It would not normally be considered appropriate or possible in practice for the Charge Surveyor to additionally perform the role of Online Surveyor. If the Contractor's intention is for the Charge Surveyor to also fulfil the role of Online Surveyor, this is to be made clear in the tender documentation, together with an explanation of how he/she will in practice conduct a full working day as Online Surveyor and then fulfil their other duties, and not be in breach of working time regulations or Contractor Fitness for Work or Fatigue Management policies[2].

[1] While Standards of Competence for Hydrographic Surveyors were amended by IHO/FIG in 2017 (Cat B) and 2018 (Cat A) putting the Cat B as the level required for leading in the field, the 5-year experience requirement of this specification means that personnel considered suitable to take on the role of Charge Surveyors would at latest have completed their training in 2015.

[2] WORKLOAD OF THE CHARGE SURVEYOR/PARTY CHIEF AND DUAL-HATTING OF THE POSITION WITH THAT OF THE ONLINE SURVEYOR

It is highly undesirable for the Charge Surveyor to also perform the role of Online Surveyor. A tender which indicates that this is the manning intention will be scored accordingly. Experience repeatedly shows that when a surveyor is given the responsibilities of two people they will inevitably succumb to remote pressure (perceived or otherwise) from the Contractor office and focus on achieving 12 hrs of data collection daily. i.e. they will revert to performing the role of Online Surveyor and will 'load shed' all the other critical elements of the QC, leadership and management role except for issuing the DPR. This is entirely predictable and defeats the intended purpose of the Charge Surveyor in his capacity of Offshore Manager; this workload is unavoidably to the detriment of their health and wellbeing, their management and leadership role, the overall conduct of the survey, adherence to the Survey Specification, data quality, the ability to recognise developing equipment/data problems which should be self-evident, attention to wider QHSE and his/her ability to oversee data processing and be to be available to communicate and develop survey operations as required with the Client Representative. This then has downstream impact on data quality, data cleaning and timely rendering of data to an acceptable standard.

A plan which amounts to having an Online Surveyor engaged in data collection for 12 hrs a day, leaving him to 'catch up' with his 'other duties' as Charge Surveyor in his supposed rest time (i.e. committing him to a routine of >14 hr days and eventual burn-out and under-performance in both roles) is unfair and not an acceptable plan as, fundamentally, it fails all reasonable QHSE considerations.

B4	**Online Surveyor**	The online surveyor is responsible for data acquisition and real-time data QC. They coordinate survey operations during live operations and ensure, by maintaining the Online Survey Logbook that an accurate narrative exists of how operations were conducted in practice. As a minimum, the Online Surveyor shall have completed an IHO/FIG Category B accredited hydrographic survey course (or have equivalent training and/or experience as agreed by the Authority).
B5	**Survey Engineer**	The Survey Engineer is responsible for Electronics and IT installation maintenance. He should have sufficient training and experience to be able to diagnose and repair any emergent faults in the survey spread. Whilst the Survey Engineer may support the online of other field surveyors during the conduct of data collection, it would not normally be expected that the Survey Engineer would also be able to conduct the role of Online Surveyor unsupervised. If it is the intention for the Survey Engineer to also fulfil the role of Online Surveyor, where he may be the only 'surveyor' onboard, this is to be made clear in the tender documentation, together with an explanation of how his/her skills, knowledge and experience will allow him/her to meet the minimum requirements specified for the Online Surveyor.
B6	**Data Processor**	The Data Processor is responsible to the Charge Surveyor for the post-processing of acquired survey data and the generation of project deliverables. As a minimum, the Data Processor shall have completed an IHO/FIG Category B accredited hydrographic survey course (or equivalent as agreed by the Authority). If the proposed plan for project manning is to have a Party Chief who is not a Surveyor (and therefore cannot additionally perform the role of Charge Surveyor), it is an acceptable alternative for the Lead Data Processor to perform the role of Charge Surveyor. If this is to be the **case,** then the Lead Data Processor in their capacity as Charge Surveyor shall be on site during all survey operations. He/she shall have completed an IHO/FIG Category **An** accredited hydrographic survey course (or have equivalent training and/or experience as agreed by the

If, despite this advice, Contractor's intention is to 'dual-hat' the Charge Surveyor as the Online Surveyor, Contractor must demonstrate how the composition and duties of the rest of the survey team will allow the Charge Surveyor to first and foremost successfully perform his duties as such, whilst maintaining a moderate 12 hr working day and then additionally run the online data collection as a secondary duty.

		Authority) and have a minimum of 5 years' hydrographic surveying experience including surveying for nautical Charting purposes and lidar operations.
B7	**Other Survey Specialists**	Other survey specialists may be proposed by the Contractor during the Tender process. It is envisaged that these might include but not be limited to: • Land surveyors for the conduct of geodetic work and levelling; • Metocean specialists for the installation of tide gauges and offshore oceanographic equipment; • Specialist operators or maintainers of unmanned autonomous vehicles, vessels and drones; • ROV pilots and technicians. Where these additional personnel are proposed, CVs and relevant documentation shall be provided to demonstrate their competency in the proposed role.
B8	**Survey Team**	The Contractor shall provide the Authority with the position, names, qualifications and experience of all the survey team sufficiently in advance of the personnel mobilising that substitutions can be proposed by the Contractor if required by the Authority. Survey teams will include a balanced mix of the personnel identified above, with adequate experience both in charge of and in assisting with all aspects of lidar surveys of complex coastal/offshore areas for nautical charting purposes, including office data compilation as well as fieldwork. The requirement for a workable manning plan which allows the Charge Surveyor to perform his primary role, without working excessive hours, is emphasised.
B9	**Flight Team**	The Company shall ensure all flight teams involved in flying lidar surveys are qualified iaw with local Civil Aviation Authority legislation (or ICAO regulation if no local authority exists) and have adequate experience in flying lidar sorties. The Authority or its representatives are to be provided with copies of relevant documentation during onsite visits prior to Lidar flights.
B10	**Boat Crew**	The UKHO Acoustic Specification V3 dated July 2018 should be referred to for all requirements while operating boats as part of any projects under these specifications.

B11	**Working Hours & Conditions**	Pilots and Survey Personnel are to comply with (UK) Working Time Regulations, and the Civil Aviation Authority regulations of the state where the project is being conducted At ITQ, the Contractor shall demonstrate how the plan for project manning, travel and accommodation will meet these legal requirements.
B12	**Remote Working**	Any changes to the above where the Contractor wish required field staff to be located elsewhere, are to be fully justified in the tender. In such instance's tenders are to include a full communications plan, with evidence, to support the transfer of data, audio and video to ensure that productivity and output is not negatively impacted. **The Authority retains final say on the working location of all staff.**

Part C – Quality, Health, Safety and Environment (QHSE)

C1	**The Authority's Intent**	A well-run Quality, Health, Safety, Environment (QHSE) management system provides an effective means of protecting employees' health and safety, as well as the environment, and doing it in a cost-effective and well-planned manner. This in turn inevitably leads to sound operational outcomes and the rendering of high-quality data to the Authority whilst also ensuring zero harm. An effective QHSE system is based on the understanding that all accidents are the result of human error and are preventable. Establishing effective QHSE management also results in overall better training and administration methods. It is the Authority's intent to demonstrate an ongoing and determined commitment to improving QHSE at work throughout our organisation and by our Contractors and Sub-Contractors. We will lead the global lidar/offshore survey industry by promoting and improving upon existing offshore industry QHSE best practice and meeting or exceeding the guidance of the UK Health and Safety Executive and other regulatory bodies. All policies and example documentation referred to in Section C shall be supplied as part of the tender.
C2	**Principles of QHSE**	A number of principles have been recognised as foundational to QHSE. These include: • Management must fully support QHSE execution by all employees; • All employees must participate and comply with all QHSE policies, procedures and rules; • Individual employees are responsible for working safely and protecting the environment; • Safety comes first - the goal is to eliminate all injuries and environmental incidents; • Good practices don't "just happen"- they must be planned and properly executed; • The potential for safety, health, or environment incidents should be eliminated during the planning stage; • Contractors must demonstrate that an effective QHSE system is in place and functional in practice; • QHSE includes all aspects of a Contractor's operation, including areas such as purchasing, logistics, the mobilisation of personnel and equipment and administrative services;

		• All QHSE related events, (as detailed in this section), must be reported to the Authority, documented, and investigated. Whilst a no-blame culture is of reporting to be promoted, this process allows performance tracking, continual improvement and prevention of a recurrence; • Monitoring and assessment should be conducted regularly.
C3	**Contractor Responsibility**	Equipment and survey personnel provided by the Contractor for work in connection with the contract shall be the Contractor's responsibility at all times. Any loss, injury or damage suffered or caused by them shall be at the Contractor's risk throughout. Any loss, injury or damage to personnel, equipment or the environment must be reported to the Authority in accordance with the guidance contained in this section and to any other relevant authority required by local regulations and the national legislation of the country in which the Contractor is headquartered. If doubt exists, the Authority is to be informed and UK standards and requirements followed as the default position. The Authority reserves the right to request, and receive in a timely manner, documentary evidence to demonstrate Contractor compliance with or the ability to meet the minimum standards laid down in this Framework, at any time throughout the life of the contract; a refusal or inability to provide relevant documentary evidence automatically signals a departure from the Framework.
C4	**Stop Work Authority**	Any person participating in the Project has both the right and the legal obligation under his/her Duty of Care to exercise Stop Work Authority (SWA) if they perceive a condition or behaviour that poses imminent danger to persons, equipment or the environment. SWA shall be formally stated as a Contractor company policy which is supported by the head of the organisation. The policy should make it clear that it is an *expectation* that an employee *will* exercise SWA if they are in doubt as to the safety of an activity and that they will never be subsequently held to be in the wrong when exercising SWA in good faith. SWA should be managed in accordance with the Contractor's internal policies and procedures. It will typically follow the general procedure of Stop, Notify, Investigate, Correct, Resume and Follow-Up. Where SWA is exercised, it shall be recorded using a Safety Observation Card and specific reference made to the event in the DPR. If there was potential for an *Incident* or *Non-Conformance* it shall also be reported

		and reviewed in accordance with the Contractor's *Near Miss* procedure or *Non-Conformance Procedure* as appropriate. The circumstances leading to the situation will be reviewed in the Weekly Safety Meeting which will formally brief any Follow-Up actions implemented to prevent a recurrence of the unsafe act or condition.
C5	**Drugs and Alcohol Policy**	Being under the influence of alcohol or drugs can seriously impair an individual's judgement and reactions, leading to an increased risk of accidents and injuries occurring. Workers who present themselves for work under the influence of drugs or alcohol are unlikely to have the physical, mental and emotional condition to be able to carry out their duties without risk to themselves or others. They are therefore not Fit for Work. The Contractor shall have in place a drugs and alcohol policy which: • Forbids the presence or possession of drugs illegal under UK or local law and of psychoactive substances or alcohol in aircraft, offices, facilities or vehicles used under this contract; • Forbids the consumption, possession or supply by project personnel of drugs which are illegal under UK or local law and of psychoactive substances; • Requires that personnel do not report or try to report for work when unfit due to alcohol or drugs, (whether illegal or not), or to substance abuse. Whether an employee is fit for work is a matter for the reasonable opinion of the Contractor management or the Client Representative; • Includes random and for-cause drug and alcohol testing whilst personnel are on the project; • Requires Aircrew, (including survey personnel working in the Aircraft and RPAS Remote Pilots), to comply with UK CAA or local CAA regulations and guidance in respect of drugs and alcohol consumption, whichever is the more stringent. The Contractor's Drugs and Alcohol policy *may* allow for social consumption of alcohol in moderation whilst not working, provided that all employees present are Fit for Work at the commencement of their next shift and their blood alcohol level complies with the Contractor's Drugs and Alcohol Policy. In the case of Aircrew, including survey personnel working in the Aircraft and RPAS Remote Pilots, UK Civil Aviation Authority (CAA) regulations and guidance are to be adhered to unless local regulations are more stringent, in which case they are to be followed. The Authority or its nominated representatives reserve the right to request evidence of and approve the regime in place at any time throughout the life of the contract.

		The Authority reserves the right to require that all project personnel are to be subject to an OGUK compliant Drug Test, (or recognised national equivalent), conducted not more than 2 weeks prior to mobilising to the Project. Personnel testing positive for a controlled substance are not to mobilise to the project and the Authority is to be informed of the situation and a replacement nominated. If the Authority exercises the right to require a pre-mobilisation drugs test, clearance certificates are to be provided to the Authority upon request. The contractor shall have in place a policy and rehabilitation system to assist any personnel who test positive for the presence of controlled substances or alcohol in the pre-mobilisation testing.
C6	**Prescription & Non-Prescription Drugs and Medications**	The Contractor shall have in place a policy which requires all project personnel to: • Ensure they are aware of the side effects of any prescription and non-prescription (legal) drugs and medications including those that may impact on their capacity for work; • Advise the Charge Surveyor immediately of any side effects of prescription drugs which may affect work performance or the health and safety of themselves or others. For example, drowsiness; • Declare any Prescription & Non-Prescription medications to the relevant authority as appropriate to the Project. This may be the Charge Surveyor, Project EMT/Paramedic or Aircraft Operator as appropriate. This should be completed prior to travel so the Contractor can confirm there are no local laws prohibiting the possession or use of said medications; • Take steps to ensure they are aware of any common drugs which are contraindicated by any prescription and non-prescription (legal) drugs and medications that they are taking. Where this is the case the relevant authority should be informed, as appropriate to the Project. This may be the Charge Surveyor, Project EMT/Paramedic or Aircraft Operator as appropriate. • Requires Aircrew, (including survey personnel working in the Aircraft and RPAS Remote Pilots), to comply with UK CAA or local CAA regulations and guidance in respect of the use of prescription and non-prescription drugs and medications, whichever is the more stringent. This Policy may be included in a wider Drugs and Alcohol policy.
C7	**Fitness for Work**	The Contractor shall have in place a Fitness for Work policy and procedure. Fitness for Work encompasses a general state of an employee's wellness, (physical, mental and emotional), which enables a worker to perform assigned tasks competently and in a manner which does not compromise the safety or health of themselves or others for the duration of their shift.

		Fitness for Work considerations should include but not be limited to: • Safe work practices and procedures and duty of care; • Health promotion; • Fatigue Management including long haul travel and sensible acclimatisation to the prevailing environment; • Impairment; • Drug and alcohol management; • Mental health; • Functional physical fitness; • Appropriate project manning levels; • Management of shift lengths and Rosters; • Mandatory rest periods for Pilots and RPAS Remote Pilots as required by cumulative flying hours; • Regular employment health assessments conducted by a medical professional; • Employee Assistance Programme.
C8	**Fatigue Management**	The Contractor shall have in place an effective Fatigue Management policy and procedure detailing the method by which the negative impact of fatigue shall be managed and Fitness for Work maintained. This should include a separate section for Pilots and Aircrew, (including survey Aircrew and RPAS Remote Pilots), if a different set of standards are mandated for these roles by an appropriate authority. The Fatigue Management Procedure may be a stand-alone document or may be incorporated as a specific aspect of the Fitness for Work Policy.
C9	**Long Haul Travel**	The Contractor shall have in place an effective Long-Haul Travel policy and procedure detailing the method by which the negative impact of Long-Haul Travel shall be managed, effective acclimatisation achieved, and Fitness for Work maintained. The Long-Haul Travel Procedure may be a stand-alone document or may be incorporated as a specific aspect of the Fatigue Management Policy.
C10	**Motor Vehicles**	The Contractor shall have in place a Motor Vehicle policy and procedure detailing the method by which Motor Vehicles, including 4x4 vehicles and bespoke RPAS support vehicles, will be safely employed during the project.

		This should include training requirements for specialist vehicles, (e.g. operation of 4x4s on unmade roads and the employment of the mobile RPAS suite), and a weekly checklist to be completed by a designated responsible person, (typically the Survey Engineer), to ensure that the vehicle remains free from basic and easily detectable defects which negatively affect safety.
C11	**Management of Change**	If a requirement emerges to depart from the survey plan as embodied in the HI, from the provisions of the Survey Specification, or from the detail described in any Contractor supplied project documentation, then the change is to be agreed with the Authority's Survey Manager or Client Representative. The Contractor is to capture the change using the Contractor's Management of Change (MoC) Form and Procedure. A completed copy of this document is to be forwarded to the Authority's Programme Manager and Client Representative before work re-commences under the new regime.
C12	**Kick Off Meeting**	Project Management Staff will be required to attend a Kick Off Meeting which will be held either at the UKHO or via teleconferencing. The project manager and field manager/charge surveyor are to attend as a minimum. The contractor should be ready to provide all field details not already provided in the original tender including: • Project dates; • Field accommodation; • Details of personnel and equipment mobilisation; • Planned tide gauge, geodetic and other fixed equipment sites as required by the HI; • Any proposed equipment or personnel amendments which depart from the tender. The Authority will provide a brief report on the meeting including confirmation of any amendment to the specification/tender/HI agreed during the meeting.
C13	**Customs/Immigration**	While the Company shall be responsible for arranging all licences, consents, customs clearance and permits in accordance with J1, the Authority will assist with in-country official arrangements, specifically customs and immigration. To this end the Company is to provide the equipment shipping waybill and all project personnel passport details on completion of the kick-off meeting to allow smooth access to the project country.

C14	**HIRA/HAZID**	The Contractor is to conduct a formal Hazard Identification Risk Assessment/Hazard Identification (HIRA/HAZID) early in the planning stage of the Project. This should be attended by as many of the nominated offshore team as possible, but as a minimum should include the Charge Surveyor, Pilot (and/or RPAS Remote Pilot if applicable) and Survey Equipment Operator for the project. The Authority is to receive early invitation to attend the HIRA/HAZID such that the Client Representative can make arrangement to attend in person or by video teleconference. The HIRA is a 'live document' which should be subject to regular review and update as planning for and conduct of the project progresses.
C15	**Survey Project Briefing**	The Contractor is to conduct a formal Project Briefing with all personnel mobilising to the project, including Pilots. Ideally this should be conducted in the Contractor Offices. Where this is not possible, the Charge Surveyor should conduct the Survey Project Briefing on arrival in the field and before commencing mobilisation activities. The Project Briefing should ensure that all personnel are aware of the contents of the HI, Survey Specification, Project Execution Plan (and Remotely Piloted Aircraft Systems Operating Safety Case (RPAS SOC) if RPAS are to be flown). Additionally, any relevant *Lessons Identified* from previous projects should be raised, together with measures to be taken to prevent a recurrence. The Authority is to receive early invitation to attend the Project Briefing such that the Client Representative can make arrangement to attend if appropriate.
C16	**Project Execution Plan**	Prior to mobilisation, the Contractor is to provide a Project Execution Plan (PEP). This document is to contain the technical detail of how the Contractor intends to execute the HI, together with a representative line plan. Where different sizes and classes of Aircraft are proposed which include Remotely Piloted Aircraft (RPA), the PEP is to refer to the RPAS OSC and summarise how these assets will be seamlessly employed, together with considerations regarding simultaneous operations with project and other local Aircraft. The PEP is to contain a Gannt style chart detailing the timeline of key project activities from award of contract to rendering of data to the Authority.

		Additionally, (where a Mobilisation/Demobilisation Plan is not provided as a separate document), the PEP should contain a section considering the specifics of Aircraft/RPAS mobilisation and demobilisation.
C17	**Remotely Piloted Aircraft Systems Operating Safety Case**	Where Remotely Piloted Aircraft Systems (RPAS) of any size or characteristics are to be used during a project, a Operating Safety Case (OSC), following the ConOps methodology, is to be provided for that system detailing how it will be operated and including any relevant system-specific safety considerations. The OSC shall follow the general format proposed in Appendix B to UK CAA's CAP 722 '*Unmanned Aircraft System Operations in UK Airspace – Guidance*' and contain the sections proposed under the section 'UAS OSC Requirements', commensurate with the size and complexity of the RPA in use and the operating environment. The Authority may, *at its sole discretion*, allow an RPA to be flown without a formal RPAS OSC. This dispensation will only normally be considered appropriate when: • It is allowed by the State in whose airspace the RPA is being flown; • The Contractor has comprehensively demonstrated in the Project Execution Plan how the skills, knowledge and experience of the proposed Operator and the size and complexity of the RPA in use and the operating environment will allow for the safe and effective operation of the system in a clearly defined role; • The RPAS utilises a Small RPA having a mass < 7kg; • Operation of the RPA is within Visual Line of Sight (VLOS) of the Remote Pilot; • Operating altitude is <120m; • Appropriate third-party liability cover is in place to cover the intended activities; • The area of operation is not near to controlled airspace or adjacent to an area or route commonly frequented by other airborne objects including gliders, handgliders, microlights, balloons, parachutists etc. It is envisaged that this dispensation will only normally apply to Small RPA which are being used for occasional ancillary project related activities, (i.e. not including day-to-day intensive surveying), and will typically involve operation over water and uninhabited land areas and away from other vessels. For example, a lightweight multirotor 'drone', intended principally for the recreational market, which is being used at low level and in very close proximity to the Remote Pilot to take video or still imagery for marketing purposes, remote visual observation of a shoal patch over which it is the intention to navigate a manned survey vessel

		or for close observation or positioning of a beached wreck which cannot be approached by the survey vessel due to navigational constraints.
C18	**Inspection and Test Plan (ITP)**	Prior to mobilisation, the Contractor is to provide a comprehensive ITP for the project covering the key activities from the start of personnel and equipment mobilisation to the end of personnel and equipment demobilisation.
C19	**Mobilisation & Calibration Report**	The Contractor's Charge Surveyor is to render a Mobilisation and Calibration Report to the Authority on completion of the Mobilisation and within 48 hrs of commencement of data collection. The contents or the Mobilisation and Calibration report are to include but not be limited to: • A description of all survey equipment and systems installed in all Aircraft/RPA; • A description of all survey, control and telemetry equipment associated with the Remote Pilot Station (if applicable); • Sensor offsets; • Geodetic Parameters Check (if required); • Description of all geodetic marks and benchmarks used during mobilisation and calibration; • Details of TG installation, levelling and pole to gauge calibration; • Details of offshore TG / Current Meter installation; • Static position check results; • Node Comparison; • Dynamic position check results; • Lidar system calibration; • Vertical Accuracy Scan Direction Comparison; • Vertical Accuracy Flightline Comparison; • Repeatability check; • System comparison (when more than one lidar sensor is in use); • Integration of Topographic, Shallow and Deep lidar sensors (when more than one lidar sensor is in use); • Comparison with MBES results (when a vessel is also in operation); • Comparison with other lidar results (when more than one Aircraft or RPA is in operation).

C20	**Health, Safety & Environment Management Plan**	A HSEMP shall be supplied to the Authority prior to survey operations being undertaken for each HI. The HSEMP shall be tailored to the HI and reflect the actual survey area, Aircraft/RPAS, offices and accommodation to be used.
C21	**Project Emergency Response Plan**	A Project ERP shall be provided for the project and supplied to the Authority prior to personnel mobilising on each HI. The Project ERP shall be tailored to the HI and the specific aircraft/RPA and area of operations. The Project ERP should include but not be limited to: • Contractor Incident management procedures; • Identification of a Contractor duty officer / 24/7 response number; • Communications Plan, e.g. GSM Voice/GSM Data/SATCOM/EPIRB/PLB/Satellite Messenger; • Response to First Aid Incidents; • Response to Aircraft related emergencies; • Response to serious Medical Emergencies; • Repatriation of injured personnel (or transfer to appropriate medical facilities); • Specific actions in the event of a disaster warnings (e.g. Hurricane and Volcano); • Specific actions in the event of unpredicted disaster as appropriate to the region and time of year, for example Earthquake, Fire, Tsunami, Flood, Civil Unrest; • Easy-access summary of key contacts and telephone numbers. The Project ERP shall be locally tested within 24hrs of personnel mobilising to the HI. The successful completion of this test shall be documented in the DPR.
C22	**Emergency Response Plan - Manned Aircraft**	A Manned Aircraft Emergency Response Plan shall be provided for each class of manned Aircraft involved in the Project and supplied to the Authority prior to the Aircraft being used for survey work. Issues to be considered in the Manned Aircraft ERP should include but not be limited to: • Fires; • Engine failure; • Other mechanical, control and electrical failures; • Radio communications failure;

		• Loss of containment (Oil and Fuel); • Response to First Aid Incidents; • Response to serious medical emergencies (on the ground and airborne); • Response to emergency landing on land and on water.
C23	**Emergency Response Plan - Remotely Piloted Aircraft**	An RPA Emergency Response Plan shall be provided for each class of RPA involved in the Project and supplied to the Authority prior to the Aircraft being used for survey work. Issues to be considered in the RPA ERP should include but not be limited to: • Issues required by the Manned Aircraft ERP which also apply to the RPA in use. The RPA ERP should additionally include system specific issues, for example including but not limited to: • Loss of telemetry and/or remote control; • Loss of navigation through GNSS failure; • Emergency landing on land and water; • Crash on land and water; • Lithium battery fire; • Action in the event of encountering another Aircraft unexpectedly. • Communications with local ATC and other (manned and unmanned) Aircraft.
C24	**Hazard Hunt**	On completion of mobilisation activities and before first flight a whole Aircraft/RPA Hazard Hunt will be conducted. This should be attended by the Senior Pilot/Remote Pilot, the Charge Surveyor, the lead Survey Engineer, the Survey Equipment Operator and, if present, the Client Representative[i]. The Hazard Hunt should include any hanger and Remote Pilot Station which is to be routinely used for project operations. Items picked up during the Hazard Hunt are to be formally recorded, together with what actions were recorded to resolve the hazard.
C25	**Daily Toolbox Talk**	The Charge Surveyor is to hold a Daily Toolbox Talk with all survey personnel and Aircraft/RPAS crew prior to the start of work. The conduct of Toolbox Talks is to be reported in the DPR. Meetings shall be minuted (briefly), posted in the mess and shall include the following headings as a minimum:

		• Date, Time, List of attendees; • Activities - Last 24 Hours; • Planned Activities – Next 24 Hours; • Safety / Hazards. The minutes of the Daily Toolbox Talk are to be retained for inspection by the Authority as required. In the case of small teams operating on a routine and repeating daily schedule, the requirement to formally minute the Daily Toolbox Talk meetings may be waived *with the agreement of the Authority*. This likely to be appropriate to routine flying operations in which the Pilot already files a daily Flight Plans with the local ATC. The conduct of the meeting is however still to be reported in the DPR.
C26	**Job Hazard Analysis/Job Safety Analysis**	A formal JHA/JSA shall be in place for each survey activity. These shall be tailored to the Aircraft and equipment in use, including RPAS, and to the prevailing environmental conditions. Examples of activities to be subject to a JHA/JSA include but are not limited to: • Personnel Mobilisation & Long-Haul Travel; • Motor Vehicle Operations; • Mobilisation & Demobilisation activities; • Dimcon; • Fieldwork Ashore; • Working in and around the airfield; • Laser safety; • RPAS mission planning, airspace considerations and site risk-assessments; • RPAS pre-flight inspection, launch, recovery and shutting down/making safe the Aircraft; • Implementation of a RPAS return-to-home function following control-link failure. Fixed wing RPA should demonstrate an equivalent procedure that results in a suitable automated, low-impact descent and landing; • RPA lithium battery charging; • Aircraft/RPA refuelling operations; • Aircraft/RPA routine maintenance.

		The Contractor's standard 'Generic JSAs' are an acceptable starting point in this process but there shall be hard-copy documentary evidence that these templates have been reviewed and updated by all participating personnel prior to commencement of work and that they reflect the actual operating conditions present on the Project. Only personnel who are signed onto the JSA are to participate in the activity. JHA/JSAs shall be subject to regular After-Action Reviews (AAR) to ensure that they remain fit for purpose. A new JHA/JSA is to be conducted whenever the procedure covered is subject to change. The conduct of JSA/JHA and AARs are to be reported in the DPR. JHA/JSA records and AARs are to be retained for inspection by the Authority as required.
C27	**Safety Observation Cards**	Safety Observation Cards, (sometimes known as Hazard Observation Cards ('HOC Cards') or STOP cards), are to be available in the shore office and at the airfield. HOC Cards are to be available to every Aircraft and RPAS team participating in the Project. In practice these may be held in the Aircraft, at the airfield, at the RPS, or in a support vehicle as most appropriate. All embarked personnel are to be encouraged to submit HOC Cards (to the Charge Surveyor) as part of the positive health and safety and continuous improvement culture. The Charge Surveyor is to forward the cards to the designated Contractor HSE manager in accordance with internal Contractor policy. Where the airfield's safety management system already uses HOC cards or similar reporting mechanism, the survey team may alternatively participate in this system. The Charge Surveyor is however to ensure that all reports submitted through this system are recorded and forwarded to the designated Contractor HSE manager. Where the subject raised is particularly noteworthy or worthy of commendation it should be remarked upon in the Charge Surveyor's comments section of the DPR. It is recommended that the Contractor operates a reward or recognition regime for 'good spots' to encourage participation and active identification and rectification of hazards. HOC cards submitted are to be statistically recorded in the HSEQ section of the DPR. They are to be retained for inspection by the Authority as required.
C28	**Toolbox Talk**	Pre-flight or prior to commencing any other survey activity, the person leading the operation is to hold a Toolbox Talk to brief the participating team members on the activity, their role in it and any health and safety

		considerations. Toolbox Talks are to be minuted (briefly) with the minutes retained for inspection by the Authority as required.
C29	**Weekly Safety Meeting**	The Charge Surveyor shall hold Weekly Safety Meetings with all field personnel. Meetings shall be minuted (briefly) and made available to all personnel. Weekly Safety Meetings shall include the following items as a minimum: • Date, Time, List of attendees; • Safety Moment; • Review of minutes of previous meeting; • Review of all Safety/Hazard Cards submitted in the previous week together with outstanding actions to rectify; • Review of all SWA exercised together with required Follow-Up actions to prevent a recurrence; • Review of all Incidents occurring in the last week under the project or as part of any other Contractor project operating similar Aircraft or RPAS; • Update of Lessons Identified; • Review of any UK Civil Aviation Authority (CAA), or equivalent national Safety or Information Bulletins relevant to the Aircraft, RPAS or operation; • Review of any ARPAS-UK or equivalent national RPAS Operator association Safety or Information Bulletins relevant to the RPAS or operation; • Review of any IMCA, Alerts, Safety Flashes or Safety Bulletins relevant to the operation; • Any Other Business. The conduct of Weekly Safety Meetings is to be reported in the DPR.
C30	**Incident Reporting**	All Incidents resulting in loss or damage to equipment are to be reported to the Authority within 12 hrs, other than where the conduct of operations is directly affected, where there has been damage sustained by a third party, or where environmental damage has occurred beyond the boundaries of the Aircraft/RPA. In these events the Incident is to be verbally reported as soon as practicable, with follow up documentary reporting submitted within 12 hrs.

		All Serious Incidents are to be verbally reported to the Authority as soon as practicable, with follow up documentary reporting submitted within 12 hrs. All Medical Treatment Incidents (MTI), Light Duty Incidents (LDI) and Lost Time Injuries (LTI) are to be reported to the Authority as soon as reasonably practicable. All Near Misses are to be reported to the Authority as soon as reasonably practicable and within 48 hrs of the Near Miss. All the above Health and Safety related events are to be reported using the appropriate Contractor form and statistically recorded in the DPR.
C31	**Near Miss Reporting**	A Near Miss is an event not causing harm, but which has the potential to cause injury or ill health or damage to the environment. This includes an event which had the potential for causing an adverse effect as defined in the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 (RIDDOR). The outcome of any subsequent investigation is to be reported to the Authority, in accordance with the Contractor company procedures, as soon as the outcome is known.
C32	**Non-Conformance Reporting**	A Non-Conformance Report documents the details of a non-conformance identified in a quality audit or other process review. The objective of the report is to make an unambiguous, defensible, clear and concise definition of the problem so that corrective action can and will be initiated by management. All Non-Conformances, together with the proposed Corrective Actions, are to be reported to the Authority in accordance with Contractor procedures.
C33	**First Aid Injury**	First Aid Injuries (FAI) are injuries which require local treatment by a project First Aider which do not ordinarily require professional medical care. An injury which is treated by a medical professional (e.g. Doctor or EMT) but which could have been dealt with by a normal first aider remains an FAI. FAIs are to be managed locally and internally reported in accordance with Contractor policy. They need not be specifically reported to the Authority, but they are to be statistically recorded in the DPR. In the event of a FAI subsequently escalating and becoming a MTI, LDI or LTI, the situation is to be reported as an Incident as soon as practicable.

C34	**Medical Treatment Injury**	A Medical Treatment Injury (MTI) is a minor injury of a non-permanent nature requiring treatment by a doctor or other qualified medical professional. The employee can return to his/her normal work immediately on completion of treatment. Or Injuries to multiple individuals of a non-life threatening, non-permanent nature which require first aid only, i.e. multiple FAIs. All MTIs are to be reported to the Authority as soon as reasonably practicable
C35	**Light Duty Injury**	A Light Duty Injury (LDI) may exceptionally result from a FAI but is more commonly an MTI in which the injured employee additionally has work restrictions requiring assignment to other than his/her normal job or in which (s)he cannot perform all aspect of his/her normal role unaided. All LDIs are to be reported to the Authority as soon as reasonably practicable.
C36	**Lost Time Injury**	A Lost Time Injury (LTI) requires treatment by a doctor or other medical professional and the injured employee cannot return to work on his/her next scheduled work day because of the injuries received. All LTIs are to be reported to the Authority as soon as reasonably practicable.
C37	**Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013**	In addition to the above reporting requirements to the Authority, the Contractor is to report all incidents as required by RIDDOR 2013. Where it is the Contractor's intention to report an incident to the Health and Safety Executive or National equivalent under RIDDOR or national equivalent, this is to be made clear in the verbal and written reporting submitted to the Authority. A copy of the RIDDOR report is to be forwarded to the Authority as soon as it is submitted to the Health and Safety Executive.

C38	**Accident Book**	An Accident Book is to be available to every Aircraft and RPAS team participating in the Project and in the Shore Offices. In practice this may be held in the Aircraft, at the airfield, at the RPS, or in a RPAS support vehicle as most appropriate. The Accident Book is to be of an HSE approved format[3]. All accidents, no matter how minor, are to be recorded in the Accident Book. On completion of the project, the accident book is to be retained by the Contractor for at least 3 years.
C39	**Lessons Identified & Continuous Improvement**	The Charge Surveyor should maintain a running list of Lessons Identified. Ideally this should be held on a communally available PC which all participating personnel can access as required. The Lessons Identified should be reviewed at the Weekly Safety Meeting and entries developed as appropriate. On completion of the project the Lessons Identified should captured in the Contractor's Lessons Identified repository to ensure Continuous Improvement. Typically, this will be through the mechanism of the Project Debrief. A copy of the Lessons Identified is to be forwarded to the Client Representative and the Authority.
C40	**Pilot Certification (Manned Aircraft)**	The Pilot of the Aircraft must hold a valid Commercial Pilot License and suitable endorsements for the type and class of Aircraft used iaw. the latest local Civil Aviation Authority regulations.
C41	**Remote Pilot Certification (RPAS)**	The default requirement is that the Remote Pilot of any RPAS must hold a valid UK CAA PfCO (i.e. Permission for Commercial Operations) qualification or recognised national equivalent qualification, together with endorsements for the type and class of Aircraft used iaw. the latest local Civil Aviation Authority regulations. The Contractor must ensure that the qualification held is valid in the Project country and if it is not, ensure that the Remote Pilot gains additional certification as locally required. The RPAS Remote Pilot must in any case have a working knowledge of and adhere to the provisions of UK CAA's CAP 722 '*Unmanned Aircraft System Operations in UK Airspace – Guidance*'. RPA Remote Pilots, (or other RPAS crew), intending to use radiotelephony on civil aviation airbands must ensure that they hold a Flight Radio Telephony Operators' Licence (FRTOL) locally valid for the privileges intended to be exercised.

[3] E.g. http://www.hse.gov.uk/pubns/books/accident-book.htm

		If local regulations do not require RPA Remote Pilots to have formal certification for the class/size of RPA in use, (when conducting operations for commercial gain or otherwise), then the Authority may, *at its sole discretion*, allow an RPA to be flown without the Remote Pilot having a UK PfCO. This dispensation will only be considered where: • It is allowed by the State in whose airspace the RPA is being flown; • The Contractor has demonstrated in the Project Execution Plan how the skills, knowledge and experience of the proposed Operator and the size and complexity of the RPA in use and the operating environment will allow for the safe and effective operation of the system in the proposed role; • The RPAS utilises a Small RPA having a mass < 7kg; • Operation of the RPA is within Visual Line Of Sight (VLOS) of the Remote Pilot; • Operating altitude is <120m; • Appropriate third-party liability cover is in place to cover the intended activities; • The area of operation is not near to controlled airspace or adjacent to an area or route commonly frequented by other airborne objects including gliders, handgliders, microlights, balloons, parachutists etc. It is envisaged that this dispensation will only normally apply to Small RPA which are being used for occasional ancillary project related activities, (i.e. not including day-to-day intensive surveying), and will typically involve operation over water and uninhabited land areas and away from other vessels. For example, a lightweight multirotor 'drone', intended principally for the recreational market, which is being used at low level and in very close proximity to the Remote Pilot to take video or still imagery for marketing purposes, remote visual observation of a shoal patch over which it is the intention to navigate a manned survey vessel or for close observation or positioning of a beached wreck which cannot be approached by the survey vessel due to navigational constraints.
C42	**Medical Certification**	All flight personnel should have an in date medical certificate based on the requirements of the state over which the lidar survey will be taking place iaw ICAO Doc 8984 1.2.7/8. All flight survey personnel including technicians must be certified as 'Fit to Fly' by their doctor. Evidence of certification may be requested by the Authority or its nominated representatives at any time.

C43	**Safety Training Certification**	Flight crew should be in-date for all relevant safety training as required by the CAA under which they are regulated. Survey flight crew should have conducted appropriate basic offshore survival training (e.g. BOSIET & HUET) or appropriate aviation industry equivalent. Evidence of certification may be requested by the Authority or its nominated representatives at any time.
C44	**First Aid & Medical Training**	All members of the survey team shall hold an in-date recognised first aid certificate equivalent or superior to the UK HSE First Aid at Work (3 Day) course. Additionally, all members of the survey team shall be trained in: • The use of Automated External Defibrillators (AED); • The control of major bleeding and the effective use of the use of the major bleeds kit; • The use of disposable resuscitators, suction devices and artificial airways; • The administration of Adrenaline autoinjectors (EpiPen); • The correct treatment for snake and insect bites and envenomation; Additionally, all members of the survey team shall be trained in any techniques, appropriate to the area of operation, which are suggested by the Contractor's HIRA/HAZID. Where oxygen resuscitation equipment is available, (e.g. as required by the HIRA/HAZID), at least 50% of the project personnel shall be qualified in its use. In projects which are manned by a small number of personnel, sufficient members of the project team, (i.e. survey personnel, Aircrew (and RPAS crew if applicable)), are to be trained as per the 'survey team' requirements above, such that a situation is unlikely to arise where a casualty is also the only first aider present at the worksite. In practice, (e.g. one Aircraft operating with 1 x Pilot and 1 x survey system Operator), this may require that 100% of the personnel present are trained to the same level.
C45	**Controlled Drugs**	Where Aircraft/RPA are working in a Remote Location[ii], a requirement for a 'Medicine Chest', containing Controlled Drugs, may be suggested by the HIRA/HAZID or activity specific JHA. This will most commonly apply to RPA where a mobile RPAS crew is deployed to a Remote Location, however could also apply to Manned Aircraft operating from a small austere airfield.

		In this event guidance as to the content of the Medicine Chest should be sought from an appropriate medical authority, together with the level of training required to administer the drugs included in the kit. In the context of remote RPAS operations it is anticipated that this would either be by the inclusion of an industrial paramedic on the team or alternatively by provision of training to an experienced first aider, enabling him to select and administer controlled drugs under the guidance of remote consultation with a doctor. In the latter case, evidence of appropriate training and a robust communications plan is to be provided to the Authority. The Contractor is to indicate in the Health and Safety Management Plan the intention for provision of suitable training to designated key individuals.
C46	**Certification of Client Representatives**	Client Representative(s) will hold medical, safety and first aid certifications meeting the minimum standards stated above. Where local aviation (or Aircraft-specific) requirements mandate a higher standard of certification, this is to be made clear in the Tender. This will have no negative impact on the scoring of the Tender but will ensure that the Client Representative(s) have sufficient notice to attend training and meet the minimum standards before visiting the project. Should the situation change during the course of the contract the Authority's Programme Manager is to be informed at the earliest opportunity.
C47	**Infectious Diseases**	All Contractor personnel are to be offered travel vaccinations for infectious diseases endemic to the area of operation. These should be provided sufficiently in advance of operations as to confer maximum immunity. When operating in malarial areas, all Contractor personnel are to be offered an appropriate Antimalarial prophylaxis for the area of operations. Appropriate physical and procedural measures, (both in the field and in offices and accommodation), are to be implemented to minimise the exposure of staff to biting insects. Statistical evidence of the number of personnel offered vaccinations and antimalarial prophylaxis, together with the uptake rate, are to be provided to the Authority upon request.
C48	**Employee Assistance Programme**	The Contractor is to offer a confidential Employee Assistance Programme (EAP) to all employees.

C49	**Lone Workers**	The requirement for Lone Working is not routinely envisaged. If a requirement for Lone Working is identified, (e.g. the Remote Pilot of small RPAS working from a car or 4x4 in a Remote Area), it must be captured in the HIRA/HAZID and JHA and measures put in place to mitigate the additional risk involved. These will be specific to the operational environment, however the simplest measure to eliminate the Lone Working hazard may simply be to mobilise two members of staff.
C50	**Safety Induction – Manned Aircraft**	All flight personnel including the survey team must undertake familiarisation training prior to flying which must ensure they are aware of aircraft-specific safety issues, including but not limited to: • How to safely approach and disembark from the aircraft when engines are running (if applicable); • Any external hazards to be avoided, e.g. moving or rotating equipment, pinch points, radiation hazards (radio and laser), hot surfaces, sharp and protruding surfaces and no-step areas; • How to safely embark and disembark from the aircraft; • Any internal hazards; • Use of the internal intercom system to communicate verbally with the pilot; • Understand and correctly respond to any visual signals which may be used be used by the pilot, Aircrew or groundcrew; • Correctly operate and secure doors and ladders; • Communicate with other persons on board on appropriate safety matters and understand safety information symbols, signs and alarms; • Know what to do if fire or smoke is detected; • In the event of fire, know how to raise the alarm and have basic knowledge of the use and types of portable fire extinguishers on board; • Know what to do in case of an emergency landing at sea or on land; • Locate and don life-jackets (and immersion suits if carried); • Identify emergency escape routes and operate emergency egress equipment, e.g emergency escape hatches, exits and push-out windows; • Locate, launch and enter life-rafts; • Where the Aircraft has onboard (i.e. inbuilt) firefighting systems, embarked survey personnel are to have a working knowledge of how these are operated such that they could go to the required internal or external location and actuate the system in an emergency. They should also be aware of any respiratory hazards associated with the gas used in the extinguisher;

		• Be familiar with the location and contents of first aid kits and of AED devices; • Be familiar with the location and operation of all safety equipment listed under the "Minimum Safety Equipment" section below; • Take immediate action upon encountering an accident or other medical emergency. In light aircraft where the crew comprises a single pilot, an early and frank discussion may be appropriate regarding the best course of action in the unlikely event of the pilot experiencing a medical emergency in the air, such will best serve to result in a least-worst outcome for personnel in the aircraft and on the ground. Evidence of training may be requested by the Authority or its nominated representatives at any time.
C51	**Safety Induction - Remotely Piloted Air System**	The information to be imparted in the safety induction for a RPAS will vary greatly depending upon the size and nature of the RPA, the complexity of the RPS and overall RPAS, the size of the support crew and the nature of the launch and recovery point. The information to be imparted under Safety Induction – Manned Aircraft may be used as a starting point in so far as it applies to the RPA in use. Additional RPAS specific safety issues may include but not be limited to: • RF hazards associated with telemetry links; • In electrically powered RPA, how to connect and disconnect batteries; • In combustion powered RPA how to start and shut down engines routinely and in emergency; • Lifting and slinging arrangements; • Charging of Lithium batteries; • Refuelling operations; • System pre-flight and post-flight checks and procedures; • RPA launch and recovery; • For mobile RPS, particularly vehicle based RPS working in a Remote Location, any hazards to personnel or the RPA associated with the environment; • Crew actions in the event of loss of telemetry and/or remote control; • Crew actions in the event of loss of navigation through GNSS failure; • Crew actions in the event of emergency landing on land and water; • Crew actions Crash on land and water; • Lithium battery fire and/or liquid fuel fire; • Action in the event of encountering another Aircraft unexpectedly.

		• Communications with local ATC and other (manned and unmanned) Aircraft. Evidence of training may be requested by the Authority or its nominated representatives at any time.
C52	**Drills and Exercises**	Regular emergency drills and exercises are to be held. The periodicity of these this will typically be in accordance with the Aircraft's own requirements. Where the Aircraft (including RPAS) has fixed firefighting arrangements and fuel or power isolations and emergency stops, all project personnel have a working knowledge of how these are operated such that they could actuate the system an emergency if required. The conduct of Drills and Exercises are to be reported in the DPR and statistically recorded.
C53	**Client Representative Visits**	The Authority reserves the right to send a Client Representative to visit during survey operations. Visits are intended to primarily focus on the conduct and quality of hydrographic processes and deliverables. It will also include an informal assessment of safety aspects relating to the Aircraft/RPAS, hanger, field office and other facilities and of compliance with the detail of the Survey Specification. If significant safety concerns are raised the Client Representative has Stop Work Authority. Issues identified are to be resolved before work recommences. If significant issues with the Aircraft/RPAS are identified, the Contractor is to contact the local CAA to resolve any issues prior to recommencement of work.
C54	**Safety Equipment - Aircraft**	Any manned Aircraft employed on the survey shall have safety and survival equipment, as required for the class of Aircraft, by the National Aviation Authority of the State of Registry. In general, it would be anticipated that the following equipment would be amongst that carried: • Adult life jackets for all embarked personnel; • A 406 MHz Emergency Position Indicating Radio Beacon (EPIRB); • A life raft appropriate to the Aircraft and crew. The life raft should be stowed in such a position that it can be easily and quickly launched; • Flares & emergency signalling kit; • Handheld firefighting equipment appropriate to the Aircraft in use and the survey equipment installed; • A portable water proof VHF Radio and spare batteries; • Waterproof torch and spare batteries;

		• First Aid Kit. The contents of the kit should be appropriate to the size of the Aircraft, number of crew and distance of the survey area from the source of professional medical assistance identified in the ERP. The contents of the kit should include (if not already specified by CAA requirements):
		  ○ Eye wash;
		  ○ Equipment suitable for controlling a major bleed, e.g. field dressings, tourniquet and haemostatic dressings;
		  ○ Automated External Defibrillator (AED). Each Aircraft is to carry an AED. All project personnel are to be trained in its use.
		
		Any deviation from this list must be discussed with and approved by The Authority.
		
		The Client Representative may verify that all items in this section have been provided to the project and are in date for inspection/test/expiry as appropriate[iii]. The Authority maintains the strongest commitment to ensuring the health and safety of its personnel and those of the Contractor. If shortcomings are noted in respect of this minimum requirement, Stop Work Authority may be exercised, at Contractor liability, until such time as defects or deficiencies are rectified.

C55	**Safety Equipment – Remote Pilot Station**	The safety equipment provided to the Remote Pilot Station (RPS) will vary greatly depending upon the nature and location of the RPS. The JHA for RPS operation should give detailed consideration to the hazards present and to the safety equipment and potentially the survival equipment required to mitigate these. For example, a static RPS suite set up in a hangar at a large commercial airfield, (for control of a large RPA by a potentially sizable support team), would be expected to have significantly different equipment *and training* requirements to the RPS for a small multirotor 'drone' operated by a lone worker or two-person team basing themselves out of a 4x4 in a Remote Location. It would however be anticipated that the following equipment would be the minimum requirement for an RPS in all circumstances: • Comprehensive first aid kit tailored to the size of the team, the efficacy of local EMT services and the proximity, (in distance and time), to the nearest hospital; • Eye wash; • Equipment suitable for controlling a major bleed, e.g. field dressings, tourniquet and haemostatic dressings; • Automated External Defibrillator (AED); • Handheld firefighting equipment appropriate to the Aircraft in use and the survey equipment installed.

Additionally, for lone workers or small mobile teams working independently in remote locations, active consideration should be given, (in addition to basic environment-appropriate field PPE), to the equipment *and associated training* requirement for:

- Vehicle emergency and recovery equipment appropriate to the vehicle, terrain and roads;
- A 406 MHz Emergency Position Indicating Radio Beacon (EPIRB);
- Satellite telephone;
- GSM telephone;
- Portable radio communications between team members and ideally the project offices;
- Flares & emergency signalling kit;
- Waterproof torch and spare batteries;
- First Aid Kit. The contents of the kit should be appropriate to the number of personnel and the distance of the operating area from the source of professional medical assistance identified in the ERP. The contents of the kit should additionally include:
    - Eye wash;
    - Equipment suitable for controlling a major bleed, e.g. field dressings, tourniquet and haemostatic dressings;
    - Snakebite kit;
    - Automated External Defibrillator (AED). Each Aircraft is to carry an AED. All project personnel are to be trained in its use.
- Survival equipment appropriate to the operating environment and the distance from potential sources of assistance. A supply of and the ability to then obtain additional clean drinking water is likely to be the dominant consideration in the current (hot/tropical) area of operations.

The Client Representative will discuss the JHA for RPS operation with the RPAS crew and will give active consideration to the appropriateness of emergency and survival equipment and training provided to the RPAS crew. The Authority maintains the strongest commitment to ensuring the health and safety of its personnel and those of the Contractor. If evident shortcomings are noted in respect of equipment, *training provision or general competency in operating in challenging field conditions*, Stop Work Authority may be exercised, at Contractor liability, until such time as defects or deficiencies are rectified.

C56	**Noise**	Personnel shall not be exposed to hazardous levels of noise[iv]. Personnel embarked in the Aircraft shall wear appropriate aviation rated hearing protection whenever the engines are running. It is anticipated that this would normally constitute an approved aviation headset combining hearing protection and wired or wireless communications between the Pilot and other embarked personnel. Ground crew, (including RPAS crew), shall wear appropriate industrial hearing protection whenever operating near to running engines which produce damaging levels of noise. To enable effective communications between participating personnel this may constitute hearing protection integrated with 2-way radio communications. In the case of larger RPAS where the ground crew may be in close proximity to the Aircraft but be unable to directly view visual signals from the Pilot at the RPS, hearing protection should be integrated with 2-way radio communications. A calibrated electronic Sound Level Meter is to be available to confirm acceptable levels of noise.
C57	**Lighting**	The default standard for office lighting intensity, (including the workstations of the Survey Equipment Operator, processing office and static RPS suites), is that it shall meet the UK requirements for office and workshop lighting[v]. It is however accepted that this will often be difficult to fully achieve in light Aircraft. An assessment of workstation lighting is therefore to be conducted prior to start of work and reported as part of the formal Ergonomic Assessment. Where this assessment determines that it is not possible for the workstation ergonomics to meet UK standards, action is to be taken to reduce all hazards presented to As Low As Reasonably Practicable (ALARP). Where it is identified that the lighting of any positions does not meet or exceed UK office standards, this is to be reported to the Authority as a non-conformance. The report is to include: • A copy of the ergonomic assessment; • A list of the personnel exposed to the hazard; • A description of material modifications undertaken to reduce the hazards identified to ALARP. A description of what systems or work patterns have been implemented to mitigate any adverse impact on exposed personnel.

C58	**Project Office Ergonomics**	Workstation ergonomics in the Project Office are to meet or exceed UK office standards. A formal ergonomic assessment of workstation configuration is to be conducted prior to start of work and any identified defects rectified.
C59	**Aircraft Survey Equipment Operator Ergonomics**	The default standard for the ergonomics of the Survey Equipment Operator's workstation is that it shall meet or exceed UK office standards. It is however accepted that this will often be difficult to fully achieve in light Aircraft. A formal ergonomic assessment of workstation configuration is therefore to be conducted prior to start of work. Where this assessment determines that, through the design of the Aircraft, it is not possible for the workstation ergonomics to meet UK standards, action is to be taken to reduce all hazards presented to As Low As Reasonably Practicable (ALARP). Where it is identified that the ergonomics of any positions do not meet or exceed UK office standards, this is to be reported to the Authority as a non-conformance. The report is to include: • A copy of the ergonomic assessment; • A list of the personnel exposed to the hazard; • A description of material modifications undertaken to reduce the hazards identified to ALARP; • A description of what systems or work patterns have been implemented to mitigate any adverse impact on exposed personnel.
C60	**RPAS Remote Pilot Station Ergonomics**	The nature of the Remote Pilot Station (RPS) will vary greatly depending upon the size of the RPAS in use. The RPS for a small multirotor 'drone' would typically be a small hand-held control unit, whereas the RPS for a large fixed wing unmanned Aircraft could be a control cabin housing a simulated Aircraft flightdeck which fully replicates all the instruments, controls and seating normally associated with a full-sized manned Aircraft with two Pilots. The default standard for the ergonomics of the RPS is that it shall meet or exceed UK office standards. It is however accepted that the practical implementation of this intent will vary greatly commensurate with the RPS in use and the complexity of the control system and any telemetry displays. A formal ergonomic assessment of control station configuration is therefore to be conducted prior to start of work, identifying hazards and demonstrating that measures have been put in place to reduce all hazards presented to As Low As Reasonably Practicable (ALARP). In practice this might be as simple as providing a padded neck strap to support the weight of a hand-held control unit or providing appropriate office furniture and adjustable monitors for larger setups featuring several flight and survey system telemetry displays.

		Where it is identified that the ergonomics of any positions do not meet or exceed UK office standards, this is to be reported to the Authority as a non-conformance. The report is to include: • A copy of the ergonomic assessment; • A list of the personnel exposed to the hazard; • A description of material modifications undertaken to reduce the hazards identified to ALARP. A description of what systems or work patterns have been implemented to mitigate any adverse impact on exposed personnel.
C61	**Work in the water**	In general, project personnel should not enter the water for the purposes of conducting project related operations. If it becomes necessary or appropriate to enter the water as a *planned* event during the normal course of operations, (including, for example, the crossing of bodies of water by RPAS teams in remote locations), the relevant section of the MBES Framework shall be adhered to.
C62	**Environmental Impact Statement**	The Contractor is responsible for providing an Environmental Impact Statement before any survey operations commence. The statement must be supplied to the Authority at least 4 weeks before commencing field work and at a minimum consider the following: • Travel and transport (personnel & equipment); • Reduction of noise and emissions; • Energy and Climate Change; • Minimisation of total energy/fuel consumption; • Air quality; • Minimisation of greenhouse gas emissions and pollution of air with gases and particulates; • Avoid harm and minimise disturbance or annoyance to people and wildlife caused by noise generated during survey activities; • Waste management; • Minimisation of waste production and promote reuse, recycling and recovery; • Reduce total water consumption, maximise efficiency of use and encourage reuse whilst minimising the risks of water pollution;

		• Nature Conservation; • Conserve and prevent loss of biodiversity; • Mitigation of potential hazards to terrestrial life including birds; • Impact upon and prevention of disturbance to historic and cultural sites, particularly sites of significant importance to indigenous peoples; • Communities and Social values; • Minimise disruption and nuisance to communities and local environments;
C63	**Carbon Footprint**	In addition to the EIS, the Contractor shall provide an estimate on tendering of the carbon footprint for all aspects of the projects including processing and delivery. Full details of the methodology and all aspects considered are to be included. The estimate is to be updated as required during the project and rendered as part of the final deliverables. The Authority aspects of the project such as client representation are not to be included.
C64	**Accommodation**	The Contractor is to pass the details of the field (hotel) accommodation to the Authority as soon as they are known. To maximise physical security and minimise logistical complications the Client Representative will seek to base himself in the same hotel accommodation as the Contractor survey team. Where the intention is to use rental accommodation, the address of the accommodation should be passed to the Authority as soon as it is known, so that the Client Representative can seek hotel accommodation nearby.
C65	**Aircraft Registration, Inspection and Approval**	Each Aircraft and RPAS tasked with surveying shall be subject to approval by the Authority prior to survey work commencing under the relevant HI. Aircraft Registration and Air Worthiness Certificates for manned Aircraft are to be provided to the Authority prior to work commencing. Where RPAS are to be used on the project, appropriate certification is to be provided to the Authority prior to work commencing. In practice this certification will be determined by the requirements of the Commercial Aviation Authority under whose jurisdiction the system is registered (if required) and under whose jurisdiction the Pilot is registered and qualified. There may potentially be additional requirements imposed by the State in whose airspace the system will fly. In practice the Authority requires Contractor to demonstrate that all relevant authorities have been engaged with to ensure that the required Registration,

		Inspection and Approvals are in place prior to the commercial employment of the Aircraft. If there is any doubt, (particularly if local standards do not exist), then the UK Civil Aviation Authority's document CAP 722, "*Unmanned Aircraft System Operations in UK Airspace – Guidance*" shall be followed. All Aircraft, including RPAS, are to be fully inspected as required by local CAA legislation. If no such legislation exists, ICAO guidelines and UK CAA guidelines are to be used for manned Aircraft and RPAS respectively. The cost of any inspection and any subsequent actions required by the local CAA and any re-inspection shall be borne by the Contractor. Evidence of inspections and approvals may be requested by the Authority or its nominated representatives at any time. Aircraft, (including RPAS), are to be fully compliant with any international and local legislation that may be in place at time of operation. Certification demonstrating compliance may be requested at any time by the Authority or its representative.
C66	**Aircraft Carrier**	Aircraft from Carriers on the EU Air Safety List (https://ec.europa.eu/transport/modes/air/safety/air-ban_en) or any similar list operated by the nation state in question will not be accepted for any work in relation to this contract.
C67	**Aircraft Suitability**	All Aircraft used for surveying must: • Meet all relevant requirements detailed in Section C, HSEQ. • Be of appropriate size and with sufficient endurance for surveying the area specified in the HI; • Be sufficiently directionally stable in a straight line at low speed so as to permit effective line-keeping without excessive holidays in the data/requirement for infill lines; • Have appropriate and reliable power to supply survey equipment. Additionally, any manned Aircraft are to: • Have characteristics which do not adversely impact crew welfare or induce excessive fatigue. For example, excessive noise, temperature and vibration or inadequate space for the comfort of personnel once survey equipment has been installed; • Meet or exceed minimum ergonomic and lighting standards for all exposed personnel, notably the seating and workstation arrangement for the Pilot, Survey Equipment Operator and other flight crew.

		Where the proposed Aircraft does not have inbuilt heads and galley facilities (i.e. the majority of light Aircraft), the Contractor must detail: • Intentions for provision of toilet facilities; • Intentions for provision of hot and cold food and drink; • Intentions for maintenance of personal hygiene, notably hand hygiene; • Intentions for allowing embarked personnel to take regular rest breaks. For safety reasons, multiple-engine Aircraft are preferred, particularly in the case of manned Aircraft and large RPAS (i.e. those weighing more than 20kg).
C68	**Air Coordination and Safety**	The Captain of the Aircraft/RPAS Remote Pilot is responsible for the safety of the Aircraft and, in manned Aircraft, of the crew. If, during the course of survey operations, the Captain of the Aircraft/RPAS Remote Pilot considers that there is a conflict of interest between the safety of the Aircraft and crew with regard to operating in the proposed survey areas, he has the overriding authority to refuse to survey those areas. The Authority is to be notified at the earliest opportunity in the event of such an occurrence so that the practical impact on overall data collection and coverage can be assessed.
C69	**Aircraft Commitment**	Once an Aircraft (including RPAS) has been approved for survey, the Contractor should seek the Authority's prior agreement to remove or replace the Aircraft with another. The Authority will only approve an Aircraft replacement if the oncoming Aircraft is an appropriate like-for-like exchange and continues to abide by the requirements of the HI, Survey Specification and tender bid (and RPAS SOC).
C70	**Working Language**	The working language onboard all Aircraft, and for all reporting, is to be English.

Part D - Positioning

D1	**Survey Geodesy**	Unless otherwise stated, every survey shall be rendered using the following geodetic parameters Datum: ITRF2014 Spheroid: GRS ’80 Projection: UTM Grid Zone: As specified in the HI Geoid model: EGM08 Unless an alternative format is stipulated by a specific H-Form, all rendered positions shall be quoted as geographical co-ordinates (i.e. in terms of Lat. / Long) as decimal degrees to at least 8 decimal places. The realisation of ITRF used (i.e. 2014) should be clearly stated in the Report of Survey.
D2	**Geodetic Parameters Check**	If a datum other than ITRF is specified, a Geodetic Parameters Check should be conducted using the survey navigation system’s inbuilt test feature to demonstrate the correct transformation of coordinates between ITRF and the survey datum. If this is required it will be specified in the HI, together with a specimen set of coordinates to use in the Check. If a Geodetic Parameters Check is required, the result of the check shall be reported in the Mobilisation and Calibration Report.
D3	**Horizontal Uncertainty**	The Horizontal Uncertainty of all soundings and positions shall be in accordance with the Standard as stated in the HI.
D4	**Positioning**	The Contractor shall demonstrate that the method chosen for sounding positioning results in the overall horizontal and vertical uncertainty requirements for the Standard as stated in the HI being met. The Contractor will state methodologies for positioning as a tender deliverable. This can be post-processed or real time.

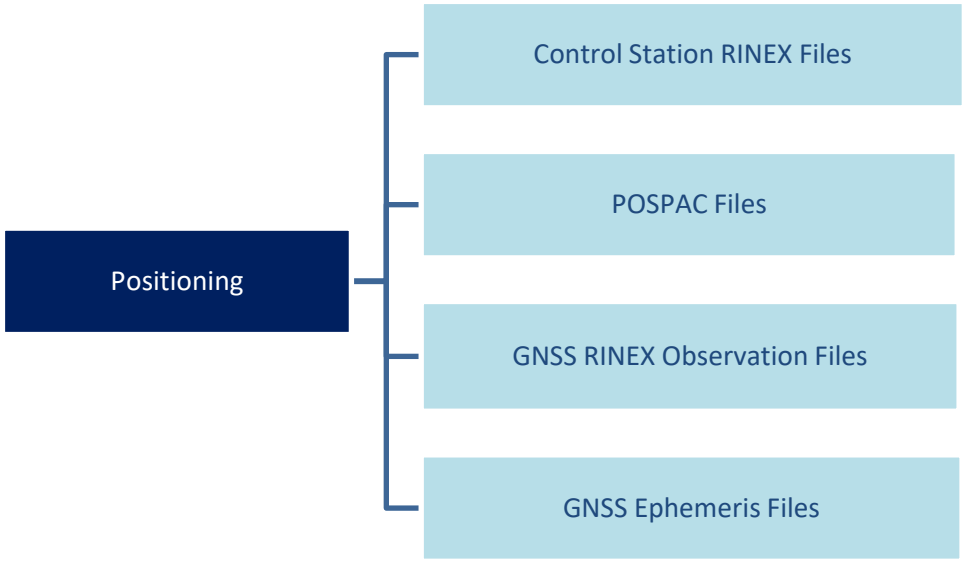
D5	**Establishment of Survey Control**	• Three-dimensional position of any existing or newly established survey control shall be determined by dual frequency carrier phase GNSS techniques, tied in to a Continuously Operating Reference Station network. • Multiple reference stations are to be used where available and a full network adjustment carried out to ensure the positional accuracies are met as stated below. • Data should be logged at 15 second intervals. • Where the maximum baseline length does not exceed 715km, a minimum of twelve hours of observations are required per station. • The observation period should be divided into two sessions of equal duration. At the end of the first session the antenna should be physically moved away from the mark and then re-established over the mark (at an appreciably different antenna height) before commencing the 2nd observation session. • Where the maximum baseline length is greater than 715km the following formula should be used to calculate the minimum required duration of observations per station in minutes: • Baseline length (in km) + (recording interval (in secs) x 0.5) The absolute uncertainty with respect to the coordinate system used (ITRF2014) for any existing or newly established survey control shall not exceed 1cm + 0.1ppm in horizontal and 2 cm + 0.1ppm in vertical (at the 95% confidence level) • When logging GNSS data care must be taken to use a suitable elevation mask (a minimum of 15°) and minimise the effects of multipath signals. This information must be included in the Report of Survey. • The height of the GNSS antenna should be measured before each logging session and clearly recorded and reported. If the height measured is a slope distance from the edge of the antenna, this shall be appropriately corrected to obtain the true vertical offset. • The static GNSS antenna shall be positioned directly over the control point using an optical plummet. • An orthometric height as described in the HI and appropriate UTM coordinate for each station shall be computed. Where necessary, co-ordinate conversion shall be conducted using appropriate (as agreed by the Authority) conversion programs and an estimated final uncertainty stated. The Authority will consider, but is not under any obligation to accept, alternative solutions to that described above. If the Contractor wishes to suggest an alternative solution, they must provide detailed technical evidence of their methodology and compliance with the absolute uncertainty requirements to the Authority within their tender.

D6	**Optical Levelling**	To perform a redundant check on any control established and/or utilised using GNSS techniques, all control points shall be optically levelled from two pre-existing control points referred to the appropriate Datum. The correct practices for traditional optical Differential Levelling are to be adhered to. In particular: • Prior to commencing a traverse, the correct calibration of the instrument is to be confirmed by performing a Two Peg Test. If required the instrument is to be adjusted and the test repeated to demonstrate that it meets the anticipated accuracy for the technique. The results of this test are to be recorded and presented as an attachment to the H532 Levelling Reduction Form. • Levelling is to be conducted between the 2 established control points, the tide pole and any existing benchmarks in the vicinity and provided in the HI. Levelling is to comprise a looped traverse, starting on the first known point and finishing on the second; no inter-sights shall be taken. Levels should be read and recorded to a precision of 0.001m. The maximum acceptable misclosure for a looped traverse is 0.02m. Any misclosure is to be in line with the apriori sounding budget. • The Authority recommend levelling is to be conducted using the Three Wire (top; middle and bottom of stadia) technique. • Levelling is to be conducted using *Foresights* and *Backsights* positioned at *Turning Points* in the traverse. The optical instrument is to be positioned at a point equidistant between the Foresight and Backsight with observations taken to both staffs. • If an area exists over which it is impossible to run differential levels with balanced sights, a new geodetic mark should be established in a location which eliminates this requirement. If this is impossible or impractical then the correct Reciprocal Levelling technique is to be employed to bridge the gap. • Every effort shall be made to ensure that the survey staffs are held vertically whilst observations are being taken. An appropriately mounted bubble Staff Level shall be employed for this purpose. • On soft or uneven ground, a Change Plate or similar is to be used to provide a footing for the survey staff at all Turning Points. • A Staff Baseplate with a pointed tip is to be used if geodetic marks used have a pronounced indentation at the measurement point. • Levelling shall be recorded using the H532 Levelling Reduction Form. Any levelling field records should also be supplied, including the results of the Two Peg Test. The calibration certificate for the optical level is to be appended.

		In some cases, this levelling requirement may be replaced by an entirely GNSS based redundant technique upon agreement with the Authority, should pre-existing control prove unsuitable or non-existent.
D7	**Station Marking & Documentation**	All geodetic stations established during survey operations shall be described, photographed and permanently marked to assist their future recovery. They shall be marked with a stainless steel, brass or bronze bolt drilled into concrete, in an area where they are unlikely to be disturbed. The bolt shall be punched to mark the precise horizontal measurement point. Stations shall not be established in tarmac. Stations should only be established on jetties or piers if assessed to be extremely stable. If a station is established on such a structure, the second station must be established on the shore. Stations deviating from the above requirements due to site conditions will only be permitted at the prior discretion of the Authority. The Authority will have the final say on geodetic station location suitability. A full station description shall be recorded using the **H159** Description of Geodetic Control Station Form, including photographs and diagrams to aid recovery. All stations are to be described in terms of ITRF2014 position and the following height datums: • ITRF ellipsoidal height • Chart datum • EGM08 • Local land datum (if known) Appropriate permissions must be obtained by the Contractor prior to establishing any permanent marks. Any new stations should be suitably positioned for GNSS observations and not be located close to buildings or anything that could obscure the sky or cause multipath problems. They should also be easily recoverable and on solid ground that is unlikely to move or be developed in the foreseeable future. H159 Description of Geodetic Control Station Forms are to be appended to the Mobilisation and Calibration Report.
D8	**Aircraft Dimensional Control**	An appropriate dimensional control survey of each aircraft utilised shall have been conducted prior to commencement. Permanent and recoverable control points are to be established on each aircraft utilised,

		coordinated to the vessel reference frame to within a tolerance ±0.01m relative (at the 95% confidence level) in X, Y and Z. All sensors shall be established within the vessel reference frame within a tolerance of ±0.02m relative (at the 95% confidence level) in X, Y and Z. Where appropriate, the rotations of each sensor around the X, Y and Z axis shall be initially determined by the dimensional control survey to within ±0.2 degrees (at the 95% confidence level). These values may be later adjusted during the lidar repeatability test if required. A copy of the dimensional control report for each aircraft shall be supplied with the RoS for each HI. Any deviation from the above must be discussed and agreed by the Authority. The results of the Aircraft Dimensional Control may be presented as a stand-alone document or, if conducted in the field, are to be included in the Mobilisation and Calibration Report.
D9	**Lidar Calibration**	A calibration of the Lidar system and associated sensors shall be performed at the start of each survey, if there is significant change in the repeatability test and after changing out or significantly reconfiguring any survey sensor iaw D10-14. Any deviation from the prescribed procedure must be proven to and agreed by the Authority.
D10	**Static Positioning Check**	A Static Positioning Check shall be performed at the start of fieldwork for each HI and after changing out or significantly reconfiguring any GNSS sensor or antennae. The positioning data to be compared must be derived using the same equipment and configurations which will subsequently be used to obtain all positions associated with the bathymetric data. The Static Positioning Check shall monitor either: • The three-dimensional position of both the primary and secondary GNSS antennae, for a period of no less than 30 minutes at a 6 second resolution or; • The three-dimensional position of another appropriate point within the vessel reference frame as calculated by navigation system computations from positions supplied by both the primary and secondary GNSS antennae and the vessel heading sensor, for a period of no less than 30 minutes at a 6 second resolution.

		The Static Positioning Check report should separately state the computed statistical reliability of both the horizontal position and the height measured. Any local survey control utilised in this procedure shall be compliant with the requirements above in Establishment of Survey Control **(D5)**. The detail of the proposed methodology and analysis shall be presented in the tender. The results of the Static Positioning Check are to be included in the Mobilisation and Calibration Report.
D11	**Lidar Dynamic height check**	A test area no smaller than 10m2 is to be surveyed on land to an accuracy of 2cm in horizontal and 5cm in vertical (at the 95% confidence level) with a grid point every 1m. The system is then to be flown over this site in a number of directions and the resultant data used to confirm the calibration of the system. Full details are to be rendered as part of the final deliverables.
D12	**Lidar Roof Test** .	A roof test is to be conducted where the system is to be flown over a building with a pitched roof from 4 directions 90^{o} apart. The resultant data is to be used to demonstrate the correct calibration of the system. On completion of the roof test the system is to be flown overland to sea. A difference of no more than 0.1m is to be achieved at this crossover. The aerial photography system is to be checked during the roof test to ensure that it is coincident with the Lidar and detailed in the Report of Survey
D13	**Bathymetric Repeatability Test**	Unless a suitable object is known (as detailed in the HI) a suitable underwater object should be identified as early in the survey as possible to conduct a bathymetry repeatability test following calibration at the start of each survey, changing out or significantly reconfiguring any survey sensor and at the end of the survey (methodology shall be detailed in tender). This test should be conducted after the dynamic height check stated above. The subsequent report should separately state the computed statistical reliability of both the horizontal position and the depth measured for the feature.
D14	**Strip Adjustments**	To achieve the data uncertainty noted at G7 and a seamless crossover between bathymetry and topography, a strip adjustment is to be conducted based on a number of Ground Control Points (GCPs) if necessary on the

		topographic data, with full details of the process and adjustment is to be noted in the tender documentation and reported in the RoS. GCPs are to be: • Spread evenly throughout the survey area • No more than 25km apart Coincidence with crosslines
D15	**Position Quality**	The navigation display shall be configured to provide a real-time indication of the 3D position and any received GNSS augmentation data. Company shall provide an indication of the continuous quality of the post-processed 3D position.
D16	**Deliverables - General**	Positioning data is to be rendered using the following structure: 

D17	**Deliverables – Milestone 1**	• Dimensional Control/Calibration/Validation Report
D18	**Deliverables – Milestone 3**	• All logged survey control geodetic observation data and reference station data. All data must be in RINEX format. • All ephemeris data used for computations. • Baseline processing and network adjustment reports for all geodetic observations.

Part E - Tides

E1	**Reduction of Soundings**	All soundings are to be reduced to Chart Datum as specified by the specific HI. This will usually be by one of two methods: • Direct reduction from local tide observations collected for the duration of survey operations. • GNSS heighting using a spheroidal separation model. Soundings are to be presented as depths below Chart Datum, as supplied by the Authority. The Contractor shall demonstrate that the method chosen for sounding reduction results in the overall depth uncertainty requirements being met. Alternate methods of sounding reduction may be approved by the authority in certain cases but must be fully outlined in individual survey tenders.
E2	**Establishing Chart Datum**	Where the Authority deems that Chart Datum within the extents of an HI area is not adequately defined by the current infrastructure or historical knowledge, the Contractor will establish a tide gauge(s) in accordance with **E3 & E4.** The location of the tide gauge(s) being agreed between the Authority and the Contractor. The HI for an area will detail if the Contractor must undertake a Transfer of Tidal Datum iaw **NP122**[4] using form **H533 or** define a Sounding Datum for the survey in accordance with **NP122**. In either case this data is to be forwarded to the Authority at the earliest opportunity to establish CD. The final value for CD will be passed back to the Contractor who is to use it for the final reduction of soundings.

[4] Extract will be provided by the Authority if required.

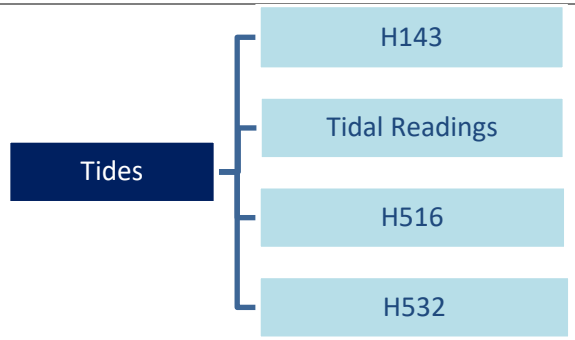
E3	**Establishment of Shore-Based and Offshore (Seabed Mounted) Tide Gauges**	Onshore/offshore tidal stations may be required within the extents of an HI area. The HI will confirm local requirements. Some HIs will require supplementary tidal stations, and some will require the use of locally available permanently installed gauges, e.g. local Port Authority or National Network tide gauges. When requested in the HI, tidal heights will be measured throughout the survey period and for a minimum of 30 days using a temporary or 'continuously operating' tide gauge capable of meeting all the requirements stated below. • Automatic tide gauges (both onshore and offshore) are to have a measurement accuracy of ±0.01m or better. • Gauge time is to be synchronised with UTC on set up and is to drift by no more than ±0.5 min in time over the course of the survey operation. Gauges should be configured to take readings on the hour and at least 10-minute intervals thereafter. • Longer term deployments of gauges are to include a mechanism (e.g. GNSS clocks or network time) to ensure the gauge remains aligned with UTC to with the required specification stated in the HI. • On demobilisation of all gauges and during data downloads or tide gauge checks, gauge time is to be checked against UTC and recorded. • Heights must be recorded to at least 2 decimal places of precision and at sample intervals no longer than 10 minutes. Offshore (and non-vented) tide gauges shall be corrected for atmospheric pressure. Temporary or permanent air pressure sensor for this purpose are to meet all of the following requirements: • Pressure is to be recorded at a location representative of the survey area in terms of air pressure. • Pressure sensors are to measure an accuracy of ±0.5hPa or better • Time is to be synchronised with UTC on set up and is to drift by no more than ±0.5 min in time over the course of the survey operation. Pressure sensors are to be configured to take readings at the same time and interval as the corresponding tide gauge(s).

E4	**Continuously Operating Tide Gauge**	Where a continuously operating tide gauge is required, the following requirements are to be met: • Robust fittings capable of withstanding Category One (Saffir-Simpson Scale) hurricane force winds. • Enough power generation (solar/wind) and storage (batteries) to enable continuous operation in expected meteorological conditions. • A minimum of two separate gauges of different types (pressure/radar/float/acoustic). • Communications equipment capable of uploading data to the GOES[5] system operated by NOAA[6]or FTP site as stated in the HI. Additionally, the following may be requested in the HI, which will also need to be configured to be uploaded with the main tide level data: • Atmospheric pressure sensor. • Continuous GNSS measurements. Where systems are going to be integrated into the IOC's GLOSS or Tsunami Warning Systems the recording characteristics are to be amended as follows: • Readings are to be taken every minute. • Upload to the GOES or FTP is to be conducted every 5 minutes.
E5	**GNSS Tide Buoys**	Where a separation model is to be used, GNSS buoys may be specified in the HI or be acceptable as a tender response. In such instances the following requirements are to be met: • The buoy is to be established in an area agreed between the Authority, Contractor and Local Authorities. • The ground mooring is to be sufficiently secure to ensure the buoy does not drag. • The buoy is to have suitable battery or power generation to operate for the entire period of survey operations and for a minimum of 30days in total. • Vertical measurements are to have a resolution of 0.01m or better • Vertical measurements are to have an overall accuracy of 0.1m or better.

[5] Geostationary Operational Environmental Satellite
[6] National Oceanic and Atmospheric Administration

		• Vertical measurements must be recorded to at least 2 decimal places of precision. • Data may be real-time or post processed providing it achieves the required resolution and accuracy requirements. • All times are to be in UTC. • The buoy should be capable of uploading data to a satellite or other link and data flow checked at least daily during survey operations to ensure there is no data outages experienced. Additionally, the following may be requested in the HI: • Atmospheric pressure sensor.
E6	**Pole-to-Gauge Calibration**	Offshore seabed mounted gauges do not require pole to gauge but must be referenced to Chart Datum using methods described in **E2.** All shore-based tide gauges must be calibrated by reference to independent readings using a tide pole/stilling well or other manual method (e.g. top down air gap measurements using a weighted tape measure from a known survey mark, see sections **D5, D6 & D7**) which can be subsequently tied into the vertical control. The **H143** spreadsheet must be used for this purpose. Readings are to be synchronised with the tide gauge and are to be taken half-hourly as a minimum, with 10-minute interval readings taken for the duration of one hour before to one hour after high and low water. If observing at a location with a tide range in excess of 5m (or where the range is perceived to be changing rapidly) the observations are to be taken every 10 minutes, and every 5 minutes for the duration of one hour before to one hour after high and low water. All tide gauges installed by the Contractor require a minimum 25-hour period of manual observations. The pole/stilling well is to be read to an accuracy of ± 0.025m, with the time of each reading recorded to within ± 5 seconds of UTC; the same applies for a 'top down air gap' measurement technique. Reports on the Pole to Gauge comparison are also to be made on Form **H516** (Summary of Checks on Automatic Tide gauge). The pole used shall be levelled to at least two permanently mounted and documented control points which meet the requirements stated in **Establishment of Survey Control (D5)** and **Station Marking and Documentation (D7)**.

		The pole and subsequently the tide gauge should also be referenced to spheroidal height to allow the Spheroid separation to be established. When a permanent / previously established tide gauge is used, a pole to gauge calibration is required to ensure the gauge is correctly calibrated (unless documented evidence can be provided in the Report of Survey that this check has been undertaken within the last 6 months by an appropriate authority). The HI will confirm local requirements.
E7	**Separation Model**	A separation model where used shall make full use of all separation values measured during the survey and any additional values provided by the Authority. Additionally, sea surface measurements are to be taken during flight lines that span the entire survey area. These lines are to: • be evenly spaced at no more than 25km intervals or as specified in the HI. • be run over any tidal stations established during the survey. • run in a direction as specified in the HI or as agreed by the Authority. • be run in the most ideal environmental conditions (low swell, sea state). • be run as close to slack water as possible. • be reduced using the final observed tides as approved by the Authority. Once separation values have been gained from these measurements they are to be used to supplement/check the tidal station separation values used. The separation model is to be provided to the Authority along with check line data and a full explanation/report of its production prior to final data reduction to allow validation.
E8	**Tidal Stream Observations**	Tidal stream shall not normally be required, but if it is the requirements in the 'UKHO Hydrographic Survey Specification (Acoustic)' are to be met.
E9	**Deliverables - General**	Tidal data is to be rendered using the following structure:



E10	**Deliverables – Formats**	Tide gauge records, including raw tide heights (not just pressure readings) and metadata, are to be submitted in .csv file format or Microsoft Excel format (.xlsx) as follows: dd/mm/yyyy,hh:mm:ss,m.mm For example: 13/01/2018,02:00:00,1.08 13/01/2018,02:10:00,1.07 13/01/2018,02:20:00,1.06…etc. The following metadata must be included in the Report of Survey and H143: I. Tidal Instrument Type, Make & Model II. Position of Tide Gauge Horizontal Datum (degrees, minutes and decimal minutes, dddmm.mm) III. Coordinate type IV. Projection (if applicable) V. Height above Chart Datum VI. GNSS Height of the gauge zero VII. Data format of supplied file(s) preferably .csv (see above paragraph for details)

		VIII. Tidal Observations Start Date, Time and Time Zone (in the format: yyyy-mm-ddThh:mm:ss±hh:mm) and Tidal Observations End Date, Time and Time Zone (in the format: yyyy-mm-ddThh:mm:ss±hh:mm) IX. If there are any data gaps in the record, enter the gap date range in the format yyyy-mm-ddThh:mm:ss±hh:mm to yyyy-mm-ddThh:mm:ss±hh:mm (Note: for the above two bullet points the hyphens are required, as is the "T" character between the date & time fields. The "±hh:mm" refers to the Time Zone of the observations (so for GMT this would be +00:00 [positive east and negative west of Greenwich Meridian). X. Time Zone of the supplied data (UTC) XI. Time interval of the tidal records (e.g. 1, 6, 10 minutes etc.) XII. Note any specific details regarding the tidal data record submission, i.e. surge, noisy data etc, or if the data been adjusted or manipulated in any way (i.e. differs to the original instrument raw data, a vertical datum adjustment part-way through, etc).
E11	**Deliverables – Milestone 3**	• H143 for all tidal stations. • Tidal records.

Part F - Bathymetry

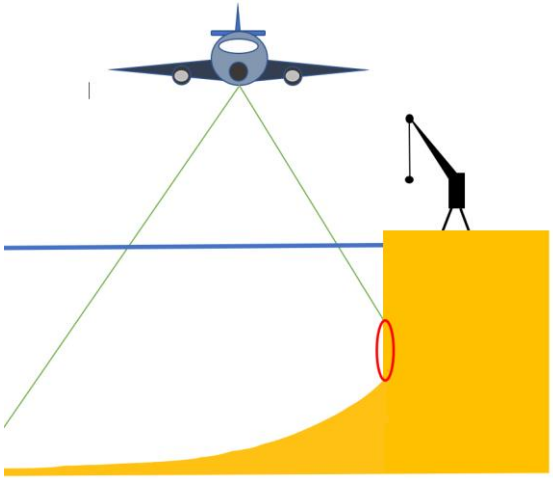
F1	**Bathymetric Data**	Depths will be measured throughout the survey area using a lidar systems or combination of systems capable of meeting the requirements stated in this part. Depth requirements will be detailed in individual HIs, but as a minimum, systems should be capable of achieving the requirements of this part to a depth of 45m in optimum water conditions. The expected maximum depth of the proposed system should be detailed in the Company's tender documentation and that achieved noted in the RoS. IHO Order 1B as described in this part is the minimum requirement for bathymetric data collected under this specification, however IHO Order 1A will usually be required in 'shallow' water. Additional requirements to meet this standard are detailed in this part. The ability of the proposed system to achieve these additional requirements is to be detailed in the Company's tender documentation and where achieved noted in the RoS. The Contractor shall provide empirical evidence of each system's ability to meet the stated requirement to the Authority as a tender deliverable.
F2	**Bathymetric Lidar Data Quality Measures**	Bathymetric quality reporting is to be based upon the following criteria: • Individual Sounding Uncertainty • Sounding Density • Lidar Coverage
F3	**Uncertainty**	Systems or combinations of systems are to be capable of achieving sounding uncertainty (in three dimensions) in accordance with the Standard as stated in the HI.
F4	**Uncertainty Model**	The Contractor shall provide a fully developed A Priori uncertainty model to the Authority prior to survey operations commencing. The model shall state all component uncertainties, as well as the combined total uncertainty.

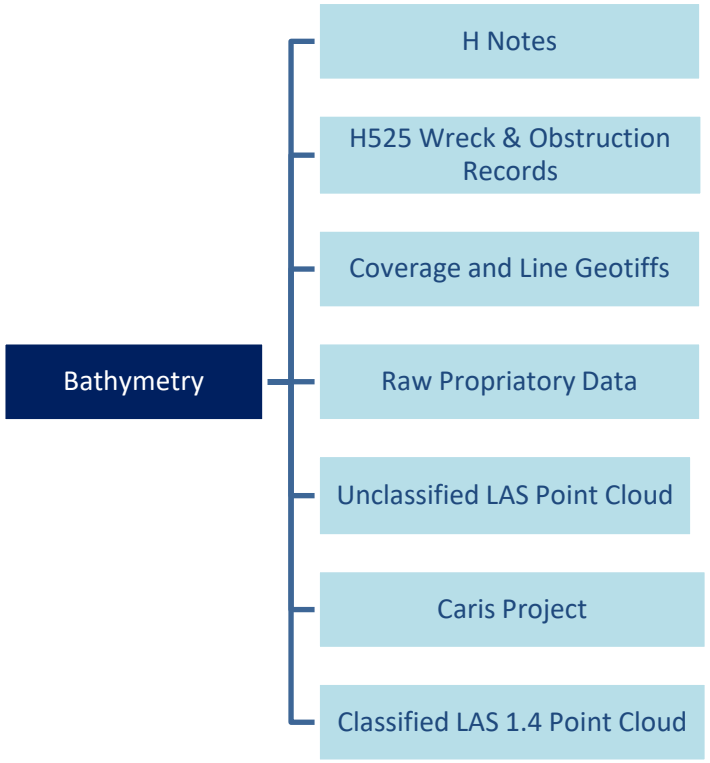
		The model is to include an estimate of footprint size and expected spreading with an indication when this exceeds the IHO Order 1A object detection for a 2m object. This should be taken as a spot with a radius greater than 1.414 m. Details from this model as well as real time factors should be entered into the processing system to ensure all soundings are attributed with realistic TPU values. These values are to be visible/reproduced in the final Caris project.
F5	**Sounding Density**	For areas quoted as 1B a minimum of 2 unique[7] accepted soundings are to be achieved in a bin with sides of 2m for at least 90% of all bins. Less than 1% of bins are to have no hits. In the case of bins with no hits there are to be no more than 4 conjoined bins. All poor performance areas are not to be in the same area (excluding areas where ships, turbidity etc have precluded data collection). Areas failing are to be geographical represented in a .hob file with relevant explanation. Where increased density is required in shallow waters as described in **F1** a minimum sounding density of 9 accepted soundings must be achieved in a bin with sides of 2m for at least 99.9% of all bins. In this case the following are to be adhered to: • No bin is to have less than 5 hits • There are to be no more than 2 conjoined bins where density is less than the requirement • There are to be no bins that do not meet the density requirement over wrecks or other obstructions Where initial density does not meet the required specification and subsequent lines run, they must be at least 45° off the main line direction to ensure different scan geometry is achieved. No more than 3 different passes are to be used to achieve the required density for order 1A. The Authority's decision on the requirement for re-flights is final.
F6	**Lidar Coverage**	Full seafloor coverage shall be achieved in the area detailed in the HI. All effort is to be made to gain valid depths throughout the survey area along coastlines and over shoal rocks and obstructions. This may be achieved by either using the topographic Lidar at low

[7] Each sounding can only contribute to 1 bin

		water or the bathymetric Lidar at high water. Methodology is to be fully described and justified in the Report of Survey. In order to ensure safety of navigation throughout defined polygon areas, full coverage is to be achieved even where depths extend deeper than the extinction depth of the Lidar system. This is to ensure that any isolated features shoaler then the extinction depth will be detected. Where possible, the Company is to collect data during periods of low turbidity (calm weather & low swell). Any gaps in coverage or density should be re-flown under different conditions. Where gaps in coverage still exist that are not delineated by the extinction depth cut off, the Company is to provide full details including; 'no bottom detection' soundings, photography, swell, and persistent low cloud, before commencing demobilisation. While it is accepted that gaps may remain, the Authority's decision on any infill requirements is final. Any remaining gaps must be similarly detailed in the Report of Survey and on the .hob file.
F7	**Crosslines**	A minimum of 4 bathymetric crosslines or one every 25km, whichever is the greater, shall be run for each Survey Block of the Hydrographic Instruction. Crosslines shall be at approximately equal spacing and be approximately perpendicular to the typical mainline orientation in that block. Crosslines shall be rendered in folders separate from the mainline data structure but may be used in the final dataset and therefore must be cleaned as per **Data Cleaning (F11)** to allow for analysis. An analysis between cross-lines and the main data set against compliancy with IHO depth accuracies is to be given in the Report of Survey.
F8	**Wreck/Obstruction Investigations**	All suspected wrecks (including those stranded at any state of tide) and manmade obstructions located during the survey shall be reported on form H525. Imagery where suitable is to be used to augment the lidar bathymetry and assist in the overall description of the wreck. A wreck/obstruction investigation is to be run for all located or suspected wrecks/obstructions (unless it uncovers and the shoalest point is captured by topographic/imagery data) consisting of running at least one additional line at approximately 90 degrees to the main line direction over the centre of the wreck/obstruction position. Speed and altitude are to be kept as low as practicable for the aircraft type in use to maximise sounding density.

F9	**Leading Lines, Tracks, Dredged Channels and anchorages**	The leading lines and recommended/dredged tracks along channels and into harbours and anchorages must be very carefully examined and are to be given priority over other areas when planning optimum times for data capture. An additional survey line is to be run along the course of the lines, track and channels as early in the survey as practicable. If navigationally significant differences between physical features and their depiction on the current Admiralty nautical charts and publications are detected, then this should be immediately reported to the relevant Port Authority and the Authority using form H102. Sounding density for all such tracks and lines is to achieve order 1B requirements as defined at paragraph 5 of this part for all bins. Where no channel limits are shown on the largest scale BA Chart, the width of a single swath of lidar data (flown at an altitude and with sensor settings as per the tender) should be taken as the limits of the channel.
F10	**Depth Data Precision**	Depth data recorded shall be logged and processed to at least two decimal places of a metre. Processing systems should be set to round down all values to give a shoaler depth than measured.
F11	**Data Cleaning**	All accepted soundings within the final bathymetric dataset shall fall within the uncertainty allowance for the IHO S44 Order as stated in the HI. All systematic errors and obvious outliers shall be rejected from the bathymetric data. Soundings falling within the uncertainty allowance, but still numerically distant from the main dataset, will be regarded as outliers and should be flagged as rejected in the Caris project or classified as noise in the LAS point cloud. All transient features (for example boats, mooring lines, birds and marine life) are to be rejected form the dataset.
F12	**Data Cleaning Guidance – Notes layer**	A CARIS 'notes' .hob layer is to be used to bring attention to items of specific interest in the dataset as well as noting them in the RoS. The list of objects to be outlined includes but is not limited to: • Pipelines • Bottom tackle for buoys or other floating objects. • Areas identified by local contacts as dump or dredge areas. • Areas identified as areas containing fishing equipment such as traps or (semi-) permanent nets.

F13	**Data Cleaning Guidance – manmade features**	All manmade features that extend above the surface (jetties, piers) are to be rejected. Types of features to look for:   Data that should be rejected: 

		Lidar data might sometimes be gathered underneath structures. In these situations, the vertical dry structures should also be supressed, and the seabed left in as described above.
F14	**Deliverables - General**	Bathymetric data is to be rendered using the following structure:  The HI may request additional deliverables or reduce the requirement of those deliverables detailed below.
F15	**Deliverables - Hydrographic Notes**	Reports of any newly discovered dangers to surface navigation shall be passed immediately to the Authority using the **H102** Hydrographic Note form or UKHO H Note Application.

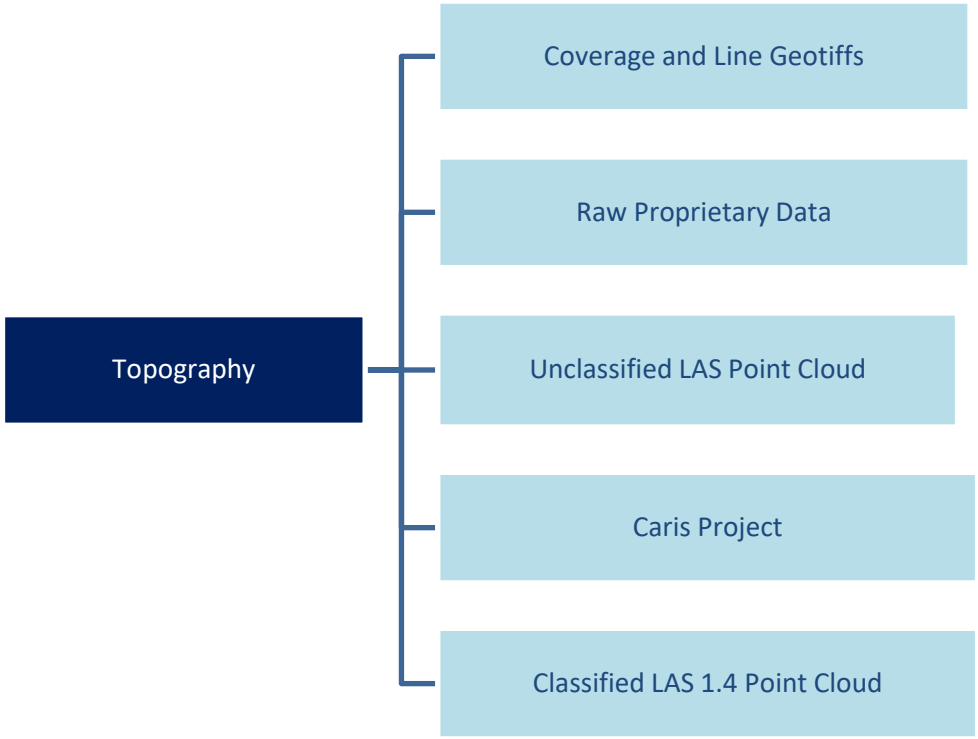
F16	**Deliverables - Fixed and Floating Aids to Navigation**	The positions and characteristics of all fixed and floating aids to navigation visible from the survey area do not need to be specifically reported. However, if navigationally significant differences between physical features and their depiction on the current Admiralty nautical charts and publications are detected, then this should be immediately reported to the relevant Port Authority and UKHO using the **H102** form or app. The final classified LAS point cloud should have all such objects classified as 44.
F17	**Deliverables - Comparison with Published Chart**	The sounding detail shown on the largest scale published Authority chart of the survey area is to be critically examined and any significant differences reported. A comment is required for any charted dangers that were not discovered during the survey, or where the least depth found over a danger during the survey is deeper than charted. Any other errors, ambiguities or other defects shall be reported.
F18	**Deliverables – Prior to Demobilisation**	• Geotiff showing final coverage achieved and statement of reasoning behind any areas not achieved. This shall show ellipsoidal heights of all areas based on a grid equating to the density requirements ($2m^2$). • Geotiff showing all flight lines undertaken. • Demobilisation report confirming completion of all planned flight lines and completion of data gathering to the required specification.
F19	**Deliverables – Milestone 2**	• Raw data (proprietary format) containing full reflectance and waveform record. • Unclassified/unfiltered LAS files with sufficient metadata to allow import into GIS software to allow visualisation of collected data.
F20	**Deliverables – Milestone 3**	• Processed (cleaned) sounding data in a CARIS HIPS Project including all accepted and rejected depths, structured by aircraft and including cleaned crosslines in separate folders. • All Lidar point cloud data in fully compliant LAS 1.4 or later (as agreed by the Authority) Point Record files. This is to be level 1 classification (Annex A6) as a minimum although the HI may specify level 2. • HOB or Shape file outlining areas that have achieved IHO standard in line with the specification. • Additional Lidar point clouds with specific features removed as required by the HI.

F21	**Bathymetric Data Attribution**	Processed bathymetric data shall contain the following attributes for each sounding as a minimum: position and depth; reflectivity; 95% statistical uncertainty estimation for position; 95% statistical uncertainty estimate for depth. Files shall be full density (i.e. not "thinned") with rejected soundings flagged but not deleted from the data set.
F22	**Processing Software**	The CARIS HIPS software version shall be up-to-date at time of rendering. Projects delivered using CARIS HIPS v9 (and later) must not be indexed. The data must be converted to full HDCS format. The version of Caris HIPS used is to be agreed with the Authority prior to commencement of work. The Authority has final say over the version used.
F23	**Point Clouds**	Bathymetric point clouds are to be provided in LAS 1.4 format as described at **Annex A**.
F24	**Data Blocks**	While the HI will detail the number of bathymetric survey blocks required, the Company may propose an alternate rendering strategy dependent on final data volumes. The Authority's decision is final.
F25	**Quality Control**	Robust quality control procedures shall be provided and adhered to during processing of all data. These procedures shall be required at tender or are to be provided to the Authority prior to survey operations commencing.

Part G - Topography

G1	**Topographic Coverage**	Heights will be measured on all land adjacent to the bathymetric survey area to a minimum of the 15m height contour based on the defined Chart Datum. All effort is to be made to gain valid topography throughout the survey area along coastlines and over exposed rocks and obstructions. This may be achieved by either using the topographic Lidar at low water or the bathymetric Lidar at high water. Methodology is to be fully described and justified in the Report of Survey. The HI may detail additional topographic requirements or horizontal coverage limits.
G2	**Flight Lines**	Flight lines used to gather topographic data may be extensions of bathymetric lines but are to be optimised to ensure maximum coverage of all topographic features. A minimum of 20% overlap is to be planned for data coverage.
G3	**Crosslines**	A minimum one every 25km are to run whichever is the closer interval. Crosslines shall be approximately perpendicular to the typical mainline orientation in that block. Crosslines may be used in the final dataset and therefore should be cleaned as per **Data Cleaning (G9)** to allow for analysis. An analysis between cross-lines and the main data set against compliancy with the required accuracies is to be given in the Report of Survey.
G4	**Point Density**	A minimum of 10 accepted data points are to be achieved per $1m^2$
G5	**Topographic Data Uncertainty**	Topographic data should conform to the following uncertainties: • +/-0.20m vertically at 95% confidence level • +/-0.50m horizontally at 95% confidence level
G6	**Uncertainty Model**	The Company shall provide a fully developed uncertainty model to the Authority prior to survey operations commencing. The model shall state all component uncertainties, as well as the combined total uncertainty.

		The uncertainty is to be quoted in terms of 95% confidence levels as described in G6 and in terms of RMSE.
G7	**Height Data Precision**	Height data recorded shall be logged to at least two decimal places of a metre.
G8	**Data Cleaning**	All systematic errors and obvious outliers shall be rejected from the topographic data. Data points falling within the accuracy requirements at **G6** but still numerically distant from the main dataset are to be regarded as outliers and rejected.
G9	**Data Blocks**	Data should be split into manageable data blocks as agreed with the Authority. These may be in line with areas in the HI or created to best manage data in terms of flight lines or processing. The Authorities decision is final.
G10	**Deliverables - General**	Topographic data is to be rendered using the following structure:



The HI may request additional deliverables or reduce the requirement of those deliverables detailed below.

G11	**Deliverables – Prior to Demobilisation**	• Geotiff showing final coverage achieved and statement of reasoning behind any areas not achieved. This shall show ellipsoidal heights of all areas based on a grid equating to the density requirements ($1m^2$). • Geotiff showing all flight lines undertaken and individual swath coverage. • Demobilisation report confirming completion of all planned flight lines and completion of data gathering to the required specification.

G12	**Deliverables – Milestone 2**	• RAW[8] unclassified LAS files with sufficient metadata to allow import into GIS software to allow visualisation of collected data. • All raw data files in native format.
G13	**Deliverables – Milestone 3**	• Processing workflow for classification, 'cleaning' and quality control. • Fully cleaned and classified LAS 1.4 Point Cloud on the ellipsoid at the classification level detailed in the HI. • Additional LAS 1.4 Point Clouds reduced to Chart Datum or other land datum may be specified in the HI. • A DSM[9] of first returns is to be provided at a 1m resolution or as specified in the HI. • Additional 'products' such as raster DEMs and DTMs[10] (for example Bare Earth) may be specified in the HI. • Fully processed topographic data reduced to Chart Datum is to be rendered as part of the Caris HIPS Project where rendered in conjunction with bathymetric data. The CARIS HIPS software version shall be up-to-date at time of rendering and agreed with the Authority prior to commencement of work. Projects delivered using CARIS HIPS v9 (and later) must not be indexed. The data must be converted to full HDCS format.
G14	**LAS Classification Scheme**	All accepted points must adhere to the modified ASPRS-LAS classification scheme at **Annex A**. Additional classes may be included as deemed suitable by the Company to best define the data and assist in data cleaning and product creation. Point data record format 9 is to be used to allow the addition of classification values 40 to 45 when combined with bathymetric data as defined in the ASPRS LAS Topo-Bathy Lidar Domain Profile.

[8] Unfiltered

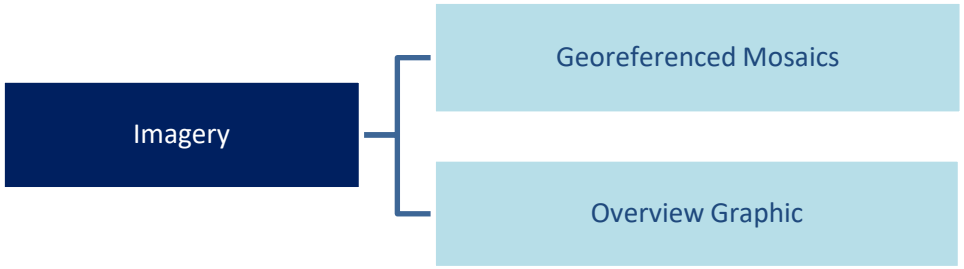
[9] Digital Surface Model (a DEM that represents surface objects, such as buildings and vegetation, as well as open terrain.)

[10] Digital Elevation Model (a representation of a continuous surface of elevation values in a digital format, usually as a raster grid). Digital Terrain Model (a DEM that represents "bare-earth" terrain.)

Part H - Aerial Photography

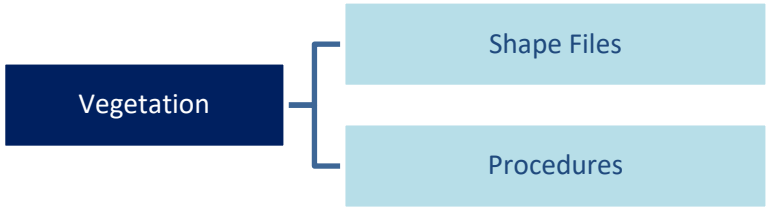
H1	**Requirement**	Aerial photography is split into two levels of complexity as detailed below: 1. Basic level for use in processing and quality control. 2. Product level photography for use in feature extraction and other application. Level 1 will be required for all lidar surveys, whereas level 2 may be requested in the Hydrographic Instruction and will be dependent on cost.
H2	**Inclusion**	Level 1 georeferenced photography of the entire survey area is to be taken coincidentally with lidar data capture. Level 2 georeferenced photography will be dependent on cost and impact on lidar data acquisition and will be fully detailed in the HI.
H3	**Coverage**	There is to be no gaps in photography between adjacent flight lines. Level 1 - The entire area defined within the HI. Level 2 – All topography, coastline out to approx. 10m contour (or as otherwise stated in the HI) and all features, manmade or otherwise, that uncover at any state of tide.
H4	**Collection**	Level 1 - The collection of aerial photography is to be secondary to the collection of lidar data. Whilst atmospheric conditions should be considered when planning optimum flight times for photography it should not do so at the expense of lidar data capture. Any data capture during hours of darkness is not to be conducted over areas of seabed that would be visible during daylight under current water clarity conditions or over land. Level 2 – The final rendered mosaics should be taken from flight lines that are specifically planned for that requirements which may be separate to the main lidar collection and run with different flight path characteristics as required to best meet the requirements of this specification and the HI. All rendered mosaicked photography is to be taken in daylight. Images as far as possible are to be free of clouds, shadows from clouds, smoke and significant haze. The Authorities decision on the requirement for re-flights is final.

H5	**Resolution**	Aerial photography is to be acquired and processed to the following minimum resolution (Ground Sample Distance); Level 1 - 0.5m Level 2 Up to 0.1m resolution depending on specific requirements detailed in the HI.
H6	**Spectral Range**	Level 1 – Three band; RGB. Level 2 – Multi-spectral (RGBN) may be specified in the HI. Data values for all photographic products should be set to the range 1-254 (not 0-255). This is to reserve the values 0 and 255 for null image data. All null values are to be a single value (0 or 255) to allow viewing of overlapping cells
H7	**Spatial Accuracy**	Level 1 - +/- 2m at 95% confidence level Level 2 - +/- 1m at 95% confidence level or as specified in the HI.
H8	**Orthorectification**	Level 1 - While it is not necessary to produce a 'true orthophoto' that corrects for building lean, seamlines are to be placed to avoid bisecting jetties, buildings or other manmade objects projecting above the bare earth terrain model. Level 2 – True orthophoto where 3D elevation data (resolution of which is to be equal to the image resolution) for buildings in addition to the bare earth model are to be used to orthorectify imagery. Additionally, pixels from adjacent frames are to be used to fill in the ground that has been obscured by building 'lean' seen in the original frames.
H9	**Colour Balancing**	Level 1 - Whilst it is not necessary to provide a completely seamless fully colour-balanced photo mosaic, care should be taken with photographic exposure and mosaicking to ensure that the imagery is suitable for processing and validation of bathymetric datasets. Level 2 – Colour balancing and colour matching between frames shall be performed to achieve a homogeneous image. Contrast and brightness of each image should be adjusted to minimize variations between images.

H10	**Mosaicking**	Photography should be orthorectified and mosaicked and provided as 1km square blocks in the specified georeferenced image file formats that do not affect null value representation. Individual blocks are to be named as a derivative of the UTM Coordinate System specified in the HI. For example, a tile with lower-left UTM coordinates 372,000E, 1,937,000N is to be named 372000-1937000. An index diagram (GeoTIFF) or Shape file to allow easy cross-referencing during validation is to be provided in a format agreed by the Authority.
H11	**Time & Date**	Time and date of photography should be supplied to enable subsequent cross referencing between photographed state of tide and actual recorded state of tide.
H12	**Deliverables - General**	Imagery data is to be rendered using the following structure:  The HI may request additional deliverables or reduce the requirement of those deliverables detailed below.
H13	**Deliverables – Milestone 3**	Level 1 • Georeferenced 8-bit RGB image mosaics of the most appropriate images that cover the entire survey area. Provided in both ECW and LZW GeoTIFF. • Index diagrams/Shape file to include a mosaicking seamline vector file. • The Report of Survey is to include details of the camera model, lense(s) fitted and a workflow for image processing and mosaicking process Level 2

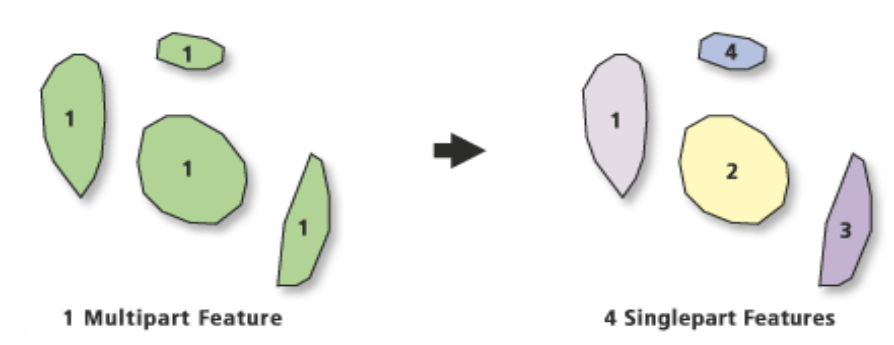
	• Separate georeferenced 8-bit RGBN image mosaics at the specified GSD of all topography, coastline and all features, manmade or otherwise, that uncover at any state of tide. Provided in both ECW and LZW GeoTIFF.

Part I – Vegetation Mapping

I1	**Requirement**	The requirement for vegetation mapping will be dependent on the area and may include areas of mangrove, macro-algae (kelp), seagrass or other marine vegetation visible from the air. Areas for vegetation mapping will be indicated either in the HI or by the Client representative during other survey work.
I2	**Inclusion**	Vegetation Mapping will be dependent on cost and impact on other survey data acquisition.
I3	**Imagery**	The imagery collected during bathymetric data collection is to be used unless specified otherwise in the HI.
I4	**Ground Truthing**	Ground Truthing may be required, if suitable small craft are available and can be safely deployed (see UKHO Acoustic Specification for requirements). All ground truth data should be logged and provided as part of the rendered data.
I5	**Deliverables - General**	Vegetation data is to be rendered using the following structure: 
I6	**Data Blocks**	While the HI may detail the number of survey blocks required, the Company may propose an alternate rendering strategy dependent on final data volumes. Where site conditions require the use of different settings throughout the survey area, the Authority is to be informed and the survey area may need to be divided in blocks of similar settings as agreed with the Authority.
I7	**Deliverables Macroalgae Classification**	The Contractor shall interpret imagery and any ground truth data to provide details of vegetation in the survey areas. This is to be rendered as an ESRI MXD or individual Shape Files. The Contractor shall also provide details of the procedures and software to be employed as a tender deliverable.

The vegetation classification will include the following:

- Point features for each ground truth data point taken.
- Area features for each vegetation type.
- Area features for surface/subsurface vegetation.
- Area features for vegetation density.
- Area features for sea surface conditions at time of survey.

I8	**Shape Files or Feature classes within a Geodatabase**	• May only hold features with the same geometry, which is defined as; point, line, or polygon. • Must be of polygon type (not polygon ZM or other type). • For each shapefile or feature class deliverable, there shall be no gaps or overlaps between adjacent polygons within that individual a shapefile or feature class. • Must have the appropriate assigned coordinate system. • Contain all specified attributes, even if the field is left blank. • Meta data must follow ESRI ISO 19115-1:2014 and shall be fully populated including geospatial information. • Each Shapefile/Feature Class must only contain single part polygons. Eg: - Individual polygons within a feature class can be individually selected, see below for an example.  The tables in I9 to I12 have been completed for macroalgae but could be amended for each vegetation type being mapped.
I9	**Vegetation Ground Truth Data**	Feature Class Name: Macroalgae_Sample Attributes:

Field Name	Field Alias	Field Type	Accuracy	Example

Date	Date			01/12/2019 12:15:00 PM
Family	Type	Text		Laminariaceae
Genus	Genus	Text		Macrocystis
Species	Species	Text		Macrocystis pyrifera
Depth below Surface	Depth	Double	To nearest 0.5 metre	0.2
Comments	Comments	Text		

I10 **Vegetation Areas**

Feature Class Name: Macroalgae_Area

Attributes:

Field Name	Field Alias	Field Type	Accuracy	Example
Family	Type	Text		Durvillaeaceae
Genus	Genus	Text		Durvillaea
Species	Species	Text		Antarctica
Comments	Comments	Text		

I11 **Vegetation Depth**

Feature Class Name: Macroalgae_Depth

Attributes:

Field Name	Field Alias	Field Type	Accuracy	Example
Depth below Surface	Depth	Float	To nearest 0.5 metre	0.2

I12 **Vegetation Density**

Feature Class Name: Macroalgae_Density

Attributes:

Field Name	Field Alias	Field Type	Example
Density	Density	Float	Medium

A simple low/medium/high scale is to be used for estimations of density. Any further descriptions of density values used should be included in the Report of Survey.

I13 **Sea Surface Conditions**

Feature Class Name: Sea_Surface_Conditions

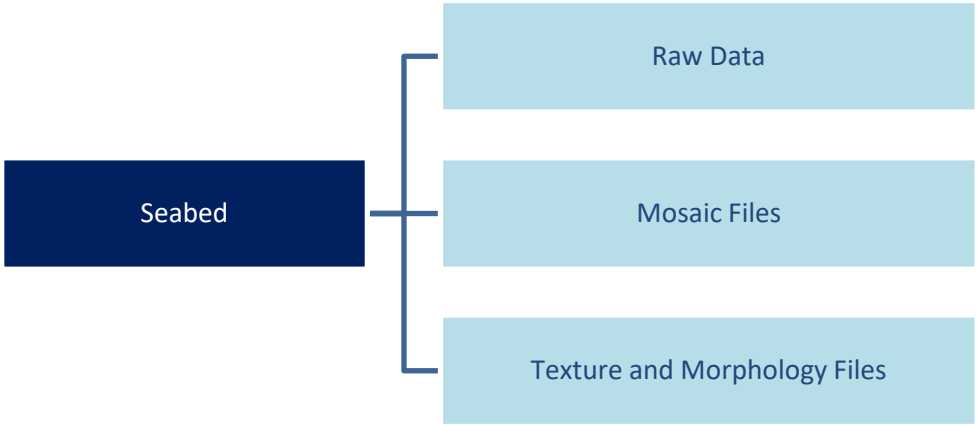
Attributes:

Field Name	Field Alias	Field Type	Example
Sea Surface Conditions	Sea Surface	Text	2

The Beaufort wind scale should be used.

Part J - Seabed Textures

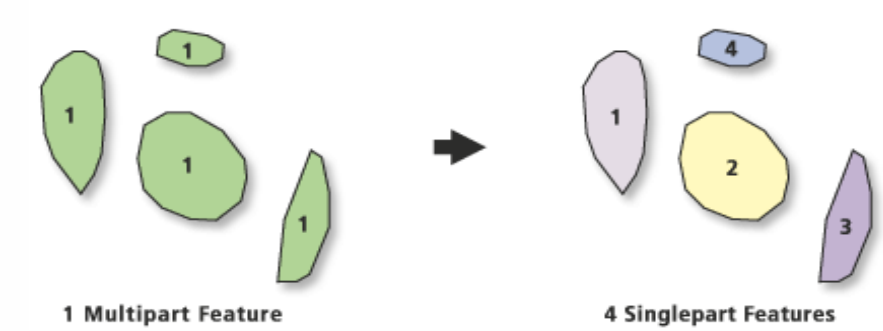
J1	**Reflectivity**	High resolution, geo-referenced reflectivity data shall be collected to inform on seabed textural change. The Company shall endeavour to ensure that systemic variations to reflectivity intensity are kept to a minimum and any changes to system settings that will affect the homogeneity of the reflectivity are minimised during data acquisition or accounted for during processing. During the mobilisation the ability to acquire high quality reflectivity data may be verified by the Authorities representative. Alternatively, a sample of processed reflectivity data may be requested during main data collection. Processes to assess and maintain the quality of reflectivity data during the survey are to be in place and agreed with the Authority.
J2	**Seabed Sampling**	Seabed sampling shall not normally be required, but if it is the requirements in the 'UKHO Hydrographic Survey Specification (Acoustic)' are to be met. See **J3.**
J3	**Deliverables - General**	Seabed textural information should where possible match the LAS classification of the rendered point cloud, specifically with points classified Annex A Numbers 43,44 and 46. Seabed reflectivity, textural and morphological interpretation data is to be rendered using the following structure:



J4	**Data Blocks**		While the HI may detail the number of survey blocks required, the Company may propose an alternate rendering strategy dependent on final data volumes. Where site conditions require the use of different settings throughout the survey area, the Authority is to be informed and the survey area may need to be divided in blocks of similar settings as agreed with the Authority.
J5	**Deliverables Milestone 3**	–	• Reflectance Mosaic • Seabed Classification
J6	**Deliverables - Reflectance Mosaic**		The reflectance mosaic should be a representation of the reflectivity intensity across the respective HIs. The reflectivity data derived will be processed so that any artefacts and reflectivity changes within homogenous areas are corrected for. Where blocks of data were collected using different settings, separate outputs will be generated for each block. Calibration and crosslines will not be included in the reflectivity deliverable. Outputs will be provided as an internally referenced 32-bit Floating Point GeoTIFF images (which preserves actual reflectivity decibel levels, rather than just greyscale values) or a GeoTIFF image with separate ASCII text file (at same resolution as GeoTIFF) containing the following information: • Latitude/Longitude or Easting/Northing.

		• Corrected reflectivity intensity in dB. The resolution of the reflectivity mosaics will be a minimum of: • 0.5 m in water less than 20 m. • 1 m in water less than 50 m. • 2 m in water depths more than 50 m. A full description of the reflectivity processing workflow (including data assessment and cleaning steps), software (including name and version) and settings (including software specific settings used during processing, eg: - overlapping data blending mode, algorithm options selected, etc) are to be included in the Report of Survey. Where corrective action was taken to produce a high-quality reflectivity mosaic, the report will detail how this was resolved.
J7	**Deliverables -Seabed Classification**	The Contractor shall interpret seabed textural changes across their respective HIs using a combination of the bathymetry, reflectivity interpretation and if specified by the HI, ground-truthing from seabed sampling. This is to be rendered as an ESRI MXD and include all area, point and line feature classes. An MXD is a file extension for a map document used by ArcMap and contain a map description, map layout, and embedded objects saved in the map. The Contractor shall also provide details of the procedures and software to be employed as a tender deliverable. Where required a seabed classification will be requested in the HI. Dependent on individual locational requirements, this deliverable will be segmented into three levels of complexity. The level(s) required will be specified in the HI. 1. Sediment textures based on categorisation of grain size – These are to be delivered in a singular Shapefile or feature class within a Geodatabase containing underlying sediment texture using the categories supplied in **G7**. 2. Landforms, morphology and anthropogenic features – Each feature is to be rendered as their own shapefile or as an additional feature class within the Geodatabase (**G8**). Eg: - All Ridges are to be rendered in a singular shapefile/feature class with each ridge delineated as a single part feature. 3. Geological interpretation – Each geological feature is to be rendered as their own shapefile or as an additional feature class within the Geodatabase. The level of this requirement will be specified in the HI (**G9**). Eg: - All Channel deposits are to be rendered in a singular shapefile/feature class with each Channel deposit delineated as a single part feature.
J8	**Shape Files or Feature classes within a Geodatabase**	• May only hold features with the same geometry, which is defined as; point, line, or polygon. • Must be of polygon type (not polygon ZM or other type). • For each shapefile or feature class deliverable, there shall be no gaps or overlaps between adjacent polygons within that individual a shapefile or feature class. • Must have the appropriate assigned coordinate system.

- Contain all specified attributes, even if the field is left blank.
- Meta data must follow ESRI ISO 19115-1:2014 and shall be fully populated including geospatial information.
- Each Shapefile/Feature Class must only contain singlepart polygons. Eg: - Individual polygons within a feature class can be individually selected, see below for an example.



J9 **Texture_Area**

Attributes:

Field Name	Field Alias	Field type	Example
Code	Texture Code	Short Integer	2
Code Descr	Code Description	Text	Sandy mud and muddy sand
Descript	Textural Description	Text	fS.M.Sh.Wd
Comments	Comments	Text	

This Feature Class shall encompass the entire survey area (as detailed in each Hydrographic Instruction) such that no gaps or overlaps shall remain.

J10 **Sediment Texture Codes**

All Sediment Texture information is to be held together in a Single shapefile or Feature Class containing a continuous representation of Seabed sediment. These must be singlepart polygons that do not overlap or have gaps.

Any additions to the below table are to be approved by the authority before submission.

Texture Code	Texture Description
0	Rock/Sediment Absent
1	Mud
2	Sandy mud and muddy sand

3	Sand
4	Mixed
5	Coarse sediment
6	Cobbles and Boulders (with or without finer sediment)

J11 Textural Description

Descriptions are to be classified with the largest composition by weight followed subsequently by the next using terms form the below table.

Main Terms	Symbol	Secondary Terms	Symbol	Qualifying Terms	Symbol	
Sand	S	Ooze	Oz	Fine	f	Only to be used for sand
Mud	M	Marl	Ml	Medium	m	
Clay	Cy	Shingle	Sn	Coarse	c	
Silt	Si	Chalk	Ck	Broken	bk	
Stones	St	Quartz	Qz	Sticky	sy	
gravel	G	Madrepore	Md	Soft	so	
Pebbles	P	Basalt	Ba	Stiff	sf	
Cobbles	Cb	Lava	Lv	Volcanic	v	
Rock, Rocky	R	Pumice	Pm	Calcareous	ca	
Boulders	Bo	Tufa	T	Hard	h	
Coral	Co	Scoriae	Sc	Small	sm	
Shells	Sh	Cinders	Cn	Large	l	
Weed (including kelp)	Wd	Manganese	Mn	glacial	ga	
Two Layers e.g Sand over Mud	S/M	Glauconite	Gc	Speckled	sk	
		Oysters	Oy	White	w	
Mixed: main constituent is given first, e.g. fine Sand with Mud and Shells	fS.M.Sh	Mussels	Ms	Black	bl	
		Sponge	Sp	Blue	b	
		Algae	Al	Green	gn	
		Foraminifera	Fr	Yellow	y	
		Globigerina	Gl	Red	rd	
		Diatoms	Di	Brown	br	
		Radiolaria	Rd	Chocolate	ch	
		Pteropods	Pt	Grey	gy	

		Polyzoa	Po	Light	lt	
				Dark	d	

Any additions to the above table are to be approved by the authority before submission.

J12 **Categories of Landforms, general morphology and anthropogenic features**

The following requirements, listed in respect of their geometry, describe the typical types of features to be included for Seabed Texture deliverables. Each survey is unique and as such not all the features may be found in an individual survey. Additional features may be requested in individual HI. The Report of Survey should detail the types of Seabed Texture information that has been found and delivered.

Each type of Seabed Texture feature has several attributes that must be included. The attributes listed are based on information required by the Authority and are not absolute - extra features and/or attributes may be added at the discretion of the surveyor.

Each Landforms, general morphological or anthropogenic feature is to be rendered as their own shapefile or as an additional feature class within the Geodatabase.

Features can be classified as only one of the following; point, line, or polygon, depending of the feature's physical representation. Where there are multiple features in an area, features should be grouped into singlepart area features.

Any additions to the above table are to be approved by the authority before submission.

Each Shapefile shall contain all instances of that feature type. For example:

- All Cables are held together in a single line Feature Class.

1	Ridge (includes: bank, dune, wave)
2	Ripple
3	Shoal/reef
4	Mound
5	Mountain (e.g. seamounts)
6	Groove or gully
7	Channel
8	Valley (includes: canyon)
9	Depression
10	Slope (includes: lobe, apron, escarpment)
11	Plane (includes: platform, terrace, sheet)
12	Vegetation areas
13	Scour Areas
14	Cable
15	Pipeline

J13 **Ridge**

Feature Class Name: Ridge

Attributes:

Field Name	Field Alias	Field Type	Units	Accuracy	Example
Aspect	Aspect	Text	Asymmetric or Symmetric	N/A	Symmetric
Height	Height (m)	Double	Metres	1 decimal place	2.7
Orient	Orientation (degrees)	Short Integer	Degrees	Whole number	155
Wavelength	Wavelength (m)	Double	Metres	1 decimal place	25.0
Comments	Comments	Text			

Where many Ridges occur in groups these shall be classed as a Ridge Area. The values given for Aspect, Height, Orientation and Wavelength shall be chosen to give a general description of the features found in this area. Where one or more of these values changes a new polygon shall be created

A ridge is defined as having a height greater than 1 metre. Features smaller than this shall be classed as ripples.

J14 **Ripple**

Feature Class Name: Ripple

Attributes:

Field Name	Field Alias	Field Type	Units	Accuracy	Example
Height	Height (m)	Double	Metres	1 decimal place	0.7
Orient	Orientation (degrees)	Short Integer	Degrees	Whole number	270
Wavelength	Wavelength (m)	Double	Metres	1 decimal place	57.6
Comments	Comments	Text			

Where many ripples occur in groups these shall be classed as a Ripple Area. The values given for Height, Orientation and Wavelength shall be chosen to give a general description of the ripples found in this area. Where one or more of these values changes a new polygon shall be created.

A ripple is defined as having a height less than 1 metre. Features greater than this shall be classed as ridges.

J15 **Shoal or Reef**

Feature Class Name: Shoal_Reef

Attributes:

Field Name	Field Alias	Field Type	Units	Accuracy	Example
Type	Type	Text		N/A	Coral Reef
Diameter	Diameter (m)	Double	Metres	1 decimal place	210.7
Orient	Orientation (degrees)	Short Integer	Degrees	Whole number	270
Comments	Comments	Text			

J16 **Mound**

Feature Class Name: Mound

Attributes:

Field Name	Field Alias	Field Type	Units	Accuracy	Example
Diameter	Diameter (m)	Double	Metres	1 decimal place	2.7
Height	Height (m)	Double	Metres	1 decimal place	3.5
Comments	Comments	Text			

J17 **Mountain**

Feature Class Name: Mountain

Attributes:

Field Name	Field Alias	Field Type	Units	Accuracy	Example
Type	Type	Text			Thermal vent
Diameter	Diameter (m)	Double	Metres	1 decimal place	210.7
Height	Height (m)	Double	Metres	1 decimal place	340.5
Comments	Comments	Text			

J18 **Groove or gully**

Feature Class Name: Groove_Gully

Attributes:

Field Name	Field Alias	Field Type	Units	Accuracy	Example
Type	Type	Text			Gully
Length	Length (m)	Double	Metres	1 decimal place	210.7
Width	Width (m)	Double	Metres	1 decimal place	30.4
Depth	Depth (m)	Double	Metres	1 decimal place	4.8
Orient	Orientation (degrees)	Short Integer	Degrees	Whole number	270
Comments	Comments	Text			

J19 **Channel**

Feature Class Name: Channel

Attributes:

Field Name	Field Alias	Field Type	Units	Accuracy	Example
Length	Length (m)	Double	Metres	1 decimal place	1528.4
Width	Width (m)	Double	Metres	1 decimal place	300.2
Depth	Depth (m)	Double	Metres	1 decimal place	60.8
Orient	Orientation (degrees)	Short Integer	Degrees	Whole number	270
Comments	Comments	Text			

J20 **Valley (includes: Canyon)**

Feature Class Name: Valley

Attributes:

Field Name	Field Alias	Field Type	Units	Accuracy	Example
Type	Type	Text			Canyon
Length	Length (m)	Double	Metres	1 decimal place	1260.5
Width	Width (m)	Double	Metres	1 decimal place	420.7

Depth	Depth (m)	Double	Metres	1 decimal place	80.9
Orient	Orientation (degrees)	Short Integer	Degrees	Whole number	270
Comments	Comments	Text			

J21 **Depression**

Feature Class Name: Depression

Attributes:

Field Name	Field Alias	Field Type	Units	Accuracy	Example
Width	Width (m)	Double	Metres	1 decimal place	80.6
Depth	Depth (m)	Double	Metres	1 decimal place	4.8
Comments	Comments	Text			

J22 **Slope (includes: lobe, apron, escarpment)**

Feature Class Name: Slope

Attributes:

Field Name	Field Alias	Field Type	Units	Accuracy	Example
Type	Type	Text			Lobe
Length	Length (m)	Double	Metres	1 decimal place	210.7
Width	Width (m)	Double	Metres	1 decimal place	30.4
Depth	Depth (m)	Double	Metres	1 decimal place	4.8
Orient	Orientation (degrees)	Short Integer	Degrees	Whole number	270
Slope Angle	Angle (degrees)	Short integer	Degrees	Whole number	30
Comments	Comments	Text			

J23 **Plane (includes: platform, terrace, sheet)**

Feature Class Name: Plane

Attributes:

Field Name	Field Alias	Field Type	Units	Accuracy	Example
Type	Type	Text			Platform
Length	Length (m)	Double	Metres	1 decimal place	210.7
Width	Width (m)	Double	Metres	1 decimal place	30.4
Depth	Depth (m)	Double	Metres	1 decimal place	4.8
Orient	Orientation (degrees)	Short Integer	Degrees	Whole number	270
Comments	Comments	Text			

J24 **Vegetation Areas**

Feature Class Name: Vegetation_Area

Attributes:

Field Name	Field Alias	Field Type	Units	Accuracy	Example
Type	Type	Text			Sea Grass
Height	Height from Seabed (m)	Double	Metres	To nearest 0.5 metre	4.5
Comments	Comments	Text			

J25 **Scour Areas**

Feature Class Name: Scour_Area

Attributes:

Field Name	Field Alias	Field Type	Units	Example
Type	Type	Text	Hydrodynamic, Dredging, Ice or Trawl	Trawl
Comments	Comments	Text		

J26 **Cable**

Feature Class Name: Cable

Attributes:

Field Name	Field Alias	Field Type	Units	Example
Type	Type	Text	Power or Telecommunications	Power
Comments	Comments	Text		

J27 **Pipeline**

Feature Class Name: Pipeline

Attributes:

Field Name	Field Alias	Field Type	Units	Example
Type	Type	Text	Oil or Gas	Oil
Comments	Comments	Text		

J28 **Geological interpretation**

Below is a non-exclusive list of the anticipated Geological features. As each survey area is unique, the HI will provide a list along with expected attribution.

Class	Simplified geological description	Explanation
1	Bedrock	Including any kind of rocky outcrop, escarpment, dyke etc.
2	Lag deposit	Sediment consisting of sand, gravel and/or coarser material left behind when smaller particles are washed away by waves or currents.
3	Biogenic reef (including coral)	Rock outcrops that are produced by the action of living organisms
4	Current-induced landform	Active or relict sediment landforms produced by the action of currents as waves or tides. It includes ripples, mega-ripples, sand-waves, dunes, bars etc.
5	Glaciogenic landform or deposit	Bedform or sediment deposit produced by the action of glaciers. It includes moraines (curved ridge deposited in front of glacier), eskers (linear glacifluvial ridges), till covers etc.
6	Fluid-escape feature	Landforms created by the actions of fluids escaping from the seabed (e.g. pockmarks)
7	Mass-wasting deposit	Cover of sediments deposited by mass movements such as submarine slides, debris flows or turbidite currents. It can form lobes, mounds or sheets
8	Channel deposit	Sediments deposited in a channel
9	Suspension deposits	Fine grained sediments (usually clay and silt) transported by and deposited from suspension, it includes pelagic oozes or suspension-settling from glaciers
10	Unspecified landform or deposit	If it does not fall in any of the previous

Each Geological feature is to be rendered as their own shapefile or as an additional feature class within the Geodatabase.

Part K - General Requirements

K1	**Customs, Licenses, Consents and Permissions**	The Company shall be responsible for arranging all licences, consents, customs clearance and permits, for access and radio communication clearance for all survey operations whether ashore, in the air or afloat to enable the survey to be conducted.
K2	**Logistics**	The Company shall be responsible for ensuring all logistic arrangements including availability of correct fuel and engineering support are available in the area of operations.
K3	**Marine Life**	Marine Life sighted during survey operations or subsequently on photography should be reported on a **H637** form.
K4	**Additional Requirements**	The following items requiring the use of a seagoing vessel may be detailed in the HI: • Acoustically collected bathymetry • Water Clarity • Tidal Stream Observations • Seabed Sampling • Views for Sailing Directions For any of these requirements the 'UKHO Hydrographic Survey Specification (Acoustic)' is to be used.
K5	**Scope**	While every effort is made to ensure the Hydrographic Instruction provided at contract award is correct in extent, the Authority reserves the right to extend the scope of the requirement due to unforeseen circumstances following contract award.
K6	**Progress Reports**	A progress report shall be completed and e-mailed to the Authority on a weekly basis throughout the duration of each HI. Specific email addresses for each project will be given at the Project Kick Off Meeting. The report is to be with the UKHO addresses by 0800 (UTC) each Monday.

The report is to include as a minimum:

- Data collection progress to date
- Planned activities
- Weather downtime
- Problems encountered
- Data processing progress for all data types required by the HI.
- The predicted delivery dates for all final deliverables with any amends to the original plan highlighted;
- Logistics forecast including downtime for routine Aircraft maintenance;
- Health and Safety summary drawn from the previous week's Daily Progress Reports;
- Any other issues or concerns.

Any specific incidents, downtime that will affect delivery dates or concerns should be raised directly to the Authority as they occur.

The Authority reserve the right to increase the frequency of progress reports to daily to better inform progress.

K7 **Quality Control**

Robust quality control procedures shall be provided and adhered to during processing of all data. These procedures shall be provided to the Authority prior to survey operations commencing.

K8 **Authority Provided Documentation**

The Authority will provide the following documentation:

Form/Document Number	Name
NP100	Mariner's Handbook
Np122(2)	Admiralty Tidal Handbook – Datums for Hydrographic surveys (2006)
	Relevant Admiralty Sailing Directions
	Relevant GeoTIFFs of latest British Admiralty charts

		UKHO Electronic Navigation chart of the area where applicable
		UKHO Report of Survey Template
	H102 (A/B)	Hydrographic Note Template
	H143	Record of Tidal Observations (Fair)
	H159	Description of Geodetic Control Station
	H525	Report on Wreck Examination or Sweeping
	H532	Levelling Reduction
	H533	Transfer of Sounding Datum
	H575	Record of Seabed Samples and Cores
	H635	Oceanographic Observations

Part L - General Deliverables

L1	**Data Delivery Deadline**	All data and associated documents must be rendered to the Authority by the date stated in the HI. Any early submissions and payments must be agreed with the Authority.
L2	**Survey Timings**	The Authority will endeavour to give a minimum notice of 130 calendar days from award of HI to the final delivery deadline. Where possible additional time will be given to allow the Company to optimise data collection in terms of weather and water clarity.
L3	**The Authority Appraisal Schedule**	The Authority intends to fully validate the deliverables within 25 working days* subject to the data passing an initial (5 day) check. The initial check will commence on successful transfer of the entire data set to the Authorities systems. If the data is delivered to the Authority earlier than described at **L1**, then the Authority will assign the survey to the next available slot in their programme. The validation timescales may increase but the Authority intend to not exceed 25 working days* past the Data Delivery Deadline **(L1).** This assumes the deliverables are fully compliant with this specification. * Working days are defined as: the days between and including Monday to Friday and do not include public/bank holidays and weekends in England.
L4	**Labelling of Records and Deliverables**	**Project Name:** As detailed in each HI Hydrographic Instruction Number: As detailed in each HI Hydrographic Instruction Name: As detailed in each HI All deliverables are to be named iaw the file conventions laid out at Annex A. All rights in intellectual property which are generated in the performance of work under the Contract shall vest in and be the property of the Authority. The Company shall take all necessary measures to secure that vesting. Where appropriate, they are to carry the following official markings:

CROWN COPYRIGHT 2019*

*year as appropriate.

Where appropriate, they are to carry the official markings: As detailed in each HI

The delivery address will be provided in the HI.

L5 **Naming Conventions**

File naming used for each type of data 'product' will follow these conventions (unless otherwise stated in this specification):

- Filenames will contain a series of elements that give information about the file contents
- These elements will be separated by an underscore (_)
- Elements will contain only letters (AaBbCc etc…) and numbers (0123…)
- Filenames should not contain spaces. If required, 'CamelCase' (capitalising the first letter in each word) can be used to make concatenated words easier to read.
- Filenames will finish with the conventional extensions (.jpg, .tif, .csv etc)

File naming for final products (e.g. image files, bathymetric surfaces) will adhere to the following convention. The use of elements within raw data and working files is encouraged, where appropriate, as 'good practice':

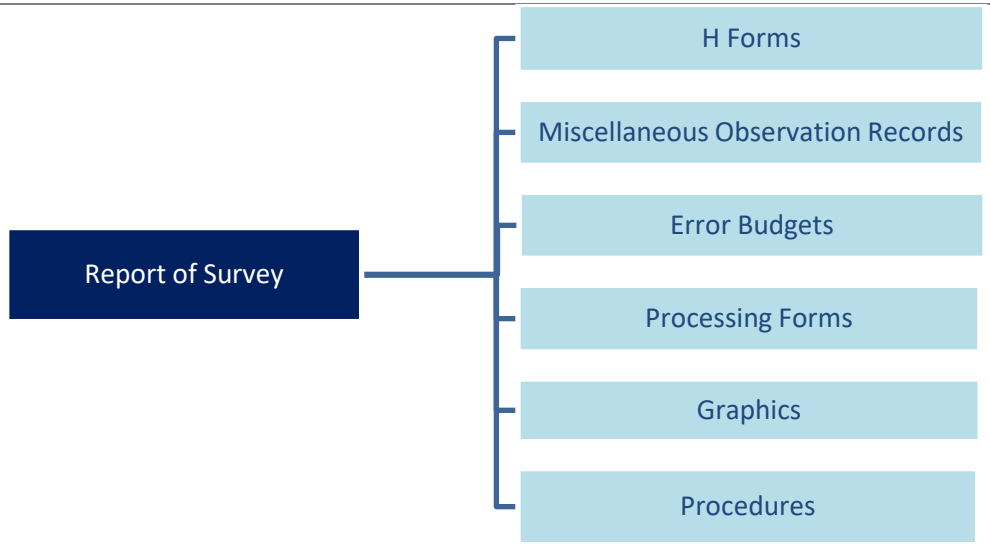
HInumber_Title_DataType_CoordSys_BinSize

Element	Description
HI number	The Hydrographic Instruction number for the survey
Title	Abbreviated survey title as supplied by the Authority.
DataType	LBXYZ = ASCII XYZ of fully corrected Lidar bathymetry LB = Lidar bathymetry GeoTIFF LBFP = floating point GeoTIFF from Lidar bathymetry

	LRXYA = ASCII X, Y, reflectivity LR= Lidar reflectivity GeoTIFF LRFP = floating point GeoTIFF from Lidar reflectivity
CoordSys	Datum and projection of the output data product. e.g. UTM29N, WGS84, ITRF2008
BinSize	Grid resolution, in metres, for raster data and XYZ. Express as a decimal, but substitute the letter 'd' for the decimal point. 0d5 = 0.5 m , 1d0 = 1.0 m, 1d5 = 1.5 m etc If Full density XYZ output use the abbreviation: FD
Additional	Further information can be added if relevant. E.g. Tile1, V1
Null values	Use NA (not applicable) to represent a null value for mandatory elements

Example: GBR_HI1234_LittleHarbour_LBXYZ_UTM30N_2d0

L6	**Report of Survey**	The Authority will provide a digital template which is to be completed for all elements covered by the project. Any additional information required to explain the procedures and processes used during the survey should also be added. The Report of Survey should act as a cover for all other documentation as shown below



L7	**H Forms**	"H Forms" have been designed by the Authority to facilitate checking and validation of rendered data. The Company shall always use the appropriate "H Form" where one exists for a process which is undertaken. **J6** provides a list of all the relevant forms.
L8	**Digital Data Media**	All Data shall be delivered on external USB 3.0 hard drives. Alternative media or FTP delivery may be authorised by the Authority. The Company shall provide all media required for rendering completed surveys to the Authority and cover all costs incurred during data rendering (postage & customs) All delivered media will be returned on final acceptance of the survey.
L9	**Retention of Data**	All raw and processed digital records shall be retained and maintained by the Company for a period of 3 years from the date of the final contract payment.

	On completion of this 3-year period, the Company is to destroy/remove data from all systems and media and confirm to the Authority that this has been done.

Annex A - ASPRS - LAS Classification Codes

A1	**LAS Version**	LAS Version 1.4-R13 utilising the LAS Domain Profile for Topo-Bathy Lidar (dated 17/07/2013) should be used for all deliverables. Newer versions may be used with the explicit approval of the Authority.
A2	**Lidar Point Cloud Classification Levels**	One of three levels as defined below and detailed at D5 will be required by the HI: **Level 0 - Undefined:** All points classified as 0 or 1 by the Lidar processing software with no classification algorithms applied. **Level 1 - (Semi) Automated Classification:** Processing of the validated point cloud into basic classes: Any anomalies of >2m in the classification levels must be corrected during QA/QC. **Level 2 - Detailed Classification and Correction:** The further classification of points to include the classes not mentioned in Level 1 classification.
A3	**Classification Accuracy**	It is expected that due diligence in the classification process will produce datasets that meet the required classification accuracies according to D3. The data set will be accepted if it meets the following: • No gross errors are present in the data. • Errors of omission must not exceed 2% of all points per class • Errors of commission must not exceed 2% of all points per class
A4	**Classification Consistency**	Point classification is to be consistent across the entire project. Noticeable variations in the character, texture, or quality of the classification between tiles, swaths, flight lines, or other non-natural divisions may lead to the entire deliverable being returned for rework or rejected entirely.
A5	**ASPRS LAS Classification**	Additional classes may be included as deemed suitable by the Company to best define the data and assist in data cleaning and product creation. Point data record format 9 is to be used to allow the addition of classification values 40 to 45 when combined with bathymetric data as defined in the ASPRS LAS Topo-Bathy Lidar Domain Profile.

A6 ASPRS LAS Classification Codes

Number	Class	Level	Description
0	Never Classified	0	Created but not subjected to a classification process.
1	Unclassified	0	Default – undergone classification process but emerged as undefined. Includes non-ground points from simple ground/non
2	Ground	1	Bare Ground
3	Low Vegetation	2	0-0.3m
4	Medium vegetation	2	0.3-2m
5	High Vegetation	2	>2m
6	Building	2	
7	Low Point	1	Spurious returns (unusable)
8	Reserved		Reserved for model key points only.
9	Water	2	Any point in water (see Number 41)
10	Rail	2	
11	Road Surface	2	
12	Reserved		Reserved for overlap data.
13	Wire – Guard (Shield)	2	
14	Wire – Conductor (Phase)	2	
15	Transmission Tower	2	
16	Wire-structure Connector	2	e.g. insulator
17	Bridge	2	
18	High Noise	1	Spurious returns (unusable)
19	Overhead Structure	2	e.g. conveyors, mining equipment, traffic lights

	20	Ignored Ground	2	e.g. breakline proximity
	21	Snow	2	
	22	Temporal Exclusion	2	Features excluded due to changes over time between data sources – e.g. water levels, landslides, permafrost
	40	Bathymetric point	1	Seafloor or riverbed (submerged topography)
	41	Water surface	0	Sea/river/lake surface from bathymetric or topographic bathymetric lidar. Distinct from Point class 9, which is used in topographic only lidar and only designates water not water surface.
	42	Derived water surface		Synthetic water surface location used in computing refraction at water surface)
	43	Submerged Object	2	Not otherwise specified (eg. wreck, rock, submerged piling)
	44	S-57 Object	2	International Hydrographic Organisation (IHO) S-57 object, not otherwise specified
	45	No bottom found	1	Bathymetric lidar point for which no detectable bottom return was received.
	46	Submerged vegetation	2	Eg. Kelp.
	50-255	User Definable		As required to better define dataset. Any use of these class definitions is to be clearly noted in the Report of Survey.

[i] HAZARD HUNT

It may be appropriate to include other project personnel in the Hazard Hunt. Good results are often achieved by using personnel not familiar with a specific work area to look for hazards, e.g. a MBES orientated surveyor looking around the hanger – the fresh set of eyes of a person who has had no prior involvement in an area can bring a new viewpoint to an unsatisfactory arrangement which other people have just come to accept.

Although not mandated, it is often best practice to have the Captain of the Aircraft sign a pre-formatted release on completion of the Hazard Hunt, stating that the mobilisation of the survey spread has had no adverse impact on the (certificate of) airworthiness of the Aircraft and that Aircraft remains in condition for safe flight. This ensures that the Charge Surveyor can demonstrate after the event that the Captain of the Aircraft was content that the survey mobilisation had no effect on the safe operation of the Aircraft.

[ii] REMOTE LOCATIONS

For the purposes of the Framework, the working definition of 'remote location' is an area which is far away in place *or time* from a populated area with a modern standard secondary care facility including a functional Casualty Department / Emergency Room. In practice if the transit time from the project accommodation, offices, airfield or RPAS Remote Pilot Station (RPS) and/or RPAS launch and recovery point to a location where ambulance/EMT services can be rendered is greater than 60 minutes, then the worksite is to be considered a Remote Location.

[iii] AIRCRAFT SAFETY STANDARDS

The Client Representative will verify that all items in this section have been provided to the project and are in date for inspection/test/expiry as appropriate. If shortcomings are noted in respect of this minimum requirement, Stop Work Authority may be exercised until such time as defects or deficiencies are rectified.

The Client Representative will be a balanced individual with broad survey experience. Inevitably he will not however have an in-depth knowledge of every possible manned and unmanned Aircraft type and flight and survey system configuration. The Client Representative will therefore adopt a common-sense approach to any issues or shortcomings which he perceives in the conduct of flight operations and will intelligently discuss these with relevant Project personnel and/or airfield staff as appropriate to clarify matters. If however perceived issues cannot be resolved by discussion, Stop Work Authority may be exercised until such time as an independent qualified specialist can be employed to provide a definitive view on the matter. The cost of any such consultation or inspection, any subsequent remedial actions and any re-inspection shall be borne by the Contractor.

[iv] NOISE

The Health and Safety Executive guidance on noise at work is to be adhered to. This is available here. In summary the employer has a duty to prevent damage to employees, including hearing damage due to noise exposure.

If sound levels are found to be in breach of HSE guidance with attendant risk of injury of survey personnel, then the Client Representative may exercise Stop Work Authority until the problem is rectified.

[v] WORKPLACE LIGHTING

The UK Health and Safety Executive guidance on workplace lighting is to be adhered to. A user guide suggesting common problems and best practice is available on the UK HSE website:

http://www.hse.gov.uk/pubnS/priced/hsg38.pdf

In summary the employer has a duty to prevent damage to employees due to poor workplace lighting. The most commonly witnessed problems in previous projects have been associated with glare across VDU screens leading to discomfort, irritability, distraction, visual and overall fatigue and, fundamentally an inability for the data processor, Survey Equipment Operator or RPAS Remote Pilot to see the data presented well enough to operate the systems with the required level of attention, accuracy and safety.