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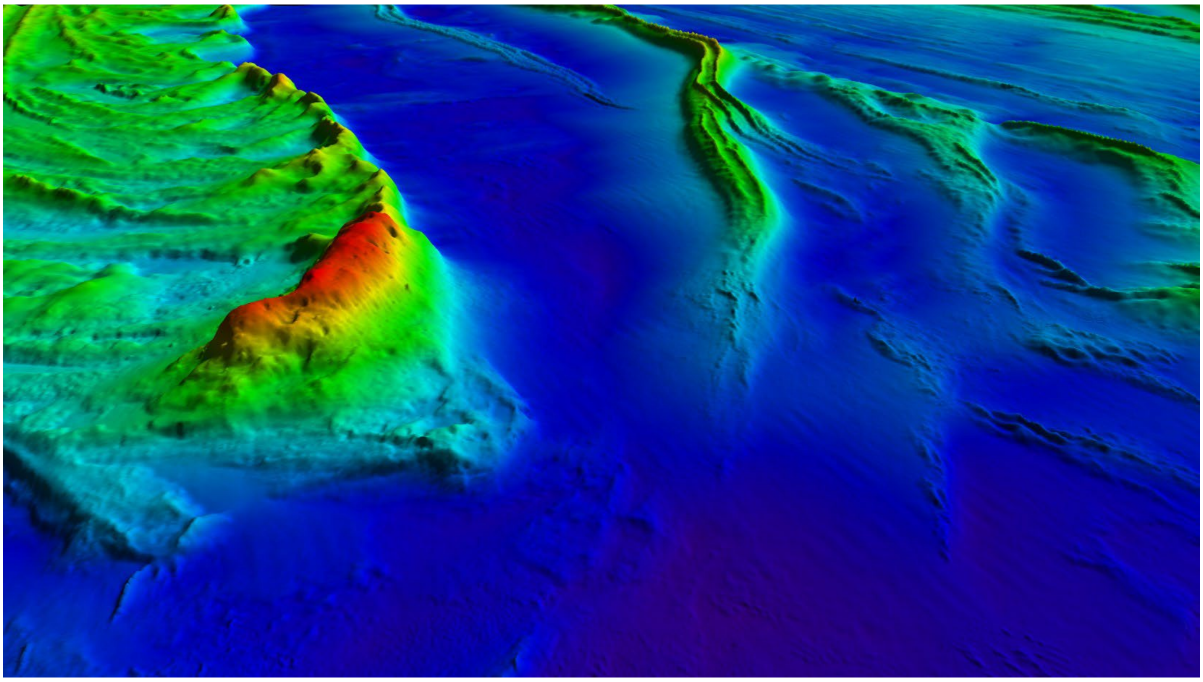
AHO | HIPP HYDROSCHEME INDUSTRY PARTNERSHIP PROGRAM

MARITIME GEOSPATIAL BRANCH QUALITY MANAGEMENT SYSTEM DOCUMENT

Ref: SPEC_03_33_ R32962928

STATEMENT OF REQUIREMENTS (SOR)



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Record of Changes

The version of this document is the same for all pages		
Version	**Date**	**Amendment**
1.0	2 Nov 2017	Initial version for SEA2400 HIPP RFT release
1.1	13 Feb 2018	Update to IHO 1b specification in Table 1
1.2	13 Mar 2018	See SOR Amendments Record for details (available on request)
2021.1	28 Oct 2020	Issued to accompany *HydroScheme* 2021See SOR Amendments Record for details (available on request)
2022.3	02 Nov 2021	Issued to accompany *HydroScheme* 2022 See SOR Amendments Record for details (available on request)
2023.2	19 Oct 2022	Issued to accompany *HydroScheme* 2023.See SOR Amendments Record for details (available on request)
2024.0	2024	Not issued due to HIPP 2 Deeds
2025.1	Jun 2024	Issued to accompany *HydroScheme* 2025 See SOR Amendments Record for details (available on request)
2026.2	14 Oct 2025	Issued to accompany *HydroScheme* 2026 Key amendments are: - Section 3.2 – Addition of a Assistant SIC (ASIC) - Section 3.6 – Updated Survey Management Plan - Addition of Sections 3.6.1 Project Quality Plan and 3.6.2 Project Work, Health and Safety Plan describing key components of the plans. - Section 4.1.7 – Added use of passage sounding to analyse AusHydroid over time - Section 5.2.1 Updated Horizontal Datums, change to ITRF2020 - Section 5.3.4 Updated TVU reporting - Section 6.1.1 Updated Tide Gauge requirements - Section 6.1.3 Levelling, change to ITRF2020 - Section 6.2 Updated Current Meter (Tidal Stream) Observations - Section 6.1.4 Updated Comparison Check for Tide Gauges and Barometers - Section 6 Add TEOS-10 pressure to depth conversion to - Section 6.4 Tidal Analysis added with the following sub-sections - Section 6.4.1 Approved Tidal Analysis Software added - Section 6.4.2 Harmonic Constituents added

		- Section 6.4.3 Inferred Constituents added - Section 6.4.4 Solar Annual (Sa) and Solar Semi Annual (Ssa) Constituents added - Section 6.4.5 Mean Sea level Anomaly Added - Section 6.4.6 Validation of Tidal Analysis Added - 6.4.7 Error Estimates in the water level data and datum determination Added - Section 6.1.2 Tide Buoys updated - Section 6.1.4 Comparison Check for Tide Gauges and Barometers updated - Section 7.1.1 MBES Setting requirements updated - Section 7.1.5 LiDAR requirements updated - Section 7.3.3 Deep water NRS updated - Section 7.4.2 SVP Requirements updated - Section 7.5 Coverage requirements updated - Section 7.5.5 ALB coverage requirements updated - Section 7.10 Passage Sounding requirement updated - Section 8.10 Updated Geographic, Undersea Feature and Place Names - Section 11.4.2 Interim Tides and Geodetics Pack updated - Section 11.5.5 Tidal Data updated. - Section 11.5.8 NRS Survey Required Data Packs - Section 12.4 Ancillary Geospatial Data – SSDM, change to ITRF2020 - Section 13.4.2.15 Removed - Section 14.3.2 QAX updated - Section 6.1.5 Surveying on the Ellipsoid added
2026.3	11 Nov 25	- Section 6.1.5 Surveying on the Ellipsoid - Hydroid Check Requirements Table Added – Table 8

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1 INTRODUCTION

As a signatory to the International Convention for the Safety of Life at Sea (SOLAS), Australia has an obligation to "*arrange to collect and compile hydrographic data, and to publish, disseminate and update all nautical information necessary for safe navigation*" (SOLAS V, regulation 9). The Australian Hydrographic Office (AHO) is the Australian Hydrographic Authority and is the competent authority responsible for meeting these obligations. The information in this specification details the requirements for hydrographic surveys undertaken on behalf of the AHO and is to be used in conjunction with other relevant survey specific Contract Documents (i.e. Survey Instructions) and professional references listed in this document to give comprehensive guidance for the delivery of the required services in its entirety.

The hierarchy of documents for the guidance of survey requirements is as follows:

- Survey Instruction (SI) as issued or subsequently updated,
- HIPP Statement of Requirements (HIPP SOR) – this document,
- Other relevant MG Branch QMS Documentation,
- IHO Special Publication S44 Ed 6,
- Professional Reference document listed in the HIPP SOR,
- Other professional reference documents.

All requirements detailed in the SOR remain extant unless specifically modified in survey specific Contract Documents. Where a conflict of requirements exists, clarification is to from the AHO HIPP Authorised Officer (Director National Hydrography (DNH)).

HydroSchemes and the Statement of Requirements are intended to be aligned (e.g. HydroScheme 2026 aligns to HIPP SOR 2026.1) and used for all RFQTS bids and surveys issued using the respective *HydroScheme*, or other survey related activity issued by the AHO for conduct in each Financial Year.

Hydrographer of Australia

Australian Hydrographic Office

8 Station Street

Wollongong NSW 2520

Australia

2 REFERENCES AND DEFINITIONS

2.1 Related Publications and References

The following publications should underpin the collection of geospatial data and augment these standards. **The most recent published versions of the following documents at the time of contract signing apply:**

1. *Standards for Hydrographic Surveys* (S-44 Ed 6). IHO.
2. *Manual on Hydrography* (C-13). IHO.
3. *The Mariner's Handbook (*NP100). Admiralty Publication.
4. *The Mariner's Handbook for Australian Waters* (AHP20). AHO.
5. *NP13 Admiralty Sailing Directions: Australian Pilot (Volume 1) 6th Edition*
6. *NP14 Admiralty Sailing Directions: Australian Pilot (Volume 2) 14th Edition*
7. *NP15 Admiralty Sailing Directions: Australian Pilot (Volume 3) 15th Edition*
8. *INT1 Symbols, Abbreviations and Terms used on Charts*. IHO.
9. *Backscatter measurements by seafloor-mapping sonars: Guidelines and Recommendations.* GeoHab Backscatter Working Group. May 2015.
10. *Admiralty Tidal Handbook No.2*, (NP122 (2)). Admiralty Publication. 1975.
11. *Guidelines for Control Surveys by Differential Levelling v2.2* (SP1). ICSM.
12. *Guidelines for Control Surveys by GNSS v2.2* (SP1). ICSM.
13. *Guideline for Installation and Documentation of Survey Control Marks v2.2* (SP1). ICSM.
14. *Geocentric Datum of Australia 2020* (GDA2020) *Technical Manual.* ICSM.
15. *Standard for the Australian Survey Control Network* v2.2 (SP1). ICSM.
16. *LiDAR Acquisition Specifications and Tender Template.* ICSM.
17. *Ellipsoidally Referenced Surveying for Hydrography,* Publication No 62. FIG.
18. *The Calibration of Shallow Water Multibeam Echo-Sounding Systems*, André Godin. University of New Brunswick, Technical Report No. 190, March 1998.
19. *Australian Tides Manual* (SP9). ICSM.
20. *Transfer Standard for Digital Hydrographic Data* (S-57) – in particular S-57 Supplement No3 Ed3.1 Section CATZOC, IHO.
21. *Bathymetric Surface Product Specification* (S-102). IHO.
22. *Manual of Codes* (No 306), WMO.
23. *Marine Sampling Field Manual for Grabs and Box Corers* Ch. 9. MHB, NESP.
24. *Oceanographic Data Standards for HIPP* (SPEC_03_33_BN16464067), AHO.
25. *IOGP Seabed Survey Data Model (SSDM) V2 (2017)*
26. *HIPP Modified SSDM Data Dictionary (*SPEC_03_33_BN32048462*),* AHO.

27. *Australian Multibeam Guidelines v2, Geoscience Australia (https://australian-multibeam-guidelines.github.io)*

28. *Backscatter measurements by seafloor-mapping sonars: Guidelines and Recommendations, A collective report by members of the GeoHab Backscatter Working Group (2015)*

29. *HIPP Guidance Note – Tidal Analysis*

2.2 Abbreviations, Terms and Definitions

2.2.1 Abbreviations

Table 1 – Abbreviations

ACVRF	Australian Charting Vertical Reference Framework
ADCP	Acoustic Doppler Current Profiler
ADHO	Assistant Director HIPP Operations
ADP	Ancillary Data pack
AGO	Australian Geospatial Intelligence Organisation
AHD	Australian Height Datum
AHO	Australian Hydrographic Office
AHSCP	Australasian Hydrographic Surveyors Certification Panel
ALB	Airborne LiDAR Bathymetry
AMSA	Australian Maritime Safety Authority
ASCII	American Standard Code for Information Interchange
ASV	Autonomous Surface Vessel
AUV	Autonomous Underwater Vehicle
AWS	Automatic Weather Station
AVWS	Australian Vertical Working Surface
BDP	Bathymetric Data Pack
BoM	Bureau of Meteorology
COD	Conditions of Deed
CR	Client Representative
CTD	Conductivity Temperature, Depth
CUBE	Combined Uncertainty Bathymetric Estimator
DGNSS	Differential Global Navigation Satellite System
DAB	Data Acquisition Block
DP	Number of Decimal Places

DXF	Drawing Interchange Format
ED	Existence Doubtful
EOS 80	1980 Equation of State
EEZ	Exclusive Economic Zone
FBC	Full Bathymetric Coverage
FGDB	File Geodatabase
FSC	Full Seafloor Coverage
FSE	Full Seafloor Ensonification
GDP	Geodetic Data Pack
GEBCO	General Bathymetric Chart of the Ocean
GFE	Government Furnished Equipment
GFI	Government Furnished Information
GFM	Government Furnished Material
GNSS	Global Navigation Satellite System
HIPP	HydroScheme Industry Partnership Program
HOR	Horizontal
HSS	HIPP Support System
IAW	In Accordance With
ICSM	Intergovernmental Committee on Surveying and Mapping
IHO	International Hydrographic Organisation
IMOS	Integrated Marine Observing System
IMU	Inertial Motion Unit
ITRF	International Terrestrial Reference Frame
ITRS	International Terrestrial Reference System
LAT	Lowest Astronomical Tide
LiDAR	Light Detection and Ranging
MBES	Multibeam Echo Sounder
MG Branch	Maritime Geospatial Branch, AGO
MHWS	Mean High Water Springs
MSL	Mean Sea Level
MTES	Multi-transducer Vertical Sweep System
MVP	Moving Vessel Profiler

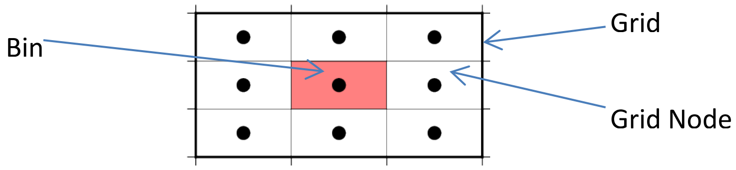
netCDF	Network Common Data Format
NGRS CORS	National Geodetic Reference System Continually Operating Reference Station
NRS	National Reference Surface
PA	Position Approximate
PD	Position Doubtful
PMP	Project Management Plan
PPP	Precise Point Positioning
PU	Positional Uncertainty
QADP	Quality Assurance Data Pack
ROS	Report of Survey
ROV	Remotely Operated Vessel
RTK	Real Time Kinematic
SBES	Single Beam Echo Sounder
SD	Sounding of Doubtful Depth
SIC	Surveyor in Charge
SMP	Survey Management Plan
SSDM	Seabed Survey Data Model
SSS	Side Scan Sonar
SST	Sea Surface Temperature
SU	Survey Uncertainty
SV	Sound Velocity
SVP	Sound Velocity Profile
TEOS-10	Thermodynamic Equation of SeaWater 2010
TDP	Tidal Data Pack
THU	Total Horizontal Uncertainty
TOF	Time of Flight
TOSD	Transfer of Sounding Datum
TPU	Total Propagated Uncertainty
TS	Tasking Statement
TVU	Total Vertical Uncertainty
UAV	Uncrewed Aerial Vehicle
USV	Uncrewed Survey Vessel

UTC	Universal Time Coordinated
VER	Vertical
WCD	Water Column Data
WMO	World Meteorological Organization
XBT	Expendable Bathy Thermograph
XML	Extensible Markup Language

2.2.2 Glossary: Terms and Definitions

Table 2 – Terms and Definitions

AUSGeoid09	A 1' by 1' (approximately 1.8 km) grid used to transfer heights between the ellipsoid (GDA94) and http://www.ga.gov.au/earth-monitoring/geodesy/geodetic-datums/australian-height-datum-ahd.html. AUSGeoid09 provides users with the height offset between the ellipsoid and AHD as opposed to the ellipsoid and the geoid.
AUSGeoid2020	A 1' by 1' (approximate 1.8km) grid used to transfer heights between the ellipsoid (GDA2020) and the Australian Height Datum (AHD). AUSGeoid2020 provides users with the height offset between the ellipsoid and AHD as opposed to the ellipsoid and the geoid.
AUSHYDROID	The AUSHYDROID is a separation model of the height of chart datum relative to the GRS80 ellipsoid.
AusTides	Software providing tidal predictions and tidal stream information equivalent that published in the pdf version of the Australian National Tide available for download from the AHO Website.
Authorised Officer	See Attachment H of Conditions of Deed
Bin	See Grid/Bin resolution
Bin Resolution	See Grid/Bin resolution
Client Representative	Representative from the Commonwealth (see Section 3.11)
Coastal	Surveys within the coastal areas to the edge of the continental shelf 0-200m depth. This includes inter island groups, reef areas, areas of critical under-keel clearance and areas of high environmental sensitivity. All survey standards cover this depth band. Ashore survey operations will be a component of most Coastal surveys
Conspicuous Object/Mark	A navigation mark or object such as peaks, churches, chimneys, masts or permanent buildings that are visible from quite a distance offshore.

Government Furnished Material (GFM)	See Attachment H of COD
Government Furnished Information (GFI)	A subset of the GFM comprising digital information issued with a Survey Instruction.
Grid	See Grid/Bin resolution
Grid/Bin Resolution	The grid is a regular grid with equal spacing overlaid over the survey area. The resolution of the grid is the size of each side of the grid. There is no required relationship between features of the bathymetry and the grid. Since the grid is a complete cover of the survey area, every sounding measurement can be assigned to one and only one cell in the set. After all of the data has been added to the grid, therefore, each cell (or bin) will contain a collection of co-located data points from one or more passes with the measurement system(s). Grid and Bin resolution are inter-related in that the grid size will determine the bin resolution 
HIPP	The HydroScheme Industry Partnership Program is the commercial acquisition program that undertakes focused hydrographic survey activities to contribute to national charting priorities. The vision for HIPP is to undertake an efficient, effective and sustainable hydrographic survey, oceanographic and marine geophysical data collection program through a partnership with Industry to deliver a true nation-building effort.
HIPP Support System (HSS)	Part of Defence's Jetstream AWS, comprised of the HSS Operating Environment for interim reports, surfaces and products, and the HSS Verification Environment for final deliverables.
Holiday	A significant gap in the data with the potential to miss significant features that pose a threat to navigation
Inshore	Surveys abutting coastal areas that cover both the hinterland and shallow depth band (0-40m). These surveys will require ashore operations and the ability to survey the tidal/ surf zone.
International Terrestrial Reference Frame	A realisation of the International Terrestrial Reference System (ITRS) produced by the International Earth Rotation and Reference Systems Service (IERS).

Key Persons	See Attachment H of the COD
National Geospatial Reference System	Current Australian National 3D reference system as adopted and officially maintained by Geoscience Australia, eg. ITRF2020. This also incorporates the current national height datum, ie. AHD71, AHD-TAS83. Refer to ICSM SP1 and Geoscience Australia website.
National Reference Surface	A high order Bathymetric Reference Surface that is managed by the AHO to provide those acquiring bathymetric data a series of surfaces to validate their MBES data against. National Reference Surfaces are distributed as GFI with each SI in a CSAR surface format relative to MSL, LAT and GRS80 Ellipsoid. They are also available on the AusSeabed Portal as public release.
Near-shore Tidal Station	Tidal station that is deployed within 3km of shoreline and 5km of an existing or new vertical benchmark. This distance is optimal for connecting the tide gauge zero to recovered LAT, or transfer of LAT to a new benchmark via levelling or simultaneous observations.
Official Order	See Attachment H of the COD
Offshore (Deep)	Deep water surveys in depths greater than 200m. Surveys within this depth band may include IHO-1a/b and HIPP-2 survey specifications.
Open Waters (tidal)	An expanse of an ocean which is distant from the shore, greater than 3km, and devoid of nearby islands or other features that would allow the deployment of benchmarks to tie tidal infrastructure to ITRF.
Positional Uncertainty (PU)	The uncertainty of the horizontal and/or vertical coordinates of a survey control mark on land with respect to the defined national datum and represents the combined uncertainty of the existing datum realisation and the new control survey. That is, PU includes SU as well as the uncertainty of the existing survey control marks to which a new control survey is connected. A fully constrained least squares adjustment is the preferred and most rigorous way to estimate and test PU. PU is expressed in SI units at the 95% confidence level.
Pre-Acquisition Report (PAR)	Report submitted for approval after completion of the mobilisation phase of the survey. Report contains the results of all calibrations and validations conducted during this phase.
Project Management Plan (PMP)	See Attachment H of the HIPP Condition Of Deed (COD) for HIPP requirements
Receiver INdependent EXchange (RINEX)	An internationally accepted format for the exchange of GNSS receiver's raw observation data between different manufacturer receivers' and software applications for GNSS data processing. It is also used for GNSS data archiving.

Seabed Survey Data Model (SSDM)	A file geodatabase containing non-bathymetric spatial data deliverables. The HIPP SSDM has been modified from IOGP SSDM V2. See SPEC_03_33_BN32048462 HIPP Modified SSDM Data Dictionary.
Survey Hydroid	A LAT to Ellipsoid separation model which is derived using the Contractor's approved tide and GNSS model and additional high quality data as determined by the AHO. This hydroid differs from the AusHydroid as it is constrained by the area of the sounding data, and is not calculated using the methods implemented at a National scale.
Survey Instruction (SI)	A template document that provides the standards, areas and requirements for each survey task. Contractors are to quote against the Survey Instruction and Tasking Statement using the Quoting Template. The SI will contain specific requirements for a particular survey, guidance on the hierarchy of standards and references are provided in the introduction.
Surveyor In Charge (SIC)	Is the senior Level 1 Certified Hydrographic Surveyor (AHSCP CPHS1) responsible for the quality of all rendered of data under the conditions of the Contract.
Survey Management Plan (SMP)	The Survey Management Plan is the management plan for all survey activities. It contains updated statutory management plans (i.e. Environment Plan) and Work Method Statement/s that are specific for all activities detailed in the Survey Instruction.
Survey Party Chief	Senior member of the Survey Party on-board the vessel, they will usually be the SIC. The SIC may delegate the Survey Party Chief role as per Section 3.3 of this document.
Survey Uncertainty (SU)	The uncertainty of the horizontal and/or vertical coordinates of a survey control mark relative to the survey in which it was observed and is free from the influence of any imprecision or inaccuracy in the underlying datum realisation. Therefore, SU reflects only the uncertainty resulting from survey measurements, measurement precisions, network geometry and the choice of constraint. A minimally constrained least squares adjustment is the preferred and most rigorous way to estimate and test SU. SU is expressed in SI units at the 95% confidence level.
Tasking Statement	See Attachment H of the COD
Uncertainty	The interval (about a given value) that will contain the true value of the measurement at a specific confidence level. The confidence level of the interval and the assumed statistical distribution of errors must also be quoted. In the context of this standard the terms uncertainty and confidence interval are equivalent.

Work Method Statement(s)	Work Method Statement(s) are the mechanism the Contractor uses to plan how all survey tasks are to be conducted and are used to direct and guide survey teams. Work Method Statement(s) form part of the Survey Management Plan.

3 GENERAL PRINCIPLES

3.1 Project Nomenclature

Tasking Statements and Official Orders issued by MG Branch for HIPP projects covering defined survey areas conducted in accordance with the HIPP Deeds and this SOR for a fixed price will state the following identifiers based on the Survey Instruction (SI) reference:

Task Identifier: HIPP SI XXXX

Project Name: Name and key geographic area

Survey Instruction Number: SI XXXX

Tasking Statements and Official Orders issued by MG Branch for HIPP projects requiring survey support but not resulting the survey of a defined area will state the following identifiers based on the Survey Support Contract (SSC) reference:

Task Identifier: HIPP SSC XXX

Project Name: Name and key geographic area

Survey Support Contract: SSC XXXX

Every page of data, every item of hard copy record, every item of electronic media and every page of every report that is rendered is to be labelled with the SI XXXX identifier, or SSC XXX, as required.

All data (including scientific data) collected throughout the course of the Contract and accompanying documents and records, both working and faired, originating from the survey, shall be rendered with survey Data Packs and where appropriate, they are to cover the following caveat:

"Commonwealth of Australia Copyright 20YY"

Generally, position formats should be provided such that they have appropriate resolution, e.g. the number of decimal points should be appropriate to the accuracy of the measurement, millimetre precision is appropriate for Geodetic Observations where metre precision is appropriate for Tide Gauge locations. Full available resolution should be retained for computations until the final result is calculated.

There is a general trend to utilise decimal degrees and this is supported, notwithstanding care should be taken in the transformation of one format (e.g. DMS in an AUSPOS report) to another format as this can lead to transcription and rounding errors.

Guidance is provided in the following table.

Table 3 – Guidance for Precision of Coordinates

Description	Geographic Coordinates	Projected Coordinates	Remarks
Geodetic Reports, e.g. Station Summaries	DDD MM SS.sssss (5 DP) (see remarks regards AUSPOS) Heights m.mmm	m.mmm (3 DP)	Millimetre precision It is appropriate to retain the same format as AUSPOS reports (i.e. 5 DP).
SSDM • **Geodetic Stations**	DDD.dddddddd (8DP)	m.mmm (3 DP)	Millimetre precision
SSDM • **Shoals** • **Wrecks** • **Reportable Features**	DDD.ddddddd (7DP)	m.mm (2 DP)	Centimetre precision
SSDM • **TG Locations** • **CM Locations** • **Buoy Locations** • **Grab Samples** • **Drop Camera**	DDD.ddddd (5 DP)	m (0 DP)	Metre precision (Note that levels for Tide stations should be quoted at millimetre resolution)
SSDM **- Polygons (CARIS ZDF)**	DDD.dddddd (6 DP)	m.m (1 DP)	Decimetre precision
Geographic Locations	DDD MM.m (1DP)	N/A	Approx. 3m precision Where using other references use the same resolution / format, e.g. ALRS
X, Y, Z ASCII Files	N/A	m.mm (2DP)	Centimetre precision

3.2 Surveyor in Charge (SIC)

The Contractor shall identify the SIC in their Survey Management Plan (SMP). The SIC is to be an AHSCP certified Level 1 Surveyor (CPHS1) and in date for Continual Professional Development (CPD) as per the list of certified Surveyors published by the AHSCP. The SIC will be responsible for:

- Overall conduct of the survey in accordance with requirements of the SMP and SOR including data collection, data processing and reporting and delivery of data,
- Approving the SMP and Survey Work Method Statement(s) (WMS),
- Maintain the SMP and project schedule and provide timely updates to the AHO on any delays or changes in schedule and request contract CCP for any amendments,
- Be in the field for Mobilisation, system setup, calibration, and at completion of 100% data collection,
- To remain in field during mobilisation until the PAR is approved by ADHO and initial data collection has commenced,
- Conduct regular field inspections to ensure that data collection is occurring in accordance with (IAW) the SMP and WMS,
- Ensure that all field data collection is complete before demobilisation,
- Approve and sign the Report of Survey (ROS) and final deliverables,
- Be the Contractor principal point of contact for all technical and operational matters during the execution of the survey and during the commonwealth's acceptance of the survey.

The SIC is to be dedicated to the conduct of the survey in a full time capacity. Contractors may nominate an Assistant Surveyor in Charge (ASIC) to assist with the conduct of SIC tasks. If nominating an ASIC, the duties of the ASIC are to be clearly documented in the SMP. An ASIC are to meet the minimum requirements of a Survey Party Chief.

3.3 Survey Party Chief (SPC)

The Survey Party Chief (SPC) is the senior surveyor on board the vessel in charge of the field survey operation; they will normally be the SIC. The contractor may nominate Survey Party Chiefs who may lead the field survey operation in the absence of the SIC when they are rotating off the vessel or field location. Survey Party Chiefs (SPC) are to be:

- A CPHS1, nominated in the SMP, or
- An experienced surveyor (IHO Cat A or with an allied degree as defined by the AHSCP Guidelines), who is obtaining "In Charge Time" under supervision of the SIC (or a CPHS1), working towards certification, with written delegation from the SIC, and with prior agreement from Authorising Officer, or
- A CPHS2 may act as the SPC, if nominated in the SMP, under the supervisor of the SIC or a CPHS1, with prior agreement from Authorising Officer.

3.4 Project Team

The Contractor shall identify names and position of all personnel proposed to be involved in the project when submitting their response to Tasking Statement. Personnel nominated in the

Contractors Project Management Plan (PMP) do not have to have CVs supplied when bidding for projects. If the Contractor nominates additional personnel after commencement of the project (i.e. not listed in the Survey Management Plan) to supplement the survey team, the Contractor must provide the names, positions, qualifications and a resume of relevant experience of these additional personnel to the Authoring Officer for approval prior to employing them on the project.

The Contractor shall identify in their Survey Management Plan their Key Persons in the initial bid submission. Key persons are the Project Manager, SIC, ASIC, PC and any other individual holding a key technical responsibility. Key person are to be nominated on submission of the SMP Part 1, along with an outline of the staffing ashore and at sea, including vessel rotations, team structure and numbers both ashore and at sea to support the project. This information is to be provided at Annex B to the SMP.

If the SMP is shortlisted, the contractor is to provide an updated Annex B with full names, qualifications and citizen or visa status of all personnel to be employed as part of the survey team on the project on submission of SMP Part 2, including the supply of CVs for nominated personnel not listed in the Project Management Plan (PMP).

3.5 Science Cruises

The Contractor shall engage an AHSCP Level 1 certified (or equivalent) Hydrographic Surveyor to set up all equipment used to collect bathymetric data for scientific purposes to enable this data to contribute to charting products.

3.6 Survey Management Plan – Work Method Statements

In providing a quotation against the Tasking Statement and Survey Instruction, in accordance with the Conditions of Deed, the Contractor shall provide a preliminary Survey Management Plan that is specific to each Tasking Statement with enough detail to allow the Authorised Officer to assess the merits of the plan against the requirements of the Survey Instruction. This submission is to include the SMP Part 1 – Executive Summary and SMP Annexes A to H as per table 4.

If shortlisted the contractor is to submit a full SMP which is to include SMP Part 1, SMP Part 2 and SMP Annexes A to H as per table 4.

Upon notification of accepted Quotation, the Contractor shall provide a final comprehensive SMP inclusive of any negotiated items with supporting Management Plans for Approval by the Authorised Officer prior to signing of the Official Order, with the exception of Appendixes A – E which are to be provided 10 working days prior to Project Kick off meeting.

This SMP Document Pack to be provided prior to signing of the Official Order shall include, but not be limited to the following:

- Updated Management Plans in accordance with clauses 6.2.3, 6.2.4, 6.2.5, 6.2.7 and 6.2.8 of the DID-PM-PMP that have been submitted to the Commonwealth as part of the Project Management Plan. Specifically project specific Management Plans are to be provided as follows:

Table 4 – SMP Requirements

Section	Name	Description
SMP Part 1	Executive Summary	Limited to 6 pages (including overview diagrams). The Executive Summary is the Panellist's free form opportunity to highlight the technical advantages, value for money, risk mitigation and overall benefits of their solution to the Commonwealth. This should highlight innovation, industry and workforce development. This is not to include a repeat of the SI or detail the Company profile.
SMP Part 2	Survey Management Plan Description	This is the descriptive plan to undertake the task listed in the SI or SSC. This section must provide the How and Why description but does not need to repeat detail in the Annexes below (The Annexes provide the What / When / Who) or the PMP (which provides procedures), but should refer to them. SMP Part 2 needs to be detailed enough to be the core of the contract and is only required from shortlisted bidders. SMP Part 2 should include but not be limited to: - Project Strategy - Mobilisation Plan - Data Collection Plan - Demobilisation Plan - Data Processing Plan
SMP Annex A	Vessel / Aircraft Details	A summary of the proposed vessel / aircraft solution and their benefits. An image of proposed vessel / aircraft is to be provided, along with a table of key characteristics. For foreign-flagged vessels, overseas transit, crewing, and AMSA requirements should be discussed. **Additional Documentation** – Vessel Spec Sheets, AMSA Class Survey, any Recent Vessel impositions to be provided in supporting folder. (Note - a Vessel Condition and Suitability inspection may be requested by the AHO as part of the Contract Negotiations).
SMP Annex B	Personnel	Description of personnel to be deployed and those supporting in the office, including table of:

		Key personnel (SIC, PM, PC) names are required at SMP Phase 1 submission, Team structure afloat and ashore – number and qualifications required. Team names are required for SMP Phase 2 Submission, Field rotations (number of personnel, deployment dates) Citizenship / visa status of proposed foreign workers **Additional Documentation** - CVs of all nominated personnel to be provided in supporting folder; can be updated at Phase 2. Note: Copies of the Visa Grant Notice are required 10 days prior to Kick Off Meeting.
SMP Annex C	Equipment (and spares)	Description of Equipment to be deployed; to include for each vessel proposed, a Table of Equipment with quantity as follows: - Table of Sounding System(s) (and spares carried) - Table of Proposed MBES system setup - Table of Positioning Systems (and spares carried) - Table of Deployed Equipment (Tidal / Current / Geodetic) - Table of Ancillary Equipment (and spares carried) **Additional documentation** – Equipment Specs and brochures are to be provided in supporting folder.
SMP Annex D	Survey Uncertainty	Description of your assessment of proposed solutions ability to meet required Survey Order. For each vessel / system combination, at a selection of likely depths (including deepest depth), provide: - Input parameters (including environmental estimates) - A-Priori TVU / THU Assessments (numerical and graphical outputs) - Feature Detection and Density estimates **Additional Documentation** – High resolution graphics (optional).
SMP Annex E	Sub Area (or DAB)	Description of your approach to the line planning

	Planning	and is to include planning assumptions such as (but not limited to) swath width, overlap, vessel speed, turn time, time on task per day, contingency, infill estimates, wreck allowance, RF investigation allowance. Should include a Table of line miles / line spacing / duration / Contingency etc. for each DAB. DAB / Line planning diagrams are to be provided. **Additional Documentation** – High resolution graphics (optional).
SMP Annex F	Project Timeline	Provide a description of the proposed project timeline, including a Table of key dates such as mobilisation start, tide gauge deployment, milestone dates, demobilisation, delivery etc. If proposed dates are outside the RFQTS nominated dates, these are to be highlighted and justified. **Additional Documentation** – Gantt chart in PDF and Excel format.
SMP Annex G	Project Deliverables	Provide a description / table of proposed deliverables to reflect the requirements of the SI and SOR and your understanding of both the interim and final deliverables.
SMP Annex H	Project Risk Assessment	High Level Risk Management Plan and Risk Matrix Table identifying key project risks and Mitigation. Plan should identify risk such as, but not limited to: Weather, Environmental Risk, Navigational Risk, Marine Parks, Native Title, Marine Traffic, seabed complexity, tidal complexity. **Additional Documentation** – Company Risk Register updated for project.
SMP Annex I	SI Compliance Table	Table reflecting SI Sections and requirements. Contractor to state for each requirement whether they will either **Comply, Not Comply or Will offer a variation**. Statements made here should reflect demonstrated compliance provided in SMP Annexes
SMP Annex J	Tides and Geodetic Plan	Brief outline to describe your approach to achieve the required Tides and Geodetic solution to satisfy the SI requirements. This should include nominating if you are adopting a hydroid or tidal

		reduction method. Details on how the process for achieving a hydroid or tidal reduction can be included in SMP Part 2 if shortlisted. Annex should include: - Table of Equipment details, numbers, redundancy approach, - Table of Deployment timelines, - Rigging Diagrams, primary / secondary recovery methods, - GNSS Buoy Approach, Barometer Approach - Tidal Model diagram if using tidal reduction method.
SMP Appendix A	Project Emergency Response and Communications Plan	To be provided 10 working days prior to Kick off Meeting
SMP Appendix B	Project Environmental Management Plan	To be provided 10 working days prior to Kick off Meeting
SMP Appendix C	Project Quality Management Plan	To be provided 10 working days prior to Kick off Meeting
SMP Appendix D	Project Work, Health and Safety Management Plan	To be provided 10 working days prior to Kick off Meeting
SMP Appendix E	Mobilisation Plan Timeline	To Be provided 10 working days prior to Kick Off Meeting Table providing the proposed timeline for mobilisation activities so that the AHO CR can plan their engagement.

If there are any major changes to the comprehensive SMP after Approval, having consulted with the Authorised Officer for endorsement, a revised SMP is to be submitted to the Commonwealth. Minor changes to the SMP will be communicated to the Authorised Officer via the agreed reporting process (see Section 13.3).

3.6.1 SMP Appendix B – Project Environmental Management Plan (EMP)

A Project Environmental Management Plan ensures all aspects of environmental management and impact assessment have been considered, addressed and mitigated to ensure the environmental impact of HIPP survey operations is minimised. This plan will ensure all environmental risks and issues **specific** to the area in which the survey is to be conducted have been assessed and mitigated so far as reasonably practicable.

Points to be addressed within the EMP include but are not limited to:

- **Waterspace Management**

The Survey Instruction's 'Waterspace Management' section, should be consulted for Marine Parks and Restricted areas identified by the AHO within the bounds of the survey area

- **Environmental Protection**
- **Permits and Access Requirements**
  It is the responsibility of the SIC to ensure all relevant permits are held and access requirements are met prior to survey commencement. These are to be detailed within the EMP along with relevant contact details and pertinent information.
- **Cetacean and other Marine Fauna Interaction Plan**
  In areas where high concentrations of marine mammals are expected to be encountered, an action plan should be included within the EMP.
- **Environmental Reporting Requirements**
- **Energy and Natural Resource Management**
- **Waste Management**
  This section should cover the vessel Waste Management Plan, non-hazardous, sewerage and garbage disposal.
- **Incident Management Plan**
  Fuel, oil and other hazardous substance, spill management plan will be detailed in this section.

3.6.2 SMP Appendix C – Project Quality Management Plan

A Project Quality Management Plan for offshore surveying provides a structured approach to ensure the delivery of high-quality survey data and deliverables. It outlines the quality standards, processes, and responsibilities needed to meet project requirements. This plan helps to control the cost of the project, establish quality standards, and determine the steps needed to achieve those standards.

Key Components of a Project Quality Management Plan for Offshore Surveying:

- **Quality Standards and Expectations:**
  Define the acceptable quality levels for survey data, deliverables (e.g., maps, reports), and processes.
- **Quality Control Processes:**
  Outline the specific quality control checks and procedures that will be used throughout the survey. This may include data validation, accuracy checks, and adherence to established standards.
- **Quality Assurance Activities:**
  Detail the quality assurance processes, including audits, inspections, and review of deliverables to ensure compliance with standards.
- **Roles and Responsibilities:**
  Clearly define who is responsible for quality management at each stage of the project, including survey crews, data processing teams, and project managers.
- **Issue and Change Management:**
  Establish processes for managing issues, changes, and incidents that arise during the survey.

- **Continuous Improvement:**
  Include mechanisms for feedback, evaluation, and learning from past projects to enhance quality management practices over time.
- **Acceptance Criteria:**
  Define the specific criteria that must be met for deliverables to be accepted by stakeholders.

3.6.3 SMP Appendix D – Project Work Health and Safety Management Plan

Work Health and Safety is to be in accordance with the *Work Health and Safety Act 2011* (WHS Act) and accompanying Regulations as amended.

It is expected that a Work Health and Safety (WHS) management plan is a document that outlines how a workplace will manage its health and safety obligations. It's essentially a blueprint for ensuring a safe work environment, focusing on risk management, hazard identification, and continuous improvement.

If the panellist is chartering a vessel of opportunity, the WHS management plan should also “interface” the two safety systems of the survey company and the vessel operator and define how they will interact, including specifying which hazard observation system will be used, which incident reporting system will be used and clarifying any other discrepancies.

Key Elements of a Project WHS Management Plan:

- **WHS Policy:**
  Outlines the organization's commitment to WHS.
- **Hazard Identification, Risk Assessment, and Control:**
  A systematic process for identifying hazards, assessing risks, and implementing controls to mitigate them.
- **Roles and Responsibilities:**
  Clearly defines the roles and responsibilities of all individuals involved in WHS on the project.
- **Training and Competencies:**
  Ensures that workers are appropriately trained and competent to perform their tasks safely.
- **Consultation:**
  Establishes mechanisms for consultation with workers about WHS matters.
- **Incident Reporting and Investigation:**
  Describes the procedures for reporting and investigating incidents.
- **Record Keeping:**
  Outlines how records will be maintained, including incidents, investigations, and training records.

- **Monitoring and Review:**
  Establishes a system for regularly monitoring the effectiveness of the WHS management plan and making improvements

3.7 Access to Land and Sea Country

The status of Aboriginal sacred and significant sites must be observed. It is up to the successful HIPP contractor to obtain all permission and the required permits for the Contractor to enter Aboriginal land and water where required to conduct survey operations. A copy of all relevant documents, including a letter of introduction specific to the project, will be provided by the Commonwealth to the Contractor following contract award.

The Contractor must liaise with the land owners to ensure a good working relationship and approval before commencing operations on Aboriginal land and water. A summary of liaison and communication with land owners is to be documented with dates, times, persons involved, topic of liaison and outcome. These communications will form part of the Pre-Acquisition Report.

3.8 Environmental Considerations

When planning and executing Hydrographic survey operations, Contractors must afford environmental considerations a high priority. Prior to the release of the Tasking Statement, the AHO will contact relevant government authorities such as the Department of the Environmental Protection and Assessment (EPA) and the Great Barrier Reef Marine Park Authority (GBRMPA) to determine any specific environmental sensitivities of the planned survey area. Specific environmental guidance will be provided with the respective Tasking Statement as GFI (if required) and may be used to update the Environmental provisions of a SMP for the survey.

Notwithstanding advice provided by the AHO it remains the responsibility of the Contractor to identify and comply with all environmental requirements.

Project specific Environmental Management Plans are to be provided as appendixes to the SMP (Appendix B).

3.9 Quality and Safety Management

The Contractor shall review the Quality Management and Work Health and Safety provisions contained in the Project Management Plan and update as required. The Quality Management provisions must cover the planning, collection and processing of all survey data required under the Survey Instruction.

Project specific Quality Management Plans and Work Health and Safety plans are to be provided as appendixes to the SMP (Appendix C and Appendix D).

3.10 Government Furnished Material (GFM)

GFM will be provided under the Contract and will be listed in the Tasking Statement. This may include items such as:

- Government Furnished Equipment (GFE) such as geodetic station plaques, seabed collection packs, Argo floats or other material; and,
- Government Furnished Information (GFI) such as published navigation charts, foundation data, satellite images, adjoining survey data, or other material.

On acceptance of the Report of Survey, survey deliverables and the successful importing of these into the AHO data management systems, the AHO will instruct the Contractor to delete all GFI and return all unused GFE to the AHO.

Further details are provided in Section 14.

3.11 Client Representation / QA Audit

A Client Representatives (CR) from the Commonwealth will be assigned to each project and will be the main point of contact between the SIC and the AHO. CR will attend mobilisations and visit a survey location during the deployment period to observe and report on all aspects of the survey activity (e.g. view the patch test and system calibrations and validations, tide gauge deployments, data collection and processing).

Representatives from the Commonwealth may also visit the Contractor's processing premises during the deployment period to observe and report on various aspects of the survey activity.

The Client Representation / QA Audit requirements for survey activity and processing premises will be identified at the Kick Off meeting, and may be advised in writing by the Authorised Officer during the course of the project. Every endeavour will be made to ensure that QA visits are timed to coordinate with practical access to survey operations to avoid unnecessary delays which may impact the cost of the operations.

3.12 Platforms - Vessels and Aircraft

All vessels/aircraft tasked with surveys under the HIPP are subject to approval prior to survey work commencing under the contract.

An 'Approval Inspection' of vessels will be required to ensure that the vessel is compliant with AMSA certification standards when operating within Australian waters. These are to be conducted by an AMSA Inspector or AMSA-approved certifying surveyor as detailed in Section 3.13.

Once a vessel/aircraft has been tasked within an approved Survey Management Plan, the Contractor must seek approval from the Authorised Officer prior to removal and replacement with another platform. The Authorised Officer will only approve a like-for-like replacement platform that continues to abide by the requirements of the specifications in the tender bid.

3.13 Contracted Vessel Seaworthiness Assurance

The Commonwealth exercises a duty of care to any embarked personnel be they Naval or civilian. In order to provide this requirement, the HIPP requires the Contractor to provide sufficient evidence to justify a seaworthiness determination. This evidence will consist of official documentation as approved by an appropriate authority such as the Government, State of Territory of Australia or New

Zealand.

Basic assurances are to be provided as a mandatory component of the Comprehensive SMP Document Pack provided prior to Official Order signature. They can consist of but are not limited to:

- Vessel Certificate of Registration;
- Vessel Certificate of Classification;
- Most recent inspection by a recognised marine surveyor (such as OVID, Lloyds or AMSA);
- Master qualifications for each rotation; and,
- Certificate of vessel insurances.

At any stage of the contract, the Authorised Officer may request a further independent Vessel Condition and Suitability surveys or other assurances to support a seaworthiness determination. This can include a site inspection by the Client Representative or access to certain inspection databases such as the Offshore Vessel Inspection Database (OVID).

Should a vessel or supporting craft be modified in order to meet a particular requirement of the survey, the Contractor is required to liaise with the vessel operator in order to provide evidence that the modifications are consistent with the vessels class requirements and that if required a resurvey of the vessel has been completed by a competent authority.

At any stage the Authorised Officer may review the seaworthiness case based upon site visits or any emerging evidence and require the Contractor to take such action to maintain the seaworthiness of the vessel and thereby permit the embarkation of the Client Representative on the vessel in question.

4 CLASSIFICATION OF BATHYMETRY

4.1 Standards

The following standards to be used for HIPP surveys are based on IHO S44 Ed 6. AHO reserves the right to specify criteria that are tailored to the required product outcomes of each survey within an individual Survey Instruction.

Table 5 – Minimum Standards for HIPP Hydrographic Surveys

HIPP ORDER	IHO Exclusive	IHO - Special	HIPP - 1	IHO - 1a	IHO - 1b	HIPP 2	IHO 2	HIPP-Passage
TOTAL HORIZONTAL UNCERTAINITY (THU)								
TOTAL HORIZONTAL UNCERTAINITY (3)	1m	2m	2m + 1% of depth	5m + 5% of depth	5m + 5% of depth	5m + 10% of depth	20m + 10% of depth	5m + 10% of depth
SEAFLOOR SEARCH REQUIREMENTS (COVERAGE & FEATURE SEARCH)								
Swath Systems (1)	Full Seafloor Coverage (FSC) 100% - Coverage 100% - Feature Search	Full Bathymetric Coverage (FBC) 100% - Coverage 100% - Feature Search	Full Bathymetric Coverage (FBC) 98% - Coverage 100% - Feature Search	Full Bathymetric Coverage (FBC) ALB – 200% flown(2) 98% - Coverage 100% - Feature Search	MBES < 100% SBES 5% ALB – 100% flown ≥ 5% - Coverage	Full Bathymetric Coverage (FBC) 98% - Coverage 100% - Feature Search	Not Required	Offset track lines (4)
FEATURE DETECTION								
Water Depth <40m	50cm	1m	1m	2m	As Specified	As Specified	Not Applicable	Not Applicable
Water Depth >40m	50cm	1m	2% of depth	10% of depth	As Specified	As Specified	Not Applicable	Not Applicable
Water Depth >200 m	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	10% of depth	Not Applicable	Not Applicable
TOTAL VERTICAL UNCERTAINITY (TVU) (5)								
TOTAL VERTICAL UNCERTAINITY (4)	a = 0.15m b = 0.0075	a = 0.25m b = 0.0075	a = 0.25m b = 0.0075	a = 0.5m b = 0.013	a = 0.5m b = 0.013	a = 0.5m b = 0.013	a = 1.0m b = 0.023	a = 1.0m b = 0.023

(1) S-44 Ed 6 defines Bathymetric Coverage and Feature Search. HIPP defines Feature Search as obtaining ensonification or illumination of the survey area by the survey system to the level required by the standard. HIPP defines Bathymetric Coverage by node density.

(2) For an IHO Order 1a LiDAR survey AHO requires the area to be flown at least twice with flights on different days.

(3) 95% Confidence Level.

(4) When multiple passage sounding track lines cover the same area, they are to be offset to maximize coverage.

(5) To calculate the error limits for depth accuracy the corresponding values of a and b listed in Table 5 have to be introduced into the formula $\pm\sqrt{a^2 + (b \times d)^2}$

where a constant depth error, i.e. the sum of all constant errors in metres

$b \times d$ depth dependent error, i.e. the sum of all depth dependent errors

b factor of depth dependent error

d depth in metres

Table 7 provides a list of TVU values at various depths for each survey standard.

Description of Each Order

4.1.1 HIPP-Precise / IHO Exclusive

HIPP Precise Order has been removed as it matches the IHO Exclusive Order standard. IHO Exclusive hydrographic surveys are of the highest accuracy and are intended to cover small-scale shallow water surveys in areas where there is an optimal use of the water column and/or critical areas of under-keel clearance. This can include dredging surveys, harbour surveys with critical clearance heights under bridges, berthing areas and critical channels with minimum under-keel clearances or surveys requiring in-depth knowledge of the seabed to aid the management of Australia’s marine environment or resource management (i.e. wind farms). This order requires high precision surveying where all error sources must be minimised and high precision positioning and vertical control is utilised. This survey order will require the use of technology and methodologies capable of detecting all features greater than 50cm cube in less than 40m of water.

4.1.2 IHO-Special

IHO Special Order hydrographic surveys are intended to be restricted to specific critical areas with minimum under-keel clearance and where bottom characteristics are potentially hazardous to surface navigation. These areas will usually be associated with Under Keel Clearance Management (UKCM) systems, Recommended Tracks and Two Way routes where depths are critical, and MBES Reference Areas. This order requires high precision vertical and horizontal control and all error sources are to be minimized. This survey order will require the use of technology and methodologies capable of detecting all features greater than 1m cube in less than 40m of water.

4.1.3 HIPP-1

HIPP Order 1 hydrographic surveys are intended to cover surveys that require a greater knowledge of the seafloor out to the continental shelf margin. As a result, this order will require equipment and techniques capable of higher-order feature detection at these depths.

If required, feature detection requirements can be altered to suit the requirements of the survey area and will be noted in the Survey Instruction.

4.1.4 IHO-1a and 1b

IHO Order 1 hydrographic surveys are intended to cover all coastal survey areas. This could include harbour approaches, recommended tracks, and coastal areas with high traffic density and where under-keel clearance is less critical. At depths less than 100m man-made and natural features can pose a risk to surface navigation and thus a full seafloor search is required (IHO Order 1a). The Survey Instruction will provide guidance on full seafloor search requirements.

IHO Order 1a surveys require FBC and feature detection. IHO Order 1b may have incomplete coverage by ALB, SBES or MBES and likelihood of all features not being fully identified. IHO Order 1b may be appropriate in HIPP projects to capture small areas where surveys cannot achieve FBC, such as where the surveys area abuts very shoal areas, e.g. reefs or very shallow coastal areas.

4.1.5 HIPP-2

HIPP 2 hydrographic surveys are intended for areas generally deeper than 200 metres where full bathymetric coverage is required with a minimum feature detection requirement. These are areas where a detailed description of the bathymetry is required to support the Australian EEZ seabed mapping and environmental base line data. Details of coverage requirements will be provided with the Survey Instruction.

4.1.6 IHO-2

IHO Order 2 hydrographic surveys are intended for areas generally deeper than 200 metres where a general description of the sea floor is considered adequate. These are areas where a general description of the bathymetry is sufficient to ensure there are no obstructions on the seafloor that will endanger the type of vessel expected to transit or work the area. A full seafloor search utilizing a line spacing to achieve full bathymetric coverage may be required for the entire survey area. Details of coverage requirements will be provided with the Survey Instruction.

4.1.7 HIPP-Passage

HIPP-Passage hydrographic surveys are intended to provide the minimum requirements for the collection of data whilst passaging to and from the survey area. Data collected during passaging may be utilized to update AUS charts, provide reconnaissance data for future surveys, contribute to GEBCO products and perform analysis against AusHydroid modelling over time.

5 CONTROL – HORIZONTAL AND VERTICAL

5.1 Introduction

All surveying activities to establish and extend survey control are to be conducted using the practices and specifications detailed in the Standard for the Australian Survey Control Network – SP1 (ICSM).

5.1.1 Total Propagated Uncertainty

TPU is comprised of horizontal (THU) and vertical (TVU) elements, the assessment of these uncertainties is key to assessing the quality of the survey; verification processes during and post the survey are to be undertaken to provide assurance that the estimated THU and TVU achieved the survey order standards.

Contractors are required to provide a-priori estimates for both TVU and THU with their initial SMP to demonstrate that the proposed survey solutions meet the survey standards.

TPU is critical to the generation of a CUBE surface and the contributing factors are to be fully documented, including an assessment of the uncertainty of tidal observations and model and analysis of the TPU layer to support the claimed order of the final derived bathymetric surface.

As the IHO and HIPP Standards are defined by the TVU and THU tolerances, a-posteriori uncertainty analysis at 95% confidence level of both TVU and THU are to be conducted to prove the survey standard has been met. This can be achieved either through the first principals a-posteriori analysis of the input survey system errors and environmental conditions and results achieved, or through the generation and analysis of TPU (Depth) and TPU (Position) layers from a SDTP type surface generation.

5.2 Horizontal Control

Extension of existing geodetic control and the establishment of new stations shall be fully documented. Survey control marks are to be coordinated relative to the survey datum (ITRF) and any deviation of the coordinates from existing control marks are to be highlighted and explained in the ROS. All geodetic control marks are to be tied into the NGRS CORS using a suitable GNSS processing service approved by AHO or other Least Squares based process utilising final ephemerid data unless stated in the Survey Instruction. Proposed Geodetic processing software and intended use should be described in the SMP.

All geodetic control marks established during a survey shall be IAW Guidelines for the Installation and Documentation of Survey Control Stations – SP1 (ICSM). Geodetic control marks will be provided as GFM.

All geodetic control stations are to be positioned using Classic Static survey techniques IAW Guidelines for Control Surveys by GNSS – SP1 (ICSM) Table 1 (p.7) to achieve **SU <15mm for horizontal position and SU <20mm for ellipsoidal height.** Session length is to be 24 hours.

A full station record including photographs and diagrams to aid recovery shall be recorded using the form F_03_32_R31793216 Survey Mark Station Summary (Section 14.1). All Raw and RINEX files shall be rendered with the Tides and Geodetics Data Pack. A copy of all Final AUSPOS reports, or equivalent reports from processing software, are to be rendered with the ROS in the final Tides and Geodetics Data Pack.

Geodetic Positions are to be quoted to DDD MM.MMM and grid positions (UTM) are to be quoted to 3 DP of a metre.

5.2.1 Horizontal Datum

All horizontal positions shall be referenced to the International Terrestrial Reference System (ITRS). Typically, this will be the datum currently supported by commonly used positioning services, e.g. ITRF 2020 (GRS80 Spheroid), EPSG:9989 (3D) or EPSG:9990 (2D). By prior approved exception, if positions are referenced to a local horizontal datum, this datum should be tied to a geocentric reference frame based on International Terrestrial Reference Frame (ITRF), which is a realization of the ITRS.

A table documenting the local datum epoch and transformation parameters is to be rendered with the ROS. In addition, all software used on the survey must contain the correct datum parameters and this should be evidenced in the ROS.

Grid positions, if used, shall be referenced to the WGS84 Universal Transverse Mercator (UTM) zone.

All horizontal datum’s used should have a standard EPSG code. Custom coordinate reference systems should not be used, to ensure compatibility across software suites. The same datum should be used for all deliverables unless otherwise specified.

5.2.2 Positioning

Soundings are to be positioned using a system capable of the specifications and horizontal uncertainty detailed in the Survey Instruction. When required, the Survey Instruction will specify the use of DGNSS Precise Point Positioning techniques (PPP) (or better) to aid in the improvement of the AUSHYDROID.

Best practice is to have multiple independent GNSS positioning systems to provide real time quality assurance, with primary and secondary positioning solutions set up to allow real-time Quality Control and system redundancy. Where possible this is the preferred mode of operating, though where this is not possible such as on small Unmanned Survey Vessels (USV), alternative methods to monitor and ensure positional quality can be nominated. The methods to be used to provide real-time position monitoring are to be clearly described in the SMP. Primary and secondary solutions are to be operational and acquiring data at all times throughout the survey.

The Contractor shall demonstrate that the method of positioning and processing meets the uncertainty requirements of the Survey Instruction as a tender deliverable.

5.2.2.1 *Validation of the Positioning System*

Position fixing systems used to control a survey shall:

- Be validated by static checks during mobilisation, followed by dynamic checks in the survey area.

- Have a method of continuously monitoring and recording the quality of the real-time 3D positional data. The method and overall results are to be detailed in the ROS.
- Allow for real-time monitoring and comparison of primary and secondary positioning solutions with operator alerts configured to warn of unexpected differences between solutions.
- Include in area dynamic positional checks over a small feature least depth position as surveyed by multiple lines from multiple directions, and where multiple survey platforms are employed all platforms should survey across one or more common features, validating the position of the features least depth.

Details of all validations, including a summary of real-time monitoring, shall be included in the ROS.

See Section 7.2.1.2 for more detail of the static positioning validation.

5.2.3 Total Horizontal Uncertainty (THU)

In determining the horizontal uncertainty all sources of uncertainty shall be quantified and the statistical method described in IHO S-44 Ed 6 adopted. All uncertainty is to be stated to 2 DP of a metre.

The Contractor shall provide an a-priori assessment of the THU at the 95% confidence level during the planning phase to demonstrate that survey operations can fulfil the THU specifications required by the Survey Instruction. The a-priori assessment of THU should be provided for the bathymetric surface “depth bands” expected in the survey area. This is to align with the bathymetric surface resolutions in Section 7.6,.or as agreed by the AHP Authorised Officer.

During survey operations THU is to be monitored and if the assessment of THU indicates that the standards in the Survey Instruction can no longer be met, the Contractor shall consider restructuring operations to meet the requirements, and keep the Authorised Officer informed of the change.

A single THU value at the 95% confidence level is to be recorded in the ROS and all associated digital datasets for each supplied bathymetric surface. The quoted THU should reflect the horizontal uncertainty of the underlying point data observations and will be used to populate the POSACC attribute in the generation of S-57 products by AHO. Surfaces should be depth banded such that the single quoted THU value is true for the shallowest 95% of the surface. The quoted THU value for each surface should at a minimum be based on two of the following methods with supporting calculations provided:

1. an a-posteriori assessment such as from a THU calculator whereby inputs are based on conditions and performance of sensors experienced throughout the survey,
2. the TPU(H) figure generated from an SDTP surface at the 95% confidence level (mean TPU(H) + 2.45 x SD)
3. built up from the results of dynamic and integrated validations whereby the configuration of

equipment is as was used for the survey.

Where one of the THU figures varies greatly from another this should be investigated and a statement made by the SIC. Generally, unless justified otherwise, the 'worst case' value should be provided for each surface.

Where THU has varied spatially or temporally, full details shall be given in the ROS including area boundaries and the typical values for the different areas. In addition to these descriptive details, a spatial polygon shall be supplied within the SSDM. This does not negate the requirement for the SIC to provide a definitive statement of a single THU value for each bathymetric surface supplied.

5.2.4 Navigation Aids and Other features

The position of all navigational aids, leading lines, dangers to navigation, other submerged features, coastline and topographical features shall be determined such that the horizontal and vertical uncertainty meets the requirements in accordance with Table 6 below. When calculating this uncertainty, all uncertainty sources not just that associated with the positioning equipment shall be taken into account.

Table 6 – Standards for the Positioning of Navigation Aids and Other Features

Ancillary Features	Maximum Allowable Uncertainty of Ancillary Features (THU and TVU)									
	IHO - Exclusive		IHO-Special		IHO-1a and b		HIPP-1 HIPP-2		IHO-2	
	HOR (m)	VER (m)	HOR (m)	VER (m)	HOR (m)	VER (m)	HOR (m)	VER (m)	HOR (m)	VER (m)
Fixed Aids and Features Significant to Navigation	0.2	0.3	0.5	0.5	2.0	1.0	2.0	1.0	5.0	3.0
Drying Rocks	0.2	0.3	0.5	0.5	2.0	1.0	2.0	1.0	5.0	1.0
Mean Position of Floating Aids to Navigation	5.0	N/A	10.0	N/A	10.0	N/A	10.0	N/A	20	N/A
Leading lines	The orientation of leading lines shall be determined +/- 0.5°									

5.3 Vertical Control

5.3.1 Sounding Datum

Shallow water surveys (depths <200 metres) are to be reduced to a datum that approximates Lowest Astronomical Tide (LAT). This requirement also applies to interim products provided to demonstrate survey progress and support milestone achievement.

Deep water surveys (depths >200 metres) are to be reduced to Mean Sea Level (MSL), which is taken to approximate LAT at these depths.

The Contractor is to propose a tide reduction strategy in the SMP for approval by the AHO prior to commencement of the survey activity. Where practicable, and dependent on limitations of the processing software employed, consideration should be given to aligning data acquisition blocks (sub areas) with tidal zone boundaries to minimise any potential tidal steps between acquisition block.

The nodes for the tide zones or blocks shall be coincident with the deployment locations of the tidal infrastructure. The use of large 'tide areas' with large numbers of stations should be avoided, a tide area or tide block should ideally have 3 tide stations, but not have more than four to five active stations, i.e. the tide strategy should be constructed to not consider tide stations outside the boundary of influence of the nearest stations. This requirement is to allow the tidal model to be easily incorporated into the AHO MSL-LAT tidal model. Final approval of the tide model and the datum for individual tide stations will be approved by the AHO following submission of the interim Tides and Geodetics Data Pack.

5.3.2 Establishing Datum

Where possible sounding datum will be recovered from an existing tidal benchmark, these will be specified in the SI. If no suitable benchmark exists at a location, and in offshore situations, LAT will be determined from analysis of a minimum of 35 days of tidal observations.

Sounding datum determined from analysis of near shore tide gauge data must be referred to a minimum of three vertical benchmarks whose elevations must be determined to the accuracy stated in the Guidelines for Control Surveys by Differential Levelling – SP1 (ICSM). Further advice on levelling requirements are provided in Section 6.1.3. At least one benchmark is to be GNSS positioned using Classic Static survey techniques (see Section 5.2)

A full station record including photographs and diagrams to aid recovery shall be recorded for each Benchmark using the form F_03_32_R31793216 Survey Mark Station Summary (Section 14.1). Where a Mark is only positioned approximately this should be noted in the Description of Station Mark.

Sounding datum determined from analysis of offshore tide gauge data must be connected to the GRS80 Ellipsoid via a minimum of 75 hours of simultaneous GNSS observations. Where a tide gauge is lost or recovered without valid data, and no backup gauge is successfully recovered, simultaneous GNSS observations must be repeated for new tide gauge deployments.

Any issue with recovering an existing datum or the establishment of a new sounding datum is to be communicated with the Authorised Officer immediately.

Proposals to reduce soundings via AUSGeoid09 or AUSGeoid2020 will not be accepted, as these Geoid models do not have the required accuracies off the coast.

5.3.3 Final Sounding Datum

An interim Tides and Geodetics Data Pack, as per section 11.4.2, is to be submitted to the AHO for approval prior to being applied to the processed data for submission with the final delivery of data. This is to be submitted via the HSS Operational Environment, in Defence's Jetstream AWS. The final

Sounding datum to be applied will be confirmed by the AHO once review of the interim data is conducted and advised to the contractor.

For completeness, final versions of all tidal data, supporting documents and information is to be included in the Tides and Geodetics Data Pack, even if these are unchanged from that previously provided; the interim Tides and Geodetics Data Pack is not considered part of the final deliverable.

The method used to apply tidal adjustments to the survey shall be detailed in the ROS along with a copy of all records and digital data used.

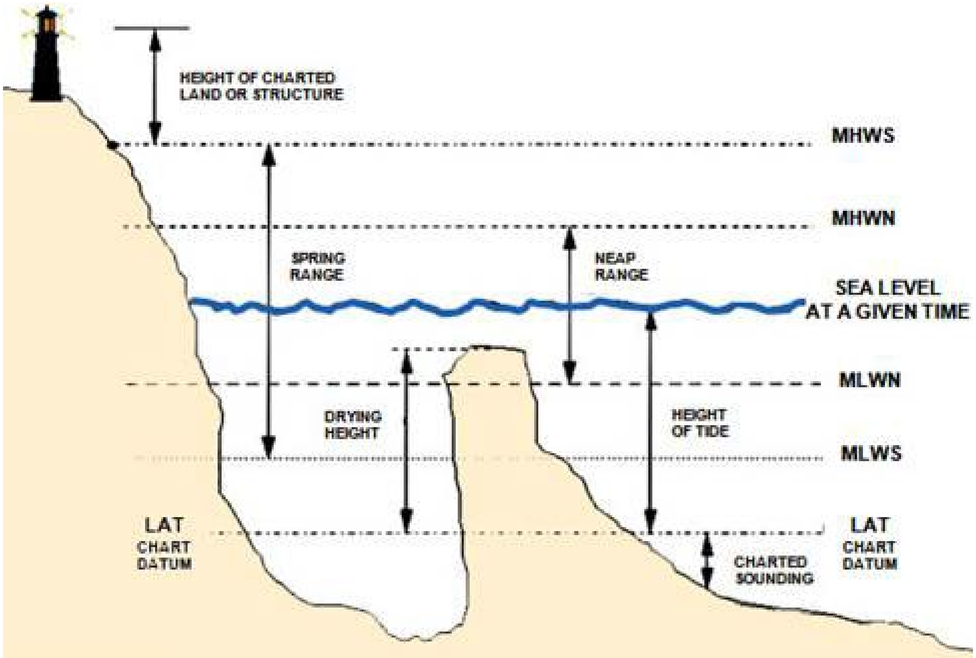


Figure 1 – Vertical Datums

5.3.4 Datum for Elevations and Overhead Clearances

All elevations and clearances must be referenced to a specific datum. In tidal waters, elevations are referenced to Mean High Water Springs (MHWS) or Mean Higher High Water (MHHW), see Figure 1 and INT1 H20 (IHO). Overhead clearances (e.g. bridges) are referenced to Highest Astronomical Tide (HAT).

In non-tidal waters, elevations are referenced to the sounding datum.

5.3.5 Total Vertical Uncertainty (TVU)

In determining the total vertical uncertainty, all sources of uncertainty shall be quantified and the statistical method described in S-44 adopted. All uncertainty is to be stated to 2 DP of a metre. The capability of the survey system should be demonstrated by the TVU calculation.

The Contractor shall provide an a-priori assessment of the TVU at the 95% confidence level during the deployment phase to demonstrate that survey operations can fulfil the TVU specifications required by the contract. The a-priori assessment of TVU should be provided for the bathymetric surface 'depth bands' expected in the survey area. This is to align with the bathymetric surface resolutions in Section 7.6.

TVU shall be monitored prior to the commencement of sounding and during the course of the survey should conditions vary from that expected. If the assessments of the TVU indicate that the standards in the Survey Instruction are unlikely to be met, the Contractor shall consider restructuring operations to meet the requirements, and keep the Authorised Officer informed of the change.

A single TVU value at the 95% confidence level is to be recorded in the ROS and all associated digital datasets for each bathymetric surface supplied. The quoted TVU per surface should reflect the vertical uncertainty of the underlying point data observations and will be used to populate the SOUSACC attribute in the generation of S-57 products by AHO. Surfaces should be depth banded such that the single quoted TVU value is true for the shallowest 95% of the surface. The quoted TVU value for each surface should, at a minimum, be based on two of the following methods with supporting calculations provided:

1. a statistical analysis of the CUBE uncertainly layer at the 95% confidence level (mean TVU + 1.96 x SD);
2. an a-posteriori assessment such as from a TVU calculator whereby inputs are based on conditions and performance of sensors experienced throughout the survey. All Inputs to the calculator are to be provided, along with statistical and graphical outputs;
3. the TPU(V) figure generated from an SDTP surface at the 95% confidence level (mean TVU + 1.96 x SD); or
4. built up from the results of the crossline comparisons, reference surface comparisons and repeated benchmark line comparisons scaled to 95% confidence level in the same fashion.

Where one of the calculated TVU figures varies greatly from another this should be investigated and a statement made by the SIC. Generally, unless justified otherwise, the 'worst case' value should be provided for each surface.

Where TVU has varied spatially or temporally, full details shall be given and explained in the ROS including area boundaries and the typical values for the different areas. In addition to these descriptive details, a spatial polygon shall be supplied with the SSDM. This does not negate the requirement for the SIC to provide a definitive statement of a single TVU value for each bathymetric surface supplied. The Surveyor in Charge shall demonstrate that the method chosen for final tidal reduction results in the overall depth accuracy (TVU) requirements being achieved.

Introduction of S-100. As a precursor to implementing the IHO S-100 data model, the SIC should begin considering the generation and reporting of an a-posteriori assessment (TVU calculator) that separates fixed (depth independent / constant depth error) sources of uncertainty from variable (depth dependent) sources of uncertainty. These fixed and depth dependent components may be provided in addition to the overall TVU for each surface that is required for S-57 purposes. The SIC should endeavour to ensure these sources of uncertainty remain within the component tolerances as defined by the "a" and "b" value in Table 5.

- For example, for an IHO Order 1a survey, the sum of the fixed vertical uncertainty values should be ≤0.5m, and the sum of the variable uncertainty values should be ≤1.3% of depth (and ideally ≤1% depth in accordance with IHO S-57).

Under this SOR a survey will still be considered compliant if all sources of uncertainty remain within the total uncertainty value tolerance as required for IHO Order 1a, and as applied to surfaces for S-57 purposes above. This additional reporting against S-100 is to allow both AHO and contractors to develop, monitor and adjust survey practice if required in preparation of S-100 implementation (which will be advised under a future SOR update) whereby depth dependent factors will need to remain within the prescribed percentage of depth.

Table 7 provides an indication of the maximum allowable TVU values for each survey order at various depths.

Table 7 – TVU Calculations at Various Depths(1)

Depth of Water	IHO Exclusive	IHO Special	HIPP-1	IHO Order 1a & 1b	HIPP-2	IHO-2	HIPP Passage
5	0.15	0.25	0.25	0.50	0.50	1.01	1.01
10	0.17	0.26	0.26	0.52	0.52	1.03	1.03
15	0.19	0.27	0.27	0.54	0.54	1.06	1.06
20	0.21	0.29	0.29	0.56	0.56	1.10	1.10
25	0.24	0.31	0.31	0.60	0.60	1.15	1.15
30	0.27	0.34	0.34	0.63	0.63	1.21	1.21
50		0.45	0.45	0.82	0.82	1.52	1.52
100		0.79	0.79	1.39	1.39	2.51	2.51
150			1.15	2.01	2.01	3.59	3.59
200			1.52	2.65	2.65	4.71	4.71
300			2.26	3.93	3.93	6.97	6.97
400			3.01	5.22	5.22	9.25	9.25
500			3.76	6.52	6.52	11.54	11.54
1000			7.50	13.01	13.01	23.02	23.02
1500			11.25	19.51	19.51	34.51	34.51
2000			15.00	26.00	26.00	46.01	46.01
2500			18.75	32.50	32.50	57.51	57.51
3000			22.50	39.00	39.00	69.01	69.01
3500			26.25	45.50	45.50	80.51	80.51
4000			30.00	52.00	52.00	92.01	92.01
4500			33.75	58.50	58.50	103.50	103.50
5000			37.50	65.00	65.00	115.00	115.00

(1) Formula for TVU: $\pm\sqrt{a^2 + (b \times d)^2}$ from Table 5

5.4 Time Datum

Coordinated Universal Time (UTC) shall be used for all time records.

6 WATER LEVEL OBSERVATIONS

Observations sufficient to determine variations in the water level across the entire survey area must be undertaken for the duration of the survey for the reduction of soundings to the provided vertical datum, and to allow for the determination of hydroid separation to allow for development of the National AUSHYDROID. Where a relationship between tidal levels and the land survey datum are known, details will be provided with the Survey Instruction.

A minimum of 35 days of continuous data, or the duration of the survey whichever is longer, is required at each deployment location.

Data collected will also be used to refine the Australian Charting Vertical Reference Framework (ACVRF) and develop the AUSHYDROID.

To ensure consistency with international and national oceanographic data collection best practices, it is recommended that Panellists utilise TEOS-10 when converting pressure to depth, including calculating the average density of sea water in the survey area based on calculations from the results of SVP observations. Some equipment manufactures still use the older EOS-80 standard and a simplified equation. If Panellists do choose to use the older simplified equations and default values for the state of seawater and disregard geopotential anomaly they should account for this in their TVU calculations. Regardless of the method there is a degree of uncertainty associated with the method of converting pressure to depth and it should be accounted for. The method to be applied is to be fully documented in the SMP, descripted in the Report of Survey with uncertainties listed and applied in the TVU calculations.

Further details on the use of TEOS-10 for conversion of pressure to depth from pressure can be found at: https://www.teos-10.org/pubs/gsw/html/gsw_z_from_p.html

6.1 Establishment of Tidal Stations (Near Shore and Offshore Gauges)

Minimum tide station requirements for each survey area will be defined in the SI. In consultation with the AHO, deployment locations may be modified or expanded to improve the tidal model or for safety of navigation purposes.

Near Shore Tide Stations are defined as tide gauge deployment sites located within 3km of the shoreline and within 5km of an existing or new vertical benchmark. For each near shore tidal station, the station will comprise two tide gauges mounted independently, at least one tide staff or GNSS tide buoy deployed for minimum of 25 hours to effect datum transfer if GRS80 Ellipsoid connection is obtained via shore observations. If GRS80 Ellipsoid connection is obtained by GNSS Tide Buoy observations, then a minimum of 75 Hours is required. Survey datum is to be referred to at least three vertical benchmarks. All near-shore tide gauges are to be tied to the ITRF via a vertical benchmark.

Offshore Tide Stations are defined as tide gauge deployment sites located greater than 5km from the shoreline and which are not referred to a shore based vertical benchmark. For each offshore tidal station, the station will compromise of two tide gauges (BMTG) deployed on independent moorings and a GNSS tide buoy deployed for at least 75 hours of concurrent GNSS observations to enable a connection between LAT and the GRS80 Ellipsoid. A 75-hour deployment will ensure 72hrs of useable observations.

6.1.1 Tide Gauge

Tide gauges are to be capable of recording sea level measurements to the following specifications:

- Processed tide files should provide a tide value every 5 minutes, or as required by the SI;
- Proposed Tide Gauges or Water Level Recorders (WLR's) must have a calibrated range scale greater than the depth of the TG location + the expected tidal range. To avoid unnecessary consumption of the vertical error budget, the proposed tide gauge or WLR should also be appropriate to the depth + expected tidal range of the deployment location. For example, if the depth + expected tidal range at the gauge location is 25m, it would not be appropriate to utilise a gauge with a calibrated range suitable for a 200m location. In this case, it would be more appropriate to deploy an instrument calibrated to 30m. This is to be demonstrated through tabular format in the SMP, the table should indicate charted depth and proposed gauge range.
- Minimum accuracy of measured tidal height shall be ±0.05% (full scale), and stability ±0.1%. The recorded value shall be the average water height taken at 1Hz over a minimum of 60 seconds centred on the time of recording;
- Height of tide is to be recorded on the hour (UTC) and at intervals not exceeding 5 minutes. Time accuracy is to be ±1 minute;
- Height of tide is to be recorded to the nearest 0.01m; and,
- Values used in a-priori uncertainty are to be based on the typical or long-term stability of the gauge.

The SIC shall ensure that all tide gauges employed in the survey have a factory calibration certificate that is within the manufacturers recommendation, or a tide gauge that is less than 2 years old.

Tide gauge internal clocks are to be validated against UTC prior to deployments and checked against UTC on every occasion when checked / downloaded, this check is to be recorded in tide gauge deployment records and observed time drift noted. Significant time drift should be brought to the attention of the Client Representative and Authorised Officer.

Non vented tide gauges and tidal data collected for IHO Exclusive, IHO Special Order, HIPP 1 and IHO Order 1 surveys are to be corrected for atmospheric pressure. Atmospheric pressure is to be recorded at fixed locations within 25nm of the gauge at a temporal resolution of no greater than 1 hour. If there is no suitable location for pressure recording within 25nm then buoy deployments shall be utilised; or, alternative locations may be proposed with appropriate consideration of the uncertainty associated with determining pressure corrections from monitoring stations at greater ranges. As a backup, atmospheric pressure shall be recorded on the vessel at 1 hourly intervals.

Prior to the deployment of any seafloor infrastructure the SIC shall satisfy themselves that the proposed deployment location is level and stable.

The Authorised Officer is to be informed of the location of all tide gauges, through inclusion in the SMP and supporting geospatial data (SSDM extract). Gauges which pose a risk to surface navigation are to be notified to AMSA and AHO in order that appropriate NAVAREA X, AUSCOAST Warnings and NtM can be issued for the location. A single Hydrographic Note (F_05_51_AA217160) is to be produced covering all planned tidal infrastructure deployments and recovery. Locations are to be provided in degrees decimal minutes. A single date range is to be provided for the notice (i.e. from the first planned gauge deployment until the last planned gauge recovery), encompassing GNSS tide buoy deployments in the vicinity of each location. Specific dates for each location are not required. A revised Hydrographic Note is to be submitted in the event of significant changes to the tidal infrastructure position(s) or deployment duration, and a notification submitted when the survey is complete and all instruments have been recovered.

Data is to be rendered in the Tides and Geodetics Data Pack (Section 11.5.5), with formats in accordance with Section 12.6.

6.1.1.1 *Tide Gauge Observation Uncertainties*

There are many components to be to be considered when assessing tidal uncertainties. All sources of error associated with the water level recording and sounding reduction method are to be considered and explained by the SIC. For bottom mounted pressure gauges the sources of error may include but is not limited to the pressure sensor accuracy, method of conversion of pressure to depth, errors of drift in the instrument, errors in the atmospheric pressure records, datum shifts due to instrument settlement, datum transfer etc. Whilst the errors are not all the same when utilising GNSS tide buoys a similar approach should be taken.

6.1.2 Tide Buoys

Tide buoys employing GNSS sensors will generally be used to facilitate a comparison between seafloor mounted Tide gauges and the ellipsoid. Tide buoys may also be used in lieu of seabed mounted gauges where approved in the SMP.

- The vertical movement of all GNSS tide buoys shall be tied to the CORS network and/or a local GNSS Base Station if possible. If a GNSS Base Station cannot be established within 50nm, observations based on a commercial network adjusted correction service will be accepted.
- GNSS tide buoy data is to be logged at 1 Hz.
- Onshore GNSS Base Stations are to be logged at 15Hz intervals.
- For simultaneous GNSS tide buoy / Tide Gauge observations the following observation periods are to be followed.
    - Minimum 25 hours for near shore tide gauges within 5km of the reference benchmark GNSS station, longer periods of GNSS tide buoy observations should be considered where the GNSS buoy is in a location exposed to significant sea or swell.
    - 75 hours for offshore sites.
- Processed GNSS heights from tide buoys are to be averaged to provide a smoothed output to minimise the effects of short term heave. This can be achieved through a variety of

methods such as a Savitzky-Golay filter or a Fast Fourier Transform (FFT) low frequency filter. It is important that the peaks and troughs of the GNSS curve are retained and any potential errors introduced by the smoothing/average method are well described.

- Linear Regression is to be conducted, and is the preferred method used to determine hydroid separation values provided correlation coefficient (R^2 values) are acceptable close to 1 (but not less than 0.95). If R value are not acceptable, then the SIC is to consider repeating the comparison as this may indicate a scale error in the observations. If the comparison is not repeated the SIC is to justify why the original comparison should be used. If linear regression is not used, SIC is to fully describe method used to obtain separation values. A clear statement is to be made as to whether the Ellipsoid is above or below LAT. The SIC shall also provide a definitive statement on the error associated with the determination of the separation value. This should also include statistical analysis of the plotted difference between the GNSS tide gauge and the bottom mount gauge.

The linear regression is to be used as follows:

a. The linear regression should have a correlation coefficient > 0.95 and a gradient close to 1 to demonstrate the suitability of connecting the GNSS data to the BMTG data.

b. Harmonic analysis is to be performed on the processed BMTG heights as per **Section 6.4**.

c. When the final MSL value (Z_{00s})* for the BMTG data is obtained, the linear regression plot is to be used to find the equivalent GNSS buoy height for that value. The LAT to MSL separation is then applied to the Ellipsoidal connection to obtain the value of LAT relative to the Ellipsoid (hydroid).

* See document “HIPP Guidance Notes on Tidal Analysis” for further description.

The Van de Casteele test is simple tool for the assessment of the performance of tide instruments and identification of errors. The SIC shall produce Van der Casteele diagrams to identify issues and assess the quality of the GNSS buoy data during mobilisation and demobilisation. Issues can then be addressed before instruments are deployed on the HIPP surveys. The results can also be used for estimation of errors associated with the GNSS buoys.

Van der Casteele test shall be used in a similar manner to compare the GNSS data collected at the survey site, using the bottom mounted tide gauge as the reference instrument.

Information on the testing method is given in the “HIPP Guidance Note on Van de Casteele Test”.

Where there is significant drag on tide buoys due to strong tidal streams, efforts are to be made to minimise the possible influence on the tide buoy height. Additional surface floats between the mooring and tide buoy, and an IMU on the tide buoy itself should be considered to mitigate and assess the effects of tidal stream on tide buoys.

6.1.3 Levelling

Each near-shore tide gauge is to be tied to the ITRF utilising at least three vertical benchmarks. This is to be achieved by the conduct of GNSS Classic static observations over at least one primary benchmark to determine the ITRF 2020 ellipsoidal height. ITRF ellipsoidal height is to be transferred to all benchmarks via two way levelling between the benchmarks and to near shore tide gauge via a tide staff comparison, or simultaneous GNSS tide buoy observations at the gauge deployment.

Near shore tide gauges must be within 5 kilometres of the benchmarks.

When recovering a tidal datum, the results of all vertical heights are to be compared with recorded data. Any marks that have been destroyed or disturbed are to be replaced with new marks, levelled and coordinated. Any discrepancies with existing data are to be investigated and reported to the Authorised Officer in the next reporting period so that records can be updated or variations advised.

Two way levelling, backsight and foresight change points for every benchmark, with a Maximum Allowable Misclosure = $12mm * \sqrt{k}\ (km)$ using either an optical/digital level or total station is to be conducted between all benchmarks and the tide staff in accordance with Guidelines for Control Surveys by Differential Levelling - SP1 (ICSM). All height values are to be recorded to 0.001m.

If a GNSS tide buoy is used in place of a tide staff, levelling runs are to be conducted between all benchmarks. The benchmark being coordinated and the GNSS tide buoy observations must be simultaneous for a minimum period of 25 hours so that an analysis can be conducted to establish the datum connection. All benchmarks are to be positioned as per Section 5.2.

The following deliverables are to be rendered with the ROS for all levelling runs:

- A diagram of the levelling run showing change points and stations locations (either digital from equipment or field notebook diagram);
- Levelling observations Form F_03_32_BN49664941; each levelling run is to be rendered as an individual MS Excel documents; and
- Confirmation that all level runs have achieved Maximum Allowable Misclosure tolerances.

Levelling should be conducted as soon as possible after tide gauge deployment.

6.1.4 Comparison Check for Tide Gauges and Barometers

6.1.4.1 *Mobilisation Checks*

The SIC shall ensure that all Tide Gauges and Barometers to be employed in the survey are field checked within one month prior to deployment.

For Tide Gauges this shall include a ‘25-hour test dip’ or 25-hour Gauge / Pole or Gauge / GNSS Buoy / vessel waterline height comparison at the mobilisation port.

For Barometers, checks must be co-located to Tide Gauges and in a stationary position for a minimum of 25hrs. The barometer check should include reference to the closest Bureau of Meteorology Station.

Tide Gauges and Tide Buoys are to be checked against the official Standard or Secondary Port Tide Gauge at the mobilisation port wherever possible. Comments on phase and amplitude differences are to be included. Details and results of these checks shall be included in the PAR.

6.1.4.2 *Demobilisation Checks*

Deployed Tide Gauges are to have a test dip comparison conducted on recovery at the demobilisation port.

The Tide Gauges must be submerged at the demobilisation port and the logging period must be a minimum of 13 hrs.

Barometers are to be co-located and logging simultaneously with the Tide Gauges. Barometers are to have a minimum 13hr comparison to the closest Bureau of Meteorology Station. These checks are to ensure the deployed gauges are following the tide correctly, ensure the stability of the gauge, and to identify errors due to gauge malfunction and movement. The SIC is to comment on the results of all checks in the PAR and ROS. Gauges that are demonstrated as not following the tide correctly are not to be deployed.

The SIC is to tabulate statistical results of the mean and standard deviation of differences of the tide measuring instruments compared to the reference gauges (Standard Port tide gauge or BOM weather station).

Observations from the instruments and differences between instruments for the duration of the checks are to be supplied as time series plots. A suitable vertical scale should be used, to enable qualitative assessment of the observations and differences.

The SIC shall conduct the Van de Casteele tests to assess the performance of the instruments and to quantify errors. The tabulated results and plots can be used to substantiate the estimation of errors in **Section 6.4.5**.

If a permanent gauge is utilised, the tide gauge zero and relationship to chart datum is to be checked. Details on permanent tide gauge datum's can be found in the Australian Tide Tables or from the local authority.

6.1.5 Surveying on the Ellipsoid

The Survey Instruction may provide additional guidance on requirements. If the AusHydroid within the Survey Area is not established with sufficient density of observations, the SI will detail additional observation points (nodes) where a combination of a minimum of 35 Days tidal observations are to be collected iaw Section 6.1.1, along with a minimum of 75 Hours GNSS Buoy observations iaw Section 6.1.2.

If a survey is approved to be undertaken to the ellipsoid, it is to be reduced to LAT via a Survey Hydroid. This is to be generated by the contractor based on observations collected above and any such observations that may be provided by the AHO as GFI. This Survey Hydroid is to be provided to the AHO for approval at Milestone 4a.

If a survey is to be reduced via a Survey Hydroid then at least two Tide Gauges which have respective concurrent GNSS Observations are to be deployed for the duration of the data collection activity. GNSS observations are to be conducted at the start and end of the survey task to determine changes in the MSL value. These are to provide a check on the derived Hydroid model, and to allow an option for a tidally reduced survey with C-O corrections based on predictions derived from the harmonic analysis of the observed tidal data in the event the Hydroid is found to be unsuitable.

To validate the reduction to LAT a comparison against an NRS Ellipsoid surface is to be conducted.

To validate survey vessel GNSS derived water level, a high-accuracy GNSS tidal buoy must be utilised to determine water levels. To confirm the GNSS water line and vessel reference frame a static validation of the model is to be conducted. This is to consist of stationing the vessel within 1km of the GNSS buoy for a minimum of 13 hours (in calm sea state) and logging the corresponding GNSS derived water levels. The 13-hour period is to include successive high and low waters, with GNSS solutions to be the same as will be employed during survey operations. The vessel is to remain in one location (anchored or alongside) throughout this period.

Results from this comparison are to be presented in both tabular (mean Differences) and graphical form (Linear Regression) and demonstrate the relationship between the GNSS water level from the buoy and the GNSS derived water level for the vessel. The SIC is to make a recommendation on the method of reduction adopted.

The GNSS buoy solution is to be capable of determining the ellipsoidal height to ±0.03m (1 sigma). To demonstrate required accuracy, the mean difference between GNSS buoys and vessel waterline height differences during pre-survey checks should not be greater than ±0.03m (1 sigma).

The Survey Hydroid model is to be checked as follows:

Table 8 – Hydroid Check Requirements

Hydroid Check	Tide Only SI	BMTGs deployed Survey Hydroid	AusHydroid Reduction
Hydroid Nodal Checks - Spot Depth Checks - depth reduced by Tide and Separation value at gauge locations.	Required	Required	Not Required
Crossline Hydroid Check - Crosslines reduced by Tide and Hydroid to provide spatial quality check. - May be passage Sounding lines between nodal points on Tide Only SI.	Required	Required	Not Required
Repeat Crossline / BM line Hydroid Check - 1 crossline / BM line established at or near Nodal point or check gauges, - Sounded at least 3 times and reduced via Tides and Hydroid.	Not Required	Required	Required
Hydroid Check Points	Not Required	Required	Required

- 2 BMTG deployed, one at each end of area for duration of sounding. - 1 BMTG deployed in centre of area for duration of sounding - 75 Hour GNSS Buoy Obs at start and end of survey at each BMTG. - Spot Depth check conducted at start and end of survey at each BMTG.			

The contractor is to deliver a Survey Hydroid model as part of the Interim Tides and Geodetics Pack at MS4a along with relevant QC checks, and an estimate of the Hydroid uncertainty. The final Survey Hydroid to be used will be approved by the AHO from the interim hydroid, the datum points submitted with the interim Tides and Geodetics Data Pack, and other information held by the AHO. If an updated Survey Hydroid is required this will be supplied to the SIC with associated metadata and usage note.

When surveying on the ellipsoid the navigation solution must be capable of <10cm (1 sigma) ellipsoidal height. For IHO Special Order surveys or higher standards, Post Processed Precise Point positioning data is to be Forward-Backwards processed using Final precise ephemerides, clock corrections and an accurate ionosphere model (i.e. IONEX), as per FIG Document No 62.

Final Integrated Verification checks using a National Reference Surface are also to be conducted for surveys conducted on the ellipsoid against the NRS Ellipsoid Surface as detailed in Section 7.2.1.8.

When surveying on the ellipsoid, coverage surfaces are required to be supplied, reduced to LAT via an appropriate method for integration into the *HydroScheme* Story Maps and correlation with the published chart.

6.2 Tidal Stream (Current Meter) Observations

Tidal stream direction and rate are to be observed in the locations specified in the Survey Instruction or in areas that the SIC deems necessary due to significant tidal stream for a period of at least 35 days.

These observations are at a minimum to determine the tidal stream in the ‘surface’ layer of the water column; which is top 25m depth band below MSL. Observations are to be undertaken within anchorages and adjacent to wharfs when the tidal stream is greater than 0.5 ms^{-1}.

In depths <130m, full water column tidal stream at a resolution appropriate to the survey order and depth of water shall be recorded using a 3D current meter (i.e. ADCP).

In depths >130m, mid column and near seabed tidal stream observations may be required for HIPP-1 surveys and will be detailed in the Survey Instruction.

When recording tidal stream data using an ADCP, the following minimum parameters in Table 9 –

ADCP Data Collection Parameters are to be set:

Table 9 – ADCP Data Collection Parameters

Water Depth range (m)	Bin Size (m)	Sampling Interval (1) (minutes)	Sample Period(2) (minutes)	Sampling Rate(2) (seconds)
0 - 10	0.3	15	2	60
0 - 20	0.5	15	2	60
0 - 30	1.0	15	1	60
0 - 130	2.0	15	1	60

(1) The sampling interval should ensure that at least 35 days of observations can be recorded, with due consideration to instrument memory capacity and battery life.

(2) The sampling rate would be typically 1 Hz, with observations average over a period of at least 1 minute.

(3) Where instrument capability can provide greater resolution or improved observation intervals and rates this should be detailed in the SMP.

The speed and direction of the tidal stream shall be determined to ±0.1 knots and ±5° respectively.

Data is to be rendered in the Tides and Geodetics Data Pack (Section 11.5.5), with formats in accordance with **Section 12.7**.

Full details of intended ADCP data collection parameters are to be provided in the SMP.

6.3 Tidal Anomalies

The limits of tidal phenomena (e.g. eddies, overfalls) shall be fixed on both directions of the tidal stream and inserted in the rendered digital dataset. Observed anomalies are to be recorded in the Amendments to Sailing Directions and in the ROS.

6.4 Tidal Analysis

Harmonic tidal analysis of all collected tidal observations is to be conducted to determine tidal planes and harmonic constituents. The preferred method of tidal analysis is via submission to the Bureau of Meteorology (BOM) National Tidal Unit (NTU), however the AHO may accept internal processing by HIPP Companies or by third party providers upon AHO approval of the process / methodologies.

Harmonic Tidal analysis is to be conducted using appropriate, accepted methodologies and competent specialists. These details are to be provided to the AHO in the HIPP Company Project Management Plan (PMP), or Annex J to the SMP for review and approval by the AHO if changing for individual projects.

Once a method is approved, it should be incorporated into the Company's PMP at which time it will be accepted as the normal process unless stated otherwise in later method submissions.

Tidal analyses conducted by HIPP companies or third party providers are to be in accordance with the Guidance Notes for Tidal Analysis. Any modifications of the methodology is to be discussed with the AHO and approved prior to implementation

6.4.1 Approved Tidal Analysis Software

The following tidal analysis software are approved for use on HIPP projects, proposed methods and procedures are to be documented in PMP or SMP Annex J for approval:

(a) IOS (Canada) Tidal analysis - https://www.dfo-mpo.gc.ca/science/data-donnees/tidal-marees/index-eng.html - similar to AHO

(b) NOC (UK) Tidal analysis - https://noc-innovations.com/services/tide-prediction-software/tidal-data-analysis - similar to BOM

(c) University of Hawaii (Tsunami Warning Centre) - http://ilikai.soest.hawaii.edu/UHSLC/jasl/jaslsoft.html - derived from (a) above

(d) Pawlowicz's MATLAB tool - https://www.eoas.ubc.ca/~rich - derived from (a) above

(e) XTide (Unix) - https://flaterco.com/xtide/index.html - derived from (a) above

(f) Vtide (Python) - https://github.com/CADWRDeltaModeling/vtide - derived from (a) above

(g) uTide (MATLAB) - UTide Unified Tidal Analysis and Prediction Functions - File Exchange - MATLAB Central – derived from (a) above.

(h) Australian Bureau of Meteorology – Tide Pack

Note that similar programmes will produce results that are within 10cm and 30 minutes of each other give or take (depending on the significant figures of frequencies used, and nodal corrections).

Most of these harmonic analysis software programs now have the option to provide an “uncertainty” value(s) for each harmonic constant resolved. The AHO does not use them, is that they relate to the quality of harmonic analysis and do not represent the error in the observed data.

If a data length is 35 days, the default options for Rayleigh Criteria can be left at 1 (range of 0 to 1).

Filtering method should be listed and provided if used to smooth the observations (example adjusting to sea level, applying Doodson filter).

6.4.2 Inferred Constituents

The principal solar, declinational lunar, larger evectional and the second order elliptical lunar harmonic constituents **(P_1, K_2, ν_2 and $2N_2$)** are significant contributors to the tides in Australian waters. They are to be included in all harmonic analyses. Where suitable lengths of data are available, the constituents can be resolved directly from the dataset. In instances where water level datasets are too short to resolve these constituents, they should be inferred IAW with the Guidance Notes for Tidal analysis.

Contractors are to clearly explain how and which harmonic constituents are inferred, in the Tides report.

6.4.3 Solar Annual (Sa) and Solar Semi Annual (Ssa) Constituents

The two long period constituents **Sa** and **Ssa** are important in tidal analysis. They resolve the components of seasonality which are significant in Australia. As such, they are to be included in the harmonic analysis of all HIPP projects. Where appropriate, the constituents can be related to a neighbouring Standard Port however, in some cases relating **Sa** and **Ssa** to a neighbouring Standard Port may not always be suitable. The methodology to include these constituents in the harmonic analysis is to be IAW the Guidance Notes for Tidal Analysis.

The Tides report must include a detailed description how **Sa** and **Ssa** harmonic constituents are included in the tidal analysis.

6.4.4 Mean Sea Level Anomaly

The mean sea level value obtained from harmonic analysis of the survey tide data, corresponds to the mean sea level for that period of time. This is different to the mean sea level reported at Standard Ports. The mean sea level at Standard Ports are computed over long periods of time, which average out long-term mean sea level variability.

Tidal analysis of collected data is to be corrected for the deviation of the short-term mean sea level of the survey tide data, from the long-term mean sea level reported at the Standard Ports IAW the document "HIPP Guidance Notes for Tidal Analysis". This difference is termed Mean Sea Level Anomaly (Δ) for the purposes of HIPP projects.

Details of how the correction for mean sea level anomaly is made on the HIPP project, should be clearly documented in the Tides Report.

6.4.5 Validation of Tidal Analysis

The results of the tidal analysis, after making adjustments described in sections 6.4.1 to 6.4.4, are to be validated. This is performed by assessment of the quality of the residuals as follows:

Residuals = Observed Water Levels – Tide predictions

where, the tide predictions are produced using the **interim constituent file**, after necessary adjustments are made.

The following are required for the validation of the tidal analysis.

- Time series plots of Observed water levels, Tide predictions and Residuals at all tide gauge locations. Axes must be a set to suitable scale to enable qualitative assessment of the plotted data.
- The statistics of mean and standard deviation of the water levels residuals must be computed, tabulated and evaluated.

The quality of the residuals are assessed from the shape, size, variation about the mean and comparison with neighbouring tide stations. Information on how to assess residuals is supplied in the document “HIPP Guidance Notes for Tidal analysis”.

The SIC is to supply the above information with a qualitative and quantitative assessment of the performance of the tidal analysis in the Tides Report and indicate the suitability of using the tidal data on the survey.

A positive assessment leads to the constituent file being the **final constituent file** that is used to produce tide predictions, compute tidal planes and establish the datum for the survey.

6.4.6 Error Estimates in the water level data and datum determination

The SIC shall estimate errors in the water level records and the datum determination. Together with other sources of error, the SIC should evaluate and document in the Tides report the following uncertainties, and the final uncertainty for each Tide Gauge node.

- Uncertainty in the Tide Gauge measurements
- Uncertainty in the Tide buoy measurement of sea level (GNSS).
- Vessel / Buoy GNSS Altitude Error
- Uncertainty in the conversion of pressure to depth of BMTG data.
- Uncertainty in the stability of the datum of the BMTG.
- Uncertainty in the Tide Mode Spatial / Zoning Error
- Uncertainty in the Harmonic Analyses
- Uncertainty due to the Mean Sea Level Anomaly (this will vary with distance form standard port and whether correction is applied)

7 BATHYMETRY – Depth Measurements

Bathymetry may be collected by a variety of sensors that meet the requirements of the survey order specified in the Survey Instruction including the feature detection specifications. The platform for these sensors could be ship, aircraft, satellite or autonomous vehicles.

7.1 Sensors

7.1.1 MBES Bathymetry

7.1.1.1 *MBES Sensor and Peripheral Equipment*

Depth shall be measured using an MBES capable of meeting the required specification of the survey order, specified in the Survey Instruction (THU, TVU, feature detection and sounding density). Proposed MBES settings including proposed swath angles, pulse frequency settings, sounding speed and line overlap are to be quoted in the SMP, with justification proving that survey order will be achieved; and, any changes justified by the SIC and approved by the Authorising Officer.

Bathymetry is to take precedence over backscatter unless stated otherwise in the SI.

For shallow water operations (<200m) the MBES should have the following characteristics and settings when bathymetry is taking precedence over backscatter:

- Operating frequency not lower than 150kHz
- Roll corrected (*mandatory*)
- Pitch correction (*desirable*)
- Yaw stabilisation (*desirable*)
- Nominal beamwidth not greater than 1.5° (at operating setting)
- For single head systems, swath angles not greater than 70° in depths <40m, and not greater than 60° in depths >40m, provided the requirements of survey order (THU, TVU, density and feature detection) are satisfied at the outer beams.
- For dual head systems, swath angles not greater than 75° in depths < 40m, and not greater than 65° in depths > 40m for Dual Head systems, provided the requirements of survey order (THU, TVU, density and feature detection) are satisfied at the outer beams.
- Swath overlap of between 10 – 20%,

For surface vessel deep water operations (>200m) the MBES must have the following characteristics:

- Roll corrected (*mandatory*)
- Pitch correction (*mandatory*)
- Yaw stabilisation (*mandatory*)
- Nominal beamwidth not greater than 2°, less than 2° is desirable.

7.1.1.2 *Vessel and Equipment Offsets and Rotations*

A dimensional control survey (DimCon) is to be conducted prior to the commencement of surveying operations for every survey vessel to be utilised to conduct HIPP surveys, and must be revised after changing out or significant reconfiguration of the survey sensors (i.e. change out of MBES sensors, GNSS or IMU).

Where there is a partial or complete pre-existing DimCon survey, a copy shall be included in the comprehensive SMP Document Pack. The suitability of any pre-existing DimCon survey will be confirmed at the project kick off meeting. Proposals to use pre-existing DimCon surveys of a vessel of opportunity greater than 2 years old need to be supported by a vessel inspection confirming there have been no changes to the vessel configuration. Pre-Existing DimCon surveys need to be updated to reflect temporary installations such as moon-pool towers or side poles. Dry-dock DimCon surveys are the preference.

Techniques that will be used to conduct the DimCon survey and uncertainties are to be described in the SMP, e.g. pre-existing DimCon, engineering drawings, total station, PPK, laser scanner, tape measure or combination thereof.

At a minimum the DIMCON report shall include:

- Clearly defined origin of the survey reference frame
- Axes of the survey reference frame
- Sign conventions of survey results
- Images of all surveyed points and sensors
- Vessel overview diagrams with surveyed points and sensors clearly displayed
- standard deviation or uncertainty of each surveyed point
- Vessel Centre of Gravity (COG) computed from the LCG/TCG/VCG values in the vessel trim and stability book, as referred to the DIMCON reference frame

The DimCon and supporting data for all vessels shall be included in the Pre-Acquisition report. It should also be demonstrated that the uncertainty of each point within the DIMCON satisfies the survey equipment manufacturer's requirements.

A copy of the vessel configuration file/s used during acquisition and processing is to be supplied with the PAR and ROS as a PDF or screenshot; and, in its proprietary format for the processing software.

7.1.1.3 *Direction and Spacing of Track-Lines*

Track-lines are to be planned such that the TVU of the outer beams are within the specifications for the survey order and provide sufficient overlap to fulfil the coverage requirements as detailed in Survey Instruction.

Care is to be taken in areas of rapidly changing depth where the sound velocity profile (SVP) is significantly different in deeper and shallower waters. In such areas, additional SVP may need to be collected.

7.1.1.4 *Crosslines*

To confirm the accuracy of positioning, tidal and Hydroid reductions, a regular pattern of cross lines shall be run, and should be planned at right angles to the main track-lines using the same parameters as the main line soundings. Crossline data should be cleaned for systematic errors to allow for a statistical analysis. A crossline comparison is to be conducted against the main track-line soundings with the sounding difference between these two datasets falling within the assessed error budget (at 95% confidence level) of the survey. The crossline comparison report is to be rendered with the ROS Annex D.

A minimum of **three (3)** bathymetric crosslines are required for each survey sub-area conducted, with crosslines no more than 4 NM apart, at approximately equal spacing. Crosslines are to be planned perpendicular to the typical mainline orientation in that survey area.

At least one crossline should be repeated on numerous occasions (at least 3 different occasions during the survey, such as after port visits) to allow for analysis of system performance and repeatability independent of tides. Where multiple survey platforms are employed all should use a common crossline for this analysis if practical. In lieu of this requirement, the SIC may also nominate a shorter dedicated Benchmark Line (BM) which includes a seabed feature and flat areas that can be used for repeat observations of system performance.

Crosslines shall be rendered in folders separate from the mainline data structure. Crosslines shall not be included in the final surface generation.

Crosslines are to be conducted first as prevailing weather conditions permit, and if safe to do so. In survey area contains large unsurveyed areas then these ares may be systematically surveyed prior to cross lines to ensure safety of navigation.

Crosslines are to be reduced using a tidal reduction model if tide gauge deployments are required by the SI. If a Survey Hydroid model is being for the reduction of the sounding, then crosslines are also to be reduced by tidal reduction and by survey hydroid, with the difference providing validation of the uncertainty of the hydroid model.

7.1.1.5 *MBES Data*

Only soundings collected from the useable swath can be incorporated into the final processed dataset. Rejected outer beams may be used for reconnaissance to reduce survey risk but are not to be incorporated in the final processed data set.

Data collected during turns can be logged but is not to be incorporated into the final processed dataset unless the Contractor can provide evidence that the soundings remains within the uncertainty requirements of the Survey Instruction.

All outliers and erroneous data are to be flagged as “rejected” and included in the final processed data set. This data shall not contribute to the final gridded surface.

7.1.2 Water Column Data (WCD)

WCD is to be logged for all wreck, obstruction and Reportable Feature investigations to determine the least depth. WCD is to be processed to assist in determining least depth over these features. The WCD Line ID is to be recorded in the SSDM for each Reportable Feature and wreck point.

WCD is to be analysed in appropriate software to compare the data captured in real time with other features that may be present in the water column. Where the least depth has been determined through analysis of the WCD, georeferenced depths are to be reduced to the same sounding datum as all other bathymetric data, as per the SI, and included in all bathymetric Level 2 and Level 3 datasets.

Where data holidays are detected following demobilisation, the SIC may digitise the seabed from WCD returns to achieve the required data density, provided that:

- All WCD collected is rendered in the appropriate data packs;
- There is no interpolation;
- No features are removed or replaced by the digitised WCD;
- A polygon is provided in the Survey_Equipment_Limits feature class of the SSDM outlining where WCD digitisation has occurred, and clearly annotating this in the Remarks field;
- Comments in the data processing logs; and
- Full details are provided in the ROS.

The Contractor shall provide details of the procedures and software used in the ROS.

7.1.3 Backscatter Data

Georeferenced backscatter intensity data from MBES is to be continuously logged throughout all areas of the survey. Where the Contractor manually configures MBES settings (i.e. gain, pulse length) during data collection, the changes are to be recorded and submitted within the ROS.

Contractors are to fully document any backscatter calibration process they may undertake prior to survey operations. Contractors are to undertake backscatter reference lines using the standard MBES settings in use at the start and end of the survey. This involves running the same line for each pulse length used during the survey, with direct overlap for a minimum distance of 500m (allowing sufficient run-in to achieve this).

The calibration process is to be fully documented in the PAR and correction values are to be supplied. In case of third party manufacture's involvement, full documentation of the methodology and resultant outcomes shall be included in PAR.

The raw backscatter data is to be rendered in accordance with Section 12.3. A list of the system parameters to be recorded is also given in Section 12.3.

Final backscatter mosaics should be generated using calibrated backscatter values and beam pattern corrections. Best practice is that backscatter mosaics are generated from the Level 2 fully processed point data. If this is not possible due to limitations of the logging or processing software, they may be generated from raw (uncleaned or partially cleaned) data. The approach taken is to be fully described in the SMP and reported on in the Report of Survey. Backscatter values are to be included in the Level 2 GSF files. File name conventions to be IAW SOR Section 11.2.1.

Specific requirements include:

- System changes (including power, gain, pulse length and pulse type) to be minimised throughout the survey and all changes documented.
- Maintain log of all system settings in use for each line.
- Maintain single frequency for specific depth ranges.
- If the SI requires backscatter to take precedence then the Angle of Incidence shall be <70° for depths less than 30m, otherwise <60°, otherwise as per 7.1.1.1.
- Coverage (minimum 10% overlap), or as specified in SI.
- Absorption is to be adjusted daily prior to commencement of data collection and **detailed in Report of Survey.**
- Oversaturation is to be minimised, maintaining an average of 70-90% saturation for >95% of the data collection.
- Collect backscatter data on crosslines.
- If multi spectral backscatter processing is proposed, this is to be fully described and documented in the SMP and is to be conducted in such a way as to preserve the coverage, density and uncertainty of the bathymetric data.

The correlation of seabed sample and backscatter intensity data should be detailed in the Report of Survey.

The Contractor is to provide an unsupervised seabed textures geospatial layer (see Section 12.4).

7.1.4 SBES

The following section applies to the conduct and collection of SBES data if proposed by a Contractor or required by an SI.

7.1.4.1 *SBES Sensor*

When SBES surveys are specified in the Tasking Statement, depth shall be measured using an SBES capable of meeting the required specification of the survey order (THU, TVU, Feature Detection). The SBES shall be capable of producing digital records (echograms) that can be processed in appropriate software.

High frequency SBES capable of determining a first bottom return in depths less than 40m with a beam width less than 8° are to be utilised for shallow water surveys. The system is to be capable of continuously tracking the bottom in steeply shelving areas. If two sounders are utilised the main sounder is to be designated “primary.”

7.1.4.2 *Calibration of SBES*

The SBES is to be calibrated for sound velocity, heave and draught offset (GNSS antennae or water lines as appropriate) using industry standard procedures and equipment at the start of each surveying period and as required to ensure that the depth and position uncertainty requirements are met for the duration of the survey.

The Contractor shall provide details of the all SBES calibration procedures in the tender documents.

7.1.4.3 *SBES Crosslines*

To confirm the accuracy of positioning, tidal and sounding reductions, a regular pattern of crosslines shall be run, and should be planned at right angles to the main track-lines using the same parameters as the main line soundings. A crossline comparison is to be conducted against the main track-line soundings with the sounding difference between these two datasets falling within the assessed error budget (at 95% confidence level) of the survey. The crossline comparison report is to be rendered with the ROS.

Crosslines are to be conducted at a maximum of 15 times the main track-line interval. When operating in areas with variable water depth, the crossline interval shall not exceed 15 times the main track-line interval for the general water depth of the survey area. Extra crosslines may be run when the SIC is not satisfied that mainline soundings have revealed all significant features, when operating in sand wave fields or near headlands.

If the crossline comparison report reveals a discrepancy in depth greater than 2 times TVU specified by the survey order, the Contractor is to investigate and resolve the discrepancy. Issues with the crossline comparison are to be highlighted to the Authorised Officer in the next scheduled report.

7.1.4.4 *Using SBES to conduct Shoal Investigations*

A shoal detected during mainline and interline sounding with an SBES is to be fully defined using a SSS and may require further investigation if it is deemed a significant feature. Full ensonification must be achieved during shoal investigations to determine least depth. At least one seabed bottom sample is required for each Reportable Feature to determine its structure.

7.1.4.5 *SBES Processing*

All SBES echograms are to be processed using appropriate software to remove outliers and systematic errors. All accepted soundings within the final dataset are to fall within the uncertainty allowances for the Survey Order specified in the Survey Instruction.

Details of SBES processing parameters including the vessel configuration and any automatic 'cleaning' algorithms are to be detailed in the ROS.

7.1.5 LiDAR

The AHO accept LiDAR technology and see it as a cost effective, safe and efficient way to safely survey coastlines, complex shallow water, reefs, and navigationally dangerous shallow areas.

Airborne LiDAR Bathymetry (ALB) may be offered as a merged ALB / MBES proposal to complete any SI area, or as a ALB only proposal when specified by the SI. When utilising ALB to conduct survey tasking the system shall be capable of meeting the required Survey Instruction specification of the survey order (THU, TVU, Feature Detection and Coverage) as modified at section 7.5.5. ALB, topographic LiDAR and aerial imagery collection, processing and derived products are to be in accordance with this SOR or the ICSM LiDAR Specification if not covered by this SOR (clearly detailing the use of relevant ICSM specifications in the Report of Survey).

7.1.5.1 *ALB Sensor Requirements*

The bathymetric LiDAR sensor must be capable of:

- Detecting the seafloor to the depths expected in the survey area in the prevailing water conditions,
- Achieving a spot spacing at the water surface of at least 2m x 2m, or as required to achieve required IHO Order for the sensor in use to the nominated depth contour,
- Modelling the sea surface and correcting seabed returns for the speed of light in water, and the effects of turbidity on the time of travel for light in water,
- Recording the reflectivity / intensity from each pulse, normalise returns between lines is desirable,
- Multiple bathymetric LiDAR sensors may be used to provide high-resolution shallow data provided overlap and depth correlation between sensors is achieved, and
- Provide concurrent imagery at resolution to match the point spacing or better. Imagery should be provided at the highest resolution possible, or as agreed with the AHO.

If used, topographic LiDAR sensors must be capable of:

- Detecting multiple discrete returns, with a minimum of 4 potential returns for each outbound laser pulse,
- Achieving at least 4 points per metre, and
- Recording the intensity of each return.

See also Section 7.5.5 for LiDAR Coverage and Feature Detection requirements.

7.1.5.2 *LiDAR Calibration Checks and Control Areas*

All LiDAR systems (topographic and ALB) are to be fully calibrated at mobilisation and have depth performance, positional accuracy and feature detection checks conducted as part of the mobilisation process and documented in a PAR. This is to include flights over control areas such as topographic benchmarks, integration points, and bathymetric referenced areas and feature detection targets.

The following control areas are required:

7.1.5.2.1 ALB Dynamic Bathymetric Feature Test

On mobilisation of the LIDAR System the feature detection capability of the system is to be proven by flying over a known target no larger than 2m x 2m at expected survey depth to which IHO Order 1a will be claimed. This may be in the vicinity of the mobilisation airport.

Within the SI area a sub surface feature (shoal) or target should be identified as early in the survey area as is practical and used to verify feature detection requirements, sounding repeatability and accuracy in both the horizontal and vertical dimension. This feature should be re-flown regularly during the survey. The least depths and positions of the features shall be analysed to confirm the repeatability and accuracy of the survey.

7.1.5.2.2 ALB Benchmark (Reference Areas)

A benchmark is a small area surveyed as part of a calibration procedure and repeat surveys should be undertaken to randomise systematic errors. Benchmark areas should be in areas of smooth seabed with no more than one metre change in depth across the benchmark. Benchmark areas should be chosen strategically during the planning stage depending upon the terrain and turbidity conditions. Ideally, a benchmark area is located on the same line as a Topographic Integration Point.

Repeat flights over a bathymetric benchmark area will give an insight into the overall turbidity within the survey area and its temporal variation. At least one benchmark area is to be flown during each flight; within an area it is preferable if the same benchmark line is flown during each flight to prove the absolute vertical accuracy of the system.

The contractor is to nominate a reference benchmark area location in the vicinity of the survey area which is to be flown at least three times, and as often as possible, and preferably on every flight to the area. This is to allow an independent check on the vertical accuracy and / or feature detection achieved. Reference areas are surveyed using MBES to the same or better THU and TVU as the planned ALB survey. Reference areas should be in areas of smooth seabed with no more than one metre change in depth across the reference area. Best practice is to have a series of benchmark areas at different depths to prove the system performance at a range of depths through the survey area.

The AHO may nominated an independent reference benchmark which is to be flown at least three times.

The daily monitoring of coverage over the benchmark lines should be assessed in real-time for decision-making and reporting. Depending upon the daily survey operations different benchmark surveys can be flown. All benchmark survey lines should be identified within the tender response. Within the first day of successful operations all benchmark surveys must be flown. The results/success of penetration within the benchmark survey must be included in the progress report during acquisition.

7.1.5.2.3 Topographic Integration Points (TIP)

Topographic integration Points are flat areas free of any vegetation or other obstructions such, as spots fields or open parks, located close to the coastal strip. TIPs are to be surveyed independently of any LiDAR GNSS operations at a grid interval smaller than the largest bathymetric spot spacing used in the survey. If possible TIPs should be co-located with Bathymetric LiDAR reference or benchmark areas. TIPs are to be surveyed with Topographic and Bathymetric LiDAR systems to allow vertical accuracy checks and comparisons to be conducted.

7.1.5.2.4 Topographic Control Points

Check points are to be surveyed independently of any LiDAR GNSS operations.

The number of check points (locations) is dependent on the extent of the survey. The following strategy should be used as a guide:

- Check points must be established to adequately cover the full extent of the survey area, and be representative of the project area landscape.
- A minimum of 20 check points (locations), then 1 per 50km² where LiDAR coverage exceeds 400km². When 20 points are tested, the 95% confidence interval would generally allow 1 point to fail the threshold given in product specifications.

The proposed Topographic check point survey design must be submitted with the quotation, and approved by the Contract Authority prior to implementation. Acceptance of the post-survey spatial accuracy report discussed above is dependent on the quality, number and distribution of these check points.

7.1.5.3 *ALB Crosslines*

Crosslines for ALB systems are to be flown to determine tidal and datum issues over the entire survey. Crosslines are to be planned avoiding areas of reef. Optimum crossline statistics are obtained when crosslines are flown over areas of flat sea floor and varying depth.

Tidal information is to be collected such that analysis confirms the method of reduction of soundings to the sounding datum is appropriate and valid.

7.1.6 Multi-Transducer Vertical Sweep System (MTES)

MTES are to be calibrated at the beginning of every survey as per manufacturer's instructions. The calibration is to cover all aspects of the survey system and is to include spatial coordinates (x,y,z) of each transducer, the GNSS antenna and motion sensor. The draught of each transducer is to be calculated. Daily draught and SV corrections are to be applied by determining the daily variation in draught of the vessel and SVP of the water column with the harmonic mean applied to the echo sounder. The system is to be proven over a National Reference Surface to ground truth the system and validate against known results.

When operating in very shallow water or areas with rapidly changing topography, care must be taken to ensure that MTES is used in a manner that meets coverage requirements.

7.1.7 Multi-Transducer Towed System (MTTS)

Each sounding platform of a MTTS is to be calibrated and checks at mobilisation as per Section 7.2. The draught of each transducer is to be calculated. Draught and SV corrections are to be applied by determining the daily variation in draught of the vessel and SVP of the water column. SV may be taken from the mother ship and applied to towed vessel system. The system is to be proven over a National Reference Surface be used to ground truth the system and validate against known results.

When operating in very shallow water or areas with rapidly changing topography, care must be taken to ensure that MTTS is used in a manner that meets coverage requirements.

7.1.8 Side Scan Sonar (SSS)

The requirement to conduct a SSS search, such as along leading lines, anchorages, recommended tracks or wreck investigations, is at the discretion of the SIC to meet the coverage and feature detection requirements specified in the SI.

SSS searches are to ensure full seafloor ensonification of the survey area is achieved. SSS with altitude and positioning data to create georeferenced seabed texture mosaics is an important survey product and may be requested in the Survey Instruction.

SSS is not to be used for determining least depth of a feature.

When used for feature detection, each feature shall be ensonified by at least five along-track pings.

Prior to commencing a SSS search, and regularly during its execution, confidence checks are to be made using known features. These confidence checks must be documented in the ROS and Pre-Acquisition Report.

7.2 Calibration and Verification of Systems

A calibration and or verification of all sounding systems and all associated sensors shall be performed at the start of each survey and after changing out or reconfiguration of the sensor suite. The calibration shall consist of a number of tests to quantify the following error sources or to verify their correct measurement:

- Survey commencement or reconfiguration
    - Sensor Offsets (Including IMU lever arms)
    - MBES Time Latency, Pitch, Roll and Heading Alignment
    - Heave sensor measurements
    - Sound Velocity Profile checks
    - Vessel Draught, settlement and squat profiles whilst underway
    - Positional uncertainties
    - Feature detection performance to required order
    - Tide Gauge and barometer checks
    - Current Meter Compass Calibrations

The following validations are to be repeated:

- After Port Visits
    - NRS or Repeat Cross Line check
    - Draught measurements readings on arrival and prior to departure after bunkering
    - MBES Time Latency, Pitch, Roll and Heading Alignment if repeat NRS or Cross Line check does not agree within 0.2m of previous checks.
- At End of Survey
    - Integrated Systems Verification (ISV) over a consistently used surface. Order of preference being an Established NRS then Temporary NRS
    - Heading Check (if error indicated by ISV)
    - Position Check (if error indicated by ISV)
    - Sound Velocity Profile checks
    - Tide gauge and Barometer check

Calibration and verification checks are to be tailored to the sensors deployed and fully documented in the SMP.

7.2.1 Mobilisation Checks

As a minimum, the following activities are to be undertaken during mobilisation, and fully reported in the Pre-Acquisition Report, and repeated as required above.

7.2.1.1 *Heading Alignment*

Heading checks require the vessel heading to be determined by an independent solution and compared to the primary heading solution. This should also be conducted over a 30-minute period with at least 1-minute resolution.

7.2.1.2 *Static Position Validation*

A heading and static position test shall be conducted at the start of the survey or after changing out or reconfiguration of the sensor suite. Methodology of validation shall be detailed in the SMP.

For position validation the surveyor shall monitor the three dimensional position of the primary GNSS antennae or another appropriate point within the reference frame of the vessel for at least 30 minutes at a 1-minute resolution. The subsequent report shall separately detail the statistical reliability of both the horizontal and vertical position of this point. The positioning data to be compared will have been derived using the same procedures used to obtain all positions associated with the bathymetric data (e.g. post-processed kinematic).

The static position validation should be performed so as to demonstrate that the lever arms are being correctly applied and subsequently the correct position of the data acquisition system is being calculated.

To provide the best assurance for static position and integration with heading, a calibration node shall be established on the vessel at a location that has the maximum practical separation from the navigation GNSS antennae, and can be directly observed by an independent system (e.g. total station or independent fixed solution GNSS system). All navigation solutions (e.g. primary and secondary solutions or as applicable) should then be referenced to the calibration node and compared with the independent solution.

Any local control used during this test is to be compliant with the requirements for geodetic control.

7.2.1.3 *Patch Test*

A calibration of the MBES and all associated sensors (i.e. patch test) shall be performed at the start of each survey period or after changing out or reconfiguration of the sensor suite. The patch test methodology shall be detailed in the SMP. Methodology and final results of all calibrations are to be detailed in the Pre-Acquisition Report and ROS (if additional Patch Tests are conducted during survey operations).

7.2.1.4 *Feature Detection Test*

For each new mobilisation, a feature detection test is to be conducted to prove the MBES system can detect features as required by the survey standard of the SI.

7.2.1.5 *Squat Test*

For each new vessel mobilisation, a squat model is to be observed and established via analysis of GNSS height variation (minus the effect of tide) resulting from the vessel operating at various RPM corresponding to likely survey speeds.

7.2.1.6 *Processed Depth Comparison*

Comparison of processed depths against a known depth, such as a National Reference Surface (NRS), provides assurance against systematic errors that might not be apparent in online checks. Where NRS validation is not possible, or the NRS is some distance from the mobilisation port, an independent depth validation assurance check is to be conducted using one or more of the following methods prior to departure from the mobilisation port, in order of preference:

- A fully processed bar check, validated using the full data processing workflow but with a zero tide value applied.
- Comparison against a feature with known or independently measurable depth, for example:
    - A dock sill or lock floor, a feature that dries and can be safely and accurately surveyed at high water, or
    - A submerged feature to which least depth can be accurately determined by a calibrated and validated depth sensor (i.e. tide gauge or man-made target placed on the seabed).
- Comparison with an independent SBES solution over a flat and featureless area.
- Lead-line depths over flat and featureless terrain of known depth.

7.2.1.7 *Acoustic Interference Check*

A check will be conducted to ensure there is no adverse interference from vessel systems on the acoustic return of the MBES.

7.2.1.8 *Final Integrated Verification*

The final procedure before commencing MBES survey operations shall be a verification of the entire integrated hydrographic suite over a known area/feature to determine that the combined platform solution falls within the specifications of the survey. The method used and calibration results are to be detailed in the Pre-Acquisition Report. Where an approved NRS is not available to validate the processed depths, further independent validation should be conducted.

Where observed tide data is not available for verification checks a temporary tide gauge shall be established in close proximity, with LAT calculated via datum transfer to allow for tide uncertainty to be minimised during review of verification data.

7.2.1.8.1 Reference Surface – Shallow Water

The preferred method for a final integration check is the use of a reference surface. If a NRS is located in the vicinity of the mobilisation port, then checks should be conducted over this surface. If no NRS is available, then a Temporary Reference Surface should be surveyed using the technique described below. Data collected over NRS during the final integration check is to be rendered to the AHO.

A series of check lines are to be run as follows inside the reference surface: two parallel lines (overlap not required) and one line where the vessel manoeuvres as experienced during normal sounding operations, e.g. close to the shoreline.

Each beam depth from the processed check lines are then compared against the reference surface and statistics computed. Statistics are to include: beam number, mean, maximum and minimum differences and standard deviation.

Reference surface verification of each MBES system is required on the following occasions:

- On completion of the MBES calibration and prior to commencing survey operations;
- Following any change in the MBES system, or relocation of any component of the MBES system such that the system laybacks will have changed;
- If the vessel(s) go off task for a period greater than 72 hours due to any operational reason other than activities associated with the conduct of a SI or logistical port visits; and,
- On completion of the entire survey period prior to demobilisation.

In the absence of a NRS, a Temporary Reference Surface should be created at the mean depth expected within the survey area. A minimum of four parallel lines are to be run with at least 150% overlap, ensuring the inner beams overlap to provide redundancy. For MBES systems with a swath width of two times the water depth, the line spacing should be less than the water depth to provide sufficient overlap. At least four parallel lines are to be run perpendicular to the previous lines with the same swath width and overlap. The same speed is to be maintained for all lines and a run-in of at least 800m is required to provide sufficient settling time for the MRU. A digital terrain model is to be created from the cleansed data using an average gridding algorithm, in line with the resolution of Table 9 – Resolution of National Reference Surfaces.

7.2.1.8.2 Temporary Reference Surface – Deep Water

In the absence of a deep water NRS, a Temporary Reference Surface should be created in water at the mean depth expected within the survey area. A minimum of four parallel lines are to be run with at least 150% overlap, ensuring the inner beams overlap to provide redundancy. The MBES should be configured with a maximum swath width of 1x water depth, equidistant footprint and the line spacing should be less than the water depth to provide sufficient overlap.

At least four parallel lines are to be run perpendicular to the previous lines with the same swath width and overlap. The same speed is to be maintained for all lines and a run-in of at least 800m is required to provide sufficient settling time for the MRU. The length of lines run in each direction should be such that the final Reference Surface area will be square.

A digital terrain model is to be created from the cleansed data using an average gridding algorithm, in line with the resolution of Table 9 – Resolution of National Reference Surfaces.

7.2.1.8.3 Squat Validation

NRS checks also provide an opportunity to validate squat values that are to be applied during the survey. To confirm that the application of squat is correctly applied statistical comparisons against the NRS shall include comparisons against lines corrected for squat, and lines not corrected for squat.

7.2.1.8.4 Dynamic Bathymetric Feature Test

A Dynamic Bathymetric Feature Test to monitor the three-dimensional position of a clearly defined feature on the seabed is to be conducted. The feature should first be surveyed near the nadir beam from multiple directions (as a minimum north/south and east/west). Secondly it should be boxed in, so it appears in the outer beams of the port side for 2 lines and starboard side for 2 lines.

Where multiple survey platforms are employed, all should use a common feature if practical.

The subsequent report should separately state the computed statistical reliability of the position and the measured depth of the feature; and, demonstrate that the combined platform solution falls within the specifications of the survey.

7.2.1.9 *Daily Verifications*

Where practicable given the operational sea conditions, the transducer draught shall be determined daily and all echo sounders (SBES and MBES) updated as required. A comparison of the MBES nadir and SBES (if fitted) is to be conducted daily.

7.2.2 Backscatter Calibration

Where a sonar calibration service or tool is available and relevant for the data logging system in use, the backscatter shall be calibrated in accordance with the procedures outlined in this service or tool. If no suitable service/tool is available, then the backscatter shall be ground-truthed IAW Sections 7.1.3 and 8.5.

7.3 National Reference Surfaces

7.3.1 National Reference Surface Requirements

The National Reference Surface (NRS) Program is a joint AHO/AusSeabed initiative to develop a series of high order reference surfaces around Australia to service the bathymetric community. These surfaces will be surveyed to a very high standard and will provide the capability to validate a MBES over multiple depth bands. Some surfaces will also include features to provide horizontal verification capacity. In most cases a high order tidal model will be established when the National Reference Surface is first established to aid in the development of the AUSHYDROID and to provide an accurate separation model between LAT and the ellipsoid to provide the ability for future users to survey on the ellipsoid over the area.

7.3.2 Survey Requirements - Shallow Water

National Reference Surfaces are to be surveyed to IHO Special Order standard. If required, a higher standard may be specified in the Survey Instruction. The survey area will be at least 500m x 500m and shall be surveyed using a swath width set at 2x water depth. Coverage requirements for the survey is Full Seafloor Coverage (i.e. 200% MBES coverage) in both the mainline and crossline direction (orthogonal). To minimise errors with the IMU, an 800m run in is to be utilised to stabilise the IMU. This effectively ensures that FBC is achieved by running lines at perpendicular to each other to cover the reference surface twice.

All National Reference Surfaces, data is to be collected relative to both the Ellipsoid (GRS80) and tidal datum (LAT) to aid in developing a vertical separation model for the area, unless specified otherwise in the Survey Instruction. When undertaking a survey of a NRS, for each NRS site, a local BMTG is to be deployed for a minimum of 75 hours with associated GNSS Buoy observations to cover the survey period. LAT is to be established by Transfer of Sounding Datum from the nearest Standard Port if semi-diurnal tides are present. For Diurnal Tides the SIC is to nominate a method to transfer datum from the standard port

A National Reference Surface should have no more than 1 metre of depth variation across the area, and the Surveyor-in-Charge should expand the area to be surveyed or propose alternative areas to the Authorised Officer if this requirement is not achievable in the proposed location.

7.3.3 Survey Requirements - Deep Water

National Reference Surfaces may be required to be established in deeper water i.e. >200m WD or at the depth of the deep water survey area. Deep water NRS should be established on a flat near featureless Seabed with minimal gradient (less than 5%)

Deep water NRS are to be surveyed to HIPP 1 Standards. The survey area should be a regular square, with sides measuring 3 x Mean Water Depth, and shall be surveyed with a maximum swath width of 1x water depth utilising equidistant beam spacing.

Coverage requirements for the survey is Full Seafloor Coverage (i.e. 200% MBES coverage) in both the mainline and crossline direction (orthogonal). To minimise errors with the IMU, an 800m run in is to be utilised to stabilise the IMU. This effectively ensures that FBC is achieved by running lines perpendicular to each other, to cover the reference surface twice.

For all deep water National Reference Surfaces, data is to be collected relative to both the Ellipsoid (GRS80) and EGM2008, unless specified otherwise in the Survey Instruction.

7.3.3.1 *Re-Survey Requirements*

Once the hydroid over the National Reference Surface has been established, it will be possible to re-survey the surface using GNSS (ellipsoidal) reduction and apply the vertical separation model to determine the reduced depth. All other requirements will remain in force when re-surveying a National Reference Surface to update the model.

7.3.3.2 *Data Processing*

All data is to be corrected for SV and both GNSS tide and observed tides reduced to LAT. Altitude and swath data is to be cleaned of systematic outliers and the outer beams may need to be flagged to be removed from the final surfaces.

Two **finalised** CUBE surfaces are to be produced at the appropriate grid size as per Table 9:

- A surface referenced to the Ellipsoid (GRS80); and,
- A tidal surface reduced to LAT.

Table 10 – Resolution of National Reference Surfaces

Depth of Water	Resolution of Surface
<40m	0.5m
40-80m	1m
64 - 160m	2m
128 - 320m	4m
256 – 640m	8m
512 – 1280m	16m
1024 – 2560m	32m

The MBES resolution achieved at the survey depth must be sufficient to generate gridded surfaces at the resolutions indicated, with these surfaces to be supported by relevant statistical layers.

Each surface is to be labelled: NRS_LLx_ddm_YYYYMMDD _vvv_c0p5

Where:

- *NRS- National Reference Surface, TRS – Temporary Reference Surface*
- *LL – Location – e.g. Cairns – CN, Darwin – DN, Torres Strait – TS*
- *x - Reference Area number in each location, e.g. 1 – Reference Surface 1*
- *ddm - Water Depth in metres*
- YYYYMMDD – *date of survey*
- *vvv – Vertical Datum, referenced to LAT or ELL*
- *c – Surface type (c- CUBE, s – SDTP, b = Backscatter)*
- *0p5 – Surface resolution*

e.g. NRS_CN3_15m_20190531_LAT_c0p5

Point data is to be filtered against the CUBE surface at 1σ.

7.3.3.3 *Data Rendering*

Each National Reference Surface is to be rendered via its own Survey Summary Form (F_05_51_AA217163) with a separate data pack structure for each reference surface. The report is to cover full details of survey type, data collection, processing and any tidal model used as well as details of the data delivered. If multiple vessels are used to survey the NRS, each vessel is to have its own Survey Summary Form.

Each National Reference Surface is to be rendered as its own processing software project (i.e. full

CARIS HIPS or QPS Qimera project) and is to contain CUBE statistical reports for a least two crosslines against each surface.

7.3.3.4 *Data Schema*

The top-level folder of the National Reference Surface data packs should clearly identify it from the Survey Instruction normal survey data, using the parent folder naming convention descried below.

Parent Folder - *NRS_LLx_ddm*_YYYYMMDD

Where:

- *NRS- National Reference Surface*
- *LL – Location – e.g. Cairns – CN, Darwin – DN, Torres Strait – TS*
- *x – Reference Area number in each location, e.g. 1 – Reference Surface 1*
- *ddm - Water Depth in metres, referenced to LAT or ELL*
- YYYYMMDD – *date of survey*

7.3.4 Utilising a National Reference Surface to validate a MBES

7.3.4.1 *Downloading the NRS*

National Reference Surfaces will be provided as GFI in a CSAR format.

The downloaded or issued NRS will be labelled:

Auth_RefSurf_Location_x_ddm_YYYYMMDD_vvv

Where:

- Auth is the issuing authority (i.e. AHO, CSIRO)

Where the YYYYMMDD is the date of issue for the NRS model and provides version control.

This surface will come with an uncertainty value.

7.3.4.1.1 Validating a MBES over a NRS

Requirements for validating survey systems against an NRS is detailed at Section *7.2.1.8* *(Final Integrated Verification).*

7.4 Sound Velocity (SV) and Draught Measurements

Refer also to Section 9 - Oceanography and Meteorological requirements – Sound Velocity probes and CTD probes.

7.4.1 Sound Velocity Sensors – Types, Capabilities and Accuracy

An essential requirement for the survey is to obtain sound velocity profiles to correct echo sounder depths. Sound velocity may be obtained in two main ways either:

- **measured** directly/in-situ with ‘sing around’ or ‘time-of-flight’ (TOF) velocity probes.

- **calculated** from depth, temperature and conductivity/salinity measurements from a CTD probe OR calculated from depth and temperature measurements from a XBT probe merged with an average/climatological salinity profile or surface salinity value from a hull mounted CTD.

'Sing around' sensors send a sound pulse over a known distance; when it is received, a further pulse is sent and so on. The repetition rate of the pulses is a function of the speed of the sound which can then be derived. An example of a sing around type is the Odom 'Digibar' sound velocity probe. Sing around instruments will have a pressure/depth sensor and possibly a temperature sensor thus producing a vertical profile of depth/sound velocity/temperature. These are not desirable for HIPP surveys of IHO Order 1a or better.

'Time of Flight' sensors use a very accurate timing circuit to measure the time that a single pulse of sound takes to travel a known fixed distance; where distance divided by time equals speed. An example of the TOF type is the Valeport SWIFT sound velocity probe. TOF instruments will have a pressure/depth sensor and possibly a temperature sensor thus producing a vertical profile of depth/sound velocity/temperature.

Calculated sound velocity from a good quality CTD probe provides a typical accuracy of ±0.25 ms^{-1}. A CTD probe can also produce a vertical profile of depth, sound velocity, temperature and salinity; which is beneficial for oceanographic uses (see Section 9).

Computed sound velocity from an XBT merged with climatological salinity is less accurate than computed sound velocity from a CTD; however, like a CTD, XBT measurements are beneficial for oceanographic uses. Ideally, the salinity should be measured on site with a CTD probe.

7.4.2 SVP Requirements

The Contractor shall observe sound velocity profiles (SVP) at an interval consistent with the error budget for the survey and the complexity of conditions within the survey area. At a minimum, SVPs must be measured at:

- 4-hourly intervals for MBES operations;
- 6-hourly intervals for SBES operations;
- 4-hourly for passage sounding operations, or more frequently when SV artefacts are identified in the bathymetry; and
- Proposed Deep Water MBES SVP frequency to be stated and justified in the SMP.

Shallow water SVP casts should be to 80% of the water depth. Where there is significant depth variation across the survey area it will often be necessary to conduct additional casts in deeper water to capture the full water column.

Deeper water operations (> 200m depth) will normally require a mix of observation and modelling to determine SVPs, with specific requirements confirmed in the SI. The majority of temporal variation occurs within the upper water column where most mixing and surface heating occurs, and these shallower depths also have the most impact on beam steering and ray tracing. Therefore, a cast to

200m captures the surface variation and demonstrates the steady trend at greater depths, which can then be extended to the operational depth or extent required by the acquisition. Typically, routine casts will be required to at least 200m with deeper values based on modelling, and validated by a smaller number of full-depth observations based on deep XBT or other sensors as agreed in the approved SMP.

For MBES operations the SV must be monitored in real time at the transducer head. SV should be re-observed when the difference between the existing SVP value and the observed value at the Transducer head exceeds 2 ms^{-1}. For HIPP-Special and HIPP-Precise Order surveys this tolerance may be reduced and will be documented in the Survey Instruction.

Equipment used to measure SV shall have the following parameters:

- SV accuracy: better than 0.5 ms^{-1}
- Depth: ±0.01 m
- Time: ±1 min
- Horizontal Position: ± 200m

Where possible, the entire sound velocity profile shall be applied directly by the echo sounder. If only a single value is accepted by the echo sounder in use, a calculated harmonic mean sound velocity shall be used. SV shall be re-applied to all MBES soundings during post-processing.

The SMP shall detail how SV is to be collected and applied to the data, and the ROS shall confirm how SV was collected and applied; and, highlight any deviation from the SMP. Uncertainty in SV is to be included in the TVU.

The SVP must be configured such that **all sensed data parameters are logged** in the proprietary sensor file format including depth, temperature and sound speed (as per SPEC_03_33_BN16464067 'Oceanographic Data Standards for HIPP', e.g. *.vp2 from Valeport SVP).

It is **recommended** that the SVP be configured in '**smart mode**' such that sound speed is recorded at fixed depth increments (say 0.5m) rather than running the SVP in '**continuous mode**' which results in an excessive amount of data. Excessive SVP data is problematic to process at the AHO (refer to 'Sampling controls' section of MG Branch QMS document SPEC_03_33_BN16464067 'Oceanographic Data Standards for HIPP').

If SVP software allows the calculation of values such as salinity, conductivity and density, then these values are to be calculated and exported.

An example of the *.csv output file with full set of observed and calculated values is shown below

Date/Time	Pressure	Temperature	Salinity	Density	Conductivity	Sound Velocity	Depth
	dBar	DegC	PSU	kg/M3	mS/cm	Ms-1	m
11:37.0	1.311	26.212	38.236	1025.416	58.772	1540.762	1.304
11:37.2	1.715	26.559	36.124	1023.713	56.262	1539.324	1.705
11:37.6	2.339	26.927	35.236	1022.929	55.424	1539.236	2.326
11:37.8	2.852	27.064	34.895	1022.631	55.092	1539.196	2.836

11:38.0	3.361	27.15	34.662	1022.429	54.855	1539.154	3.342
11:38.2	3.817	27.233	34.445	1022.242	54.637	1539.121	3.795

All sound velocity measurements are to be rendered as digital files in the Raw Data Pack (Section 11.5.2), with formats in accordance with Section 12.5.

7.4.3 Draught Readings

AHO acknowledge that conducting a daily bar check on large vessels (>25m) is not practical, nor is conducting daily draught checks in the open ocean. Measuring a vessels draught accurately at sea is a difficult proposition. Where possible daily draught measurements are to be taken through methods such as fitting a pressure sensor to the sensor head, or through, a draught tube installed inside the vessel and marked with the draught, or other innovative methods, which are to be proposed in the SMP.

At the very least, draught measurements should be taken on arrival at port and just before departure. The vessel should be alongside when these measurements are taken. These vertical measurements can be taken using a weighted surveyors tape.

A log of draught readings for each sensor platform should be kept throughout each survey instruction.

<u>Example of MBES draught register</u>

From MV “Survey Platform” Dimensional Control Report [document number] vertical distance from MBES acoustic centre to main deck = **9.95m**

Vertical measurements are then taken from main deck to water line at arrival and departure of every port call. Port and starboard measurements are taken in line with the transducer being measured.

MBES depth to waterline observed measurements to be subtracted from **9.95m**

Date	Location (Port)	Arrival or Departure	Port to Waterline (m)	Stbd to Waterline (m)	Mean (m)	MBES Draught (m)
01/01/2024	Fremantle	Departure	4.25	4.61	4.43	5.52
01/02/2024	Fremantle	Arrival	4.65	5.05	4.85	5.10

A similar log should be kept for single beam echo sounder and any vessel mounted sub bottom profilers.

7.5 Sounding Density, Coverage, Gaps and Feature Detection

Bathymetric coverage, density and feature detection requirements as per the Survey Order shall be achieved over the entire survey area.

Unless stated otherwise in the SI, coverage requirements are further relaxed as follows:

- Where the survey lies adjacent to the coastline or islands, the coverage requirements shall extend to the 10m contour (reduced to chart datum).
- Isolated shoals within the survey area limits are to be fully investigated and a least depth found if navigationally safe to do so.
- A navigational safety buffer zone of up to 200m may be applied to drying features for larger survey vessels.

7.5.1 Swath Coverage for MBES

To comply with these standards, the 'swath' is the usable part of the swath that meets the required uncertainty standards for the survey at the 95% Confidence Level (Figure 2). This may require the outer beams to be 'rejected' in order to meet this standard. Rejected outer beams may be used for reconnaissance to reduce survey risk but are not to be incorporated in the final processed data set.

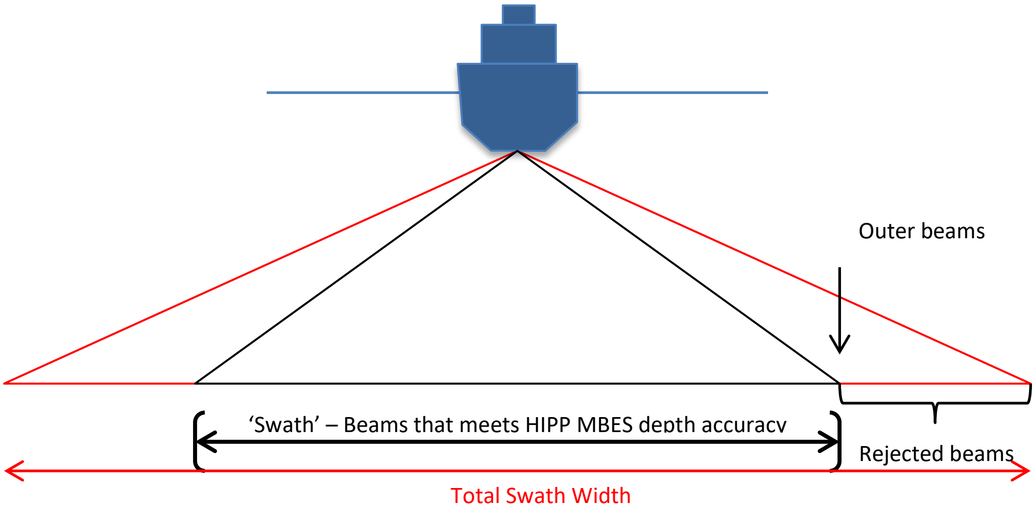


Figure 2 – Usable Swath

When determining line spacing for MBES the following overlap may be considered:

7.5.1.1 *Full Seafloor Ensonification*

Full Seafloor feature search requirements will be achieved via full Ensonification (or Illumination if using LiDAR based system) which is to be achieved for the entire Pink chart area for all IHO Order 1a Survey tasks or above. This will normally be achieved via the main sensor (MBES or LIDAR). A full seafloor search can also be fulfilled utilising SSS and MBES as per Figure 3. This is the least preferred method for HIPP surveys as CUBE relies on the overlap between adjacent lines to minimise errors and generate a statistical surface. This method of surveying may be proposed for IHO Order - 2 surveys or below in the SMP. Any significant feature detected within the SSS swath is to be ensonified by MBES.

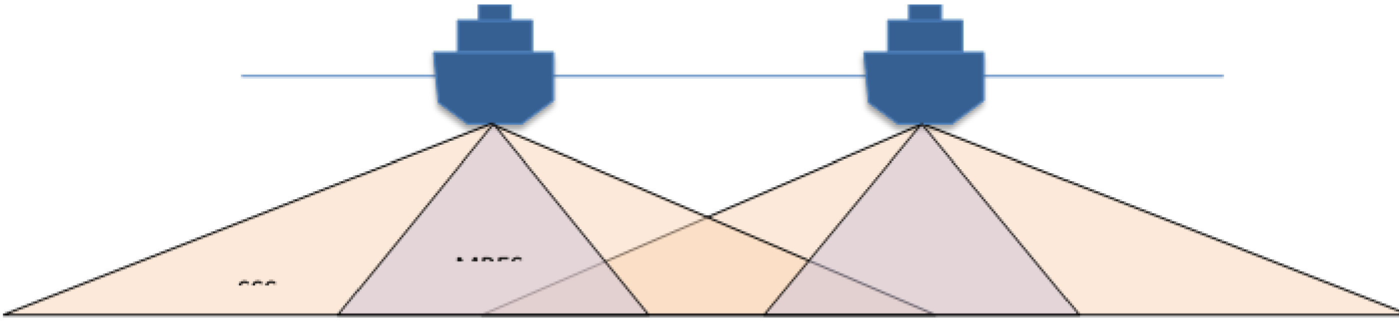


Figure 3 – Full Seafloor Ensonification Utilising SSS and MBES

7.5.1.2 *Full Bathymetric Coverage (98% coverage)*

Full Bathymetric Coverage is determined to have been achieved when at least 100% of the pink chart area has been ensonified and 98% of the pink chart area has been surveyed to the required standard with at least 5 soundings per cell, which is evidenced within the Final Survey Data surface products demonstrating 98% cell coverage at the required density. Gaps in the coverage due to data holes and data holidays (Section 7.5.3) are not allowed and must be infilled. Less than 98% coverage may be accepted by the AHO if coverage was adversely affected by existence of depths below 5m (at Chart Datum) within the pink chart area which represent a navigational hazard and for other reasons which were outside the control of the panellist. Such instances would need to be discussed and agreed upon by the AHO prior to demobilisation.

Full Bathymetric Coverage requires lines to be planned such that the outer beams touch. To account for roll, this will require overlap between the outer beams (Figure 4). The amount of overlap is expected to be no less than 10%, and will generally be between 10% – 20%, but may be more if the situation requires and is dependent on survey conditions. The level of overlap shall be recommended by the SIC and nominated in the Survey Management Plan (SMP). This will be discussed and agreed to by the AHO at contract negotiation.

Full Bathymetric Coverage is the default requirement for IHO Order 1a or HIPP 1 survey tasks.

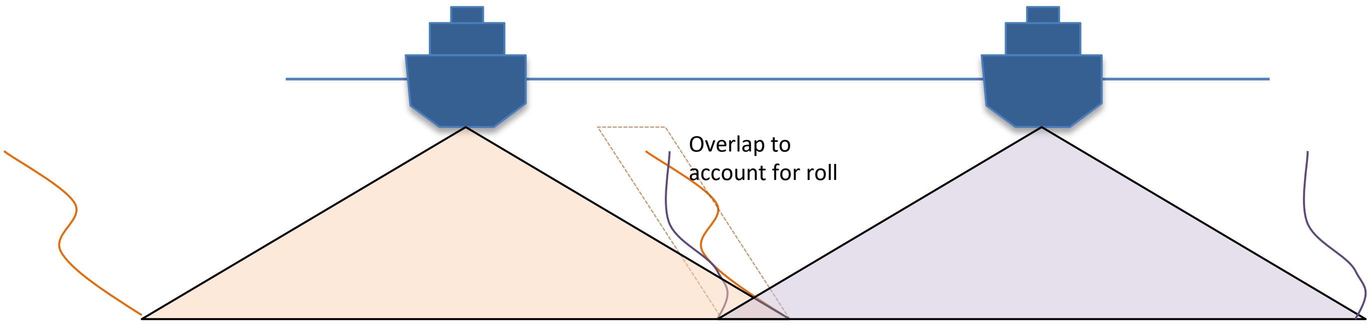


Figure 4 – Swath overlap for Full Bathymetric Coverage

7.5.1.3 *Full Seafloor Coverage (100% Coverage, 200% Ensonification)*

Full Seafloor Coverage requires a very high-density dataset over the entire survey area (Figure 5). To account for lower uncertainty in both the nadir and outer beams, it is recommended that lines be planned such that the outer beams are to meet the nadir beam of the next line.

Full Seafloor Coverage is determined to have been achieved when no less than 100% of the pink chart has been surveyed to the required standard with at least 9 soundings per cell, achieved through 200% ensonification, which will be evidenced within the Final Survey Data surface products demonstrating 100% cell coverage at the required density. Less than 100% coverage may be accepted by the AHO if coverage was adversely affected by existence of depths below 5m (at Chart Datum) within the pink chart area and for other reasons which were outside the control of the panellist. Such instances would need to be discussed and agreed upon by the AHO.

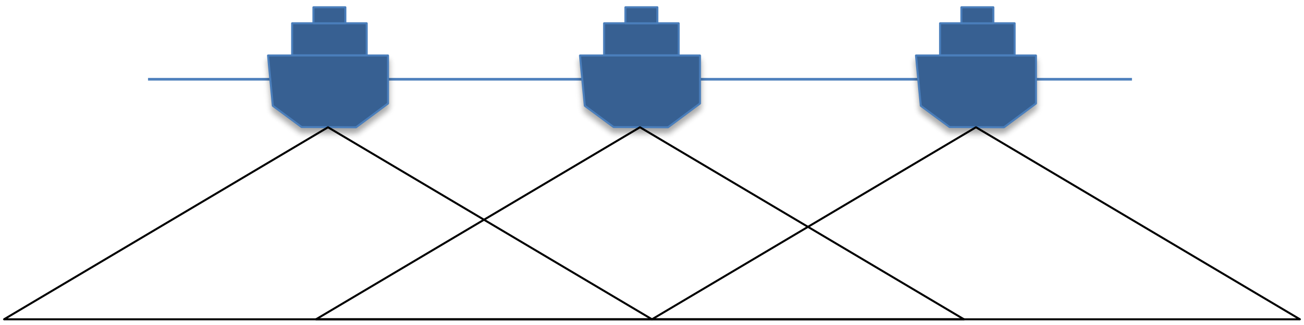


Figure 5 – Swath overlap for Full Seafloor Coverage

7.5.2 Sounding Density

Accepted MBES theory states that to ensure detection of small wavelength features on the seafloor, a minimum of 9 soundings are required to strike the feature (three across-track and three along-track pings). This will require MBES equipment capable of meeting the-feature detection requirements for the Survey Order stated in the Survey Instruction at the target depth, and survey techniques to optimise detection. Other sounding systems must be able to prove their capability to achieve a similar feature detection capability for feature size and target depth. IHO S-44 Ed 6 provided further guidance on the surface resolution required for a level of feature detection and nominated a resolution of half the desired feature detection size.

The AHO has adopted the IHO S-44 Ed 6 recommendations with regard to the resolution and density of supplied gridded Final Surfaces and have adopted this as the basis for proving coverage, density and feature detection throughout the survey area. Based on these recommendations, the standard requirement for a HIPP Survey is as follows:

- Grid Resolution (cell resolution): Half the required feature detection at depth for survey order, or as per Table 10;

- Minimum Cell Density: at least 5 soundings or more per cell for Full Bathymetric Coverage (FBC) and at least 9 soundings per cell for Full Seafloor Coverage (FSC);
- Feature Search: 100% Ensonification to be achieved for acoustic systems, or 100% illumination to be achieved for LIDAR systems, for IHO Order 1a or above;
- Full Bathymetric Coverage: 98% bathymetric coverage for HIPP 1, IHO Order 1a or Special Order Survey orders (100% of cells on top of all Reportable Features are to contain at least 5 soundings per cell);
- Full Seafloor Coverage: 200% bathymetric coverage for IHO Exclusive Order or above; and
- Intended Category of Zone of Confidence (CATZOC): IHO ZOC A1 for IHO Order 1a or above, may be reduced for lower orders survey task as specified in Survey Instruction.

Density calculations are to be based on the premise of each sounding only being counted against a single cell, even where a sounding may influence multiple cells such as for a CUBE generated surfaces.

A density surface of the final processed dataset is to be rendered with the survey at the same resolution as the bathymetric surface. The best format for this has proven to be SDTP.

Data Gaps shall not account for more than 2% of the total area (FBC) and shall conform to the definition provided at Section 7.5.3.3 and be random in nature. Systematic data gaps are not to be included in the 2% allowance. The SIC shall review WCD and any rejected data to assess the likelihood of any features existing within gaps. The SIC is to certify that Data Gaps contain no significant features in the Report of Survey.

Data Holidays and Data Holes as defined by Section 7.5.3 are not allowed.

7.5.2.1 *Deep Water Sounding Density*

Deep water survey requirements will be confirmed in the SI, noting considerable variation in achievable resolution and sounding density dependent on the systems to be deployed. Sounding density for deep water survey may also vary dependent on the broader requirements of the project, noting the use of other acoustic sensors may require ping rates to be restricted to avoid interference between systems, thus reducing achievable sounding density.

Based on consideration of the systems to be employed, the nature of the survey task and the priority of all acoustic sensors to be deployed, the SI will provide specific guidance for sounding density.

7.5.3 Data Holidays, Data Holes and Data Gaps

To aid in coverage and density assessments by the SIC and AHO staff the following definitions are introduced.

7.5.3.1 *Data Holidays*

The IHO definition of a Data Holiday is an unintentional unsurveyed area within a given hydrographic survey where the spacing between sounding lines or surveys exceeds the maximum allowable limits (IHO Dictionary S-32). The AHO interpretation of a Data Holiday is where seabed ensonification has not occurred for any reason such as systematic sensor failure, environmental conditions, line keeping error, planning failure or any other event resulting in a lack of returns resulting in a lack of seabed ensonification.

Data Holidays are not allowed and must be filled by infill sounding lines as they represent a failure to achieve 100% ensonification.

7.5.3.2 *Data Holes*

Data Holes are an area where no processed bathymetric data is represented in the final surface, or do not meet the Minimum Cell Density (see Section 7.5.2), but where ensonification has been achieved. A Data Hole is a significant hole in bathymetric data which has the potential to contain a significant feature or obstruction as defined by the survey order, Data Holes are random and cannot be systematic in nature or exist over significant features.

Data Holes are not allowed and may be remediated by merging data from the Water Column Data, provided the data is non-erroneous and representative of the seabed, or by data acquired from infill lines.

Data Holes on the bathymetric surface will be represented by a series of at least nine adjacent surface cells that do not meet the Minimum Cell Density. The series of cells are arranged in a way which presents as three cells by three cells or bigger as demonstrated below:

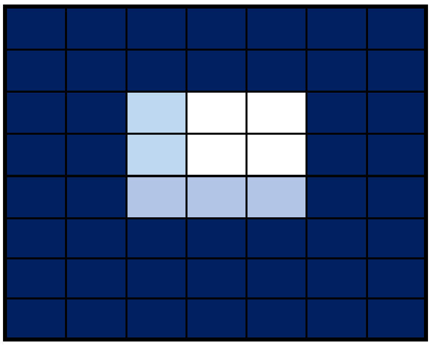


Figure 6 – Data Holes

Dark Blue cells meet or exceed the Minimum Cell Density, light blue cells contain less than the Minimum Cell Density and white cells contain no soundings. White and light blue areas represent the minimum threshold for a data hole.

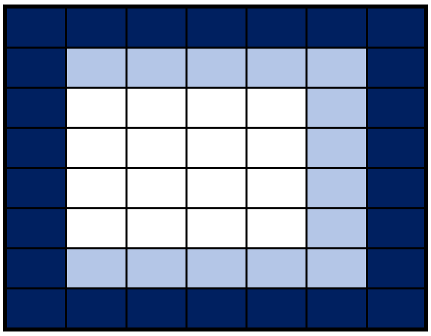


Figure 7 – Data Holes

Dark Blue cells meet or exceed the Minimum Cell Density, light blue cells contain less than the Minimum Cell Density and white cells contain no soundings. White and light blue areas represents a larger single data hole.

7.5.3.3 *Data Gap*

A Data Gap is an insignificant gap in bathymetric data, but where ensonification was achieved and which does not present the potential to contain a significant bathymetric feature or obstruction as defined by the survey order at Table 5. Data Gaps should not account for more than 2% of the total coverage.

Data Gaps are allowed, and do not need to be infilled provided they total less than 2%.

Data Gaps on bathymetric surfaces will be represent by cells that contain less than the Minimum Cell Density but which do not meet the minimum threshold to be defined as a Data Hole. Examples are in Figure 8 below:

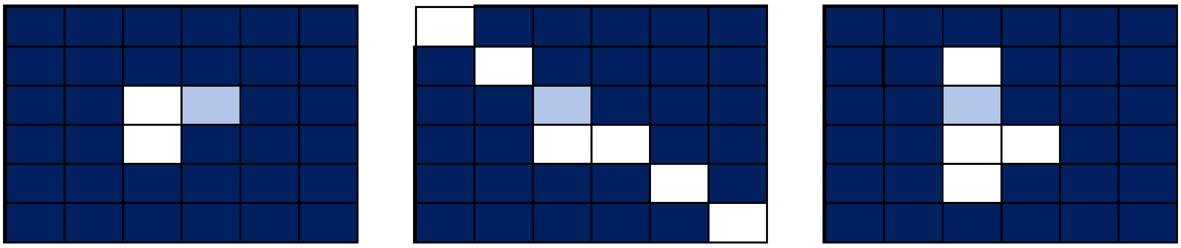


Figure 8 – Data Gaps

Dark Blue cells meet or exceed the Minimum Cell Density, light blue cells contain less the Minimum Cell Density and white cells contain no soundings. White and light blue areas represent allowable data gaps.

7.5.3.4 *Systematic Data Gaps*

A Systematic Data Gap is any consistent, repeated failure to achieve the minimum data density on a given survey line. In the context of data density deficiency in a bathymetric surface, this is expressed as a pattern of surface cells, which is repeated, and which contain less than 5 soundings that are associated with faulty or incorrectly configured equipment, faulty procedure or the outcome of MBES data acquisition in environmental conditions which exceed the limitations of the survey system.

Systematic Data Gaps are not allowed and must be filled by infill sounding lines as they represent a failure to achieve 100% ensonification, a system failure or procedure. Early identification of Systematic Data Gaps is key in order to allow for this issue to be remediated with observed bathymetric data. If there is any doubt as to whether Systematic Data Gaps exist, the AHO Client Representative is to be notified in good time in order to determine a course of action.

7.5.4 Line Spacing and Survey Speed for SBES

7.5.4.1 *Line Spacing*

When SBES are utilised for surveys not requiring full seafloor ensonification (IHO Order 1b and IHO Order 2) the following guidelines are to be followed:

- Line spacing is to be determined by the SIC and documented in the Survey Management Plan. Line spacing will be dependent on the SBES beam width, depth of water and complexity of the survey area detailed in the Survey Instruction. This plan is to be approved by an Authorised Officer. Major changes to line planning and execution of the plan are to be advised to the Authorised Officer and agreed via updated SMP.
- The use of SSS to provide additional inter-line coverage is required to aid in achieving Full Seafloor Ensonification.
- Additional sounding lines are to be obtained along recommended tracks, areas used for anchorages and off headlands where the mariner may pass closer to shore than normal;
- When operating in areas with sandwaves (known or suspected), mainlines are to be planned at right angles to the line of the crests to minimise the risk of missing the shoalest depth due to running along the troughs;
- Where irregularities are found to exist, or where the nature of the seabed or adjacent coastline features may indicate previously undetected dangers, the areas must be more carefully sounded using interlines and/or cross-lines.
- In detecting shoals the Contractor must make the most of an efficiently spaced network of sounding lines, which both maximize the possibility of determining the least depth and minimize the effort required to sound the area.

7.5.4.2 *Survey Speed*

Survey speed and pulse repetition rate shall be such that the along track density of valid soundings shall not exceed 5m and be dense enough to detect significant features on the seabed.

7.5.5 Airborne LiDAR Bathymetry (ALB) Coverage and Feature Detection

The coverage and feature detection requirements for bathymetric LiDAR are defined below.

7.5.5.1 *ALB Coverage*

Areas of ALB coverage are to achieve the IHO Order 1a standard, to the level of coverage specified in the SI, this will be either 80%, 85%, 90% or 95%. If the SI does not nominates a minimum level of coverage for ALB then the contractor is to nominate a price for a level of coverage between 80% and 95% with supporting information on why the nominated level is chosen and 95% is unlikely to be achieved.

The contractor is to nominate an appropriate level of re-fly activity to achieve the nominated coverage to IHO Order 1a standards, with the remaining area is to meet IHO Order 1b standards.

For combined ALB / MBES proposals areas not meeting the minimum coverage requirements for IHO Order 1 are to be infilled with MBES.

ALB areas not meeting IHO Order 1a requirements are to be submitted as IHO Order 1b areas.

Areas achieving IHO Order 1a and IHO Order 1b are to be defined by a polygon in the 'Survey_Uncertainty' feature class of the HIPP SSDM.

For IHO Order 1a coverage a minimum of 3 soundings per 2m bin, to 75% of laser extinction depth with 200% illumination is to be achieved on separate days. Contractors proposing ALB systems are to provide evidence of their feature detection capability in relation to laser foot print and spot density, and that they can meet or exceed the requirements above for IHO Order 1a. Contractors are to demonstrate the achieved laser extinction depth, and show how the 75% level is calculated.

ALB only surveys may be requested to maximise the financial benefits of the utilisation of the ALB technology in shallow complex and navigationally dangerous areas. In these cases, an ALB solution will be awarded if the AHO believes it represents a financial saving over an MBES survey. If the SI nominates a ALB-only survey then the contractor is to nominate a price for a level of coverage for the achievement of IHO Order 1a between 80% and 95%, factoring in an appropriate level of re-fly the remaining area is to be to IHO Order 1b standards.

Tiles intersecting the land and survey boundary are removed for assessment purposes, 200% data should be collected in the surf zone with data collection occurring at different tide states.

If multiple bathymetric sensors are used the Contractor is to ensure that each sensor is optimised to achieved maximum depth performance, that suitable overlap between sensors is achieved with no gaps, and that redundant shallow returns from the deep sensor is removed.

If the Contractor identifies an area where they believe the required coverage cannot be achieved due to persistent water clarity issues they are to bring this to the attention of the Authorising Officer as soon as possible so that a contract amendment can be negotiated or alternative areas nominated. Sufficient evidence for the whole of the survey period in the form of "no bottom detection" soundings, photography, waveforms, swell or other records shall be supplied as a justification.

The Survey Management Plan is to include a Turbidity Management plan outlining the Contractor's understanding of the Turbidity issues affecting the survey area and their intentions to minimise the effects on the turbidity on the final coverage. Where possible, the Contractor should collect data during periods of low turbidity e.g. calm weather and low swell, and most appropriate tide window.

If feasible, gaps shall be filled by re-flying under different weather and tidal conditions. The Contractor should exercise judgement when considering 200% coverage or re-flying at a later date to achieve agreed level of coverage.

200% coverage flown is defined as flight lines flown at half the standard flight line separation with adjacent lines flown on different flights.

7.5.5.2 *ALB Feature Detection*

Object detection requirements needed to achieve IHO feature detection standards by LiDAR are defined as follows:

- IHO Order 1a – A minimum of 2x2m spot spacing collected at 200% (flown twice) to 75% of the laser extinction depth i.e. 3 soundings per 2m bin, with 200% coverage (flown on different days)..
- IHO Order 1b - Feature detection requirements are not specified, areas flown by ALB where the above IHO Order 1a coverage requirements are not met.

7.6 Bathymetric Surface Resolution

The resolution of the final gridded dataset shall be dependent on the Order of Survey, feature detection criteria and the depth of water. It shall be such that all significant features for that order of survey are retained and apparent. This means the grid resolution/bin size should be half the distance of feature detection criteria for the depth range.

Table 10 shows the minimum MBES surface resolution related to the object detection requirements for each survey order.

Table 11 – Minimum MBES Surface Resolution

Depth Band	IHO Exclusive Order	IHO Special	HIPP-1	IHO 1a	HIPP - 2	HIPP Passage
0 – 40m	0.25m	0.5m	0.5m	1m	N/A	4m
32 – 80m	N/A	0.5m	1m	2m	N/A	4m
64 – 160m	N/A	N/A	2m	4m	N/A	8m
128 – 320m	N/A	N/A	4m	8m	8m	16m
256 – 640m	N/A	N/A	8m	16m	16m	32m
512 – 1280m	N/A	N/A	16m	32m	32m	64m
1024 – 2560m	N/A	N/A	32m	64m	64m	128m
2048 – 5120m	N/A	N/A	64m	128m	128m	256m

In areas of steep slope, the overlap between grids of different resolutions may need to be increased to prevent gaps in their junction. In these cases, the courser resolution grid should have its shoaler extent modified to prevent this coverage gap.

If a series of grid resolution surfaces are created, then resolutions within the series should not be missed out unless detailed in the SI (i.e. 1m → 2m → 4m surfaces for IHO-1a and b). Note that while some software will produce multi-resolution grids the AHO cannot currently process these. Where more than one grid resolution is used each shall be rendered as separate surfaces.

In discussion with the AHO Client Representative, the above depth bands may be modified to suit the survey area based on surveyed depths achieved, to reduce the horizontal overlap and the inadvertent creation of isolated deep and shallow features. Further guidance is provided in the

HIPP Guidance Note for Generating Complex Depth Banded Surfaces, and summarised below:

- Create as few surfaces as possible as long as density requirements are met,
- Once max depth is > 15% of the depth band, a new grid is likely to be required to comply with TVU,
- Each surface must comply with Survey Order as nominated in SI,
- All surfaces to be < 15 GB,
- 1m Surface must include the 40m contour,
- AHO require a single TVU and THU for each surface to populate S57 attributes
- Any RF or SCD features must be fully contained within the grid appropriate for the least depth, extending to the next standard contour (e.g. 30m, 50m, 100m) or where depths are consistent with the surrounding seafloor (whichever is shallower).
- Depth cut off should be adjusted to avoid an excessive number of non-contiguous clusters, where the density and uncertainty of the surrounding area would allow these to be encompassed in a single contiguous surface.

LiDAR data is to be rendered as finalised Shoal Depth True Position surfaces at a resolution appropriate to the laser footprint and to support the documented feature detection capability of the system in use, this is to be fully detailed in the SMP and agreed to by AHO.

7.6.1 Deep Water Bathymetric Surface Resolution

For deep surveys (>200m) panellists are to state their ability in the SMP to meet or exceed the minimum surface resolution, based on the criteria of achieving five soundings per node **based on the premise of each sounding only being counted against a single node**, and should furthermore describe a more detailed table of achievable resolution versus depth based on the capability of the solution offered, with due consideration of the nature of the survey area.

7.6.1.1 *SBES and Low Resolution linear surveys*

A holiday is defined as a departure of over 10% of the line spacing with a maximum deviation of 20m allowable, except in areas where obstructions exist (Table 11).

Table 122 – Maximum Allowable Off-Track Deviation from Track-Line

Line Spacing (m)	Maximum deviation allowable (m)
25	2.5
100	10
200	20
300	20

The SIC is to analyse the daily run-lines logs to determine the need to conduct interlines to account for holidays taking into account the distance off-line compared to the scale of the survey, the risk of missing significant features, the bottom topography and the time required to run the interlines.

7.7 Significant Bathymetric Features

Identification, investigation, determination of least depth and reporting of Significant Bathymetric Features (SBF) is a fundamental part of a nautical charting hydrographic survey and of ensuring the safety of navigation within the survey area. The compilation of a traditional Shoal Summary has been the classic tool for ensuring the field surveyor undertakes appropriate due diligence in the identification, review and investigation of shoals to determine a least depth whilst in the field and the reporting and highlighting of these to the national Hydrographic Office and its cartographic staff. Likewise, the field checking of navigational charts in use through the conduct of a chart comparison is the only independent field check on the quality of the charts produced by the national Hydrographic Office and is of equal importance. Whilst the evolution of modern MBES and the Full Bathymetric Coverage surveys has seemingly made the identification of shoals a simpler visual task, there is still value in a rigorous process to ensure the survey achieves the desired feature detection required by the survey standard and SI. It is also important to ensure that the least depth of shoals is assessed and measured, and that the modern navigational surface (final CUBE Surface for HIPP surveys) truly reflects the actual measured least depths (point data). The field checking of published navigational charts remains a part of the modern nautical charting hydrographic survey.

A bathymetric feature is defined as an item on the seafloor which is distinctly different from the surrounding area; it can be anything from an isolated rock on a flat sand seafloor to a wreck or obstruction. All features greater than the feature detection limit specified in the Survey Instruction are to be identified.

IHO S-44 Ed 6 defines Significant Features as a feature that poses a potential danger to navigation or an object one would expect to see depicted on a nautical chart. IHO S-57 Ed 3.1 Sup 3 defines Significant Features as listed in Table 12 which conforms to the S-44 feature detections standards.

Table 133 – Significant Features

Depth (m)	Is a Significant Feature if the variation in depth is greater than…
<40m	2.0 m
>40m	10% of Depth

It is very likely that a large number of such features (IAW IHO S-44 Significant Feature definition) will be detected during the course of a hydrographic survey, and require an unknown level of additional work to fully delineate their least depth and extent. The HIPP SOR introduces the concept of the Reportable Features (RF) to highlight those features that the SIC should be focusing their efforts upon for investigation, examination and reporting, and to ensure the task remains reasonable.

For HIPP surveys the traditional Shoal Summary and chart comparison is achieved through the 'Seabed_Feature_Pnt' (Point) feature class of the HIPP SSDM with appropriate designation of feature type; these were formerly separate Reportable Features (RF) and Significant Charted Differences

(SCD) feature classes, and have been consolidated to remove duplicate reporting. The 'Seabed_Feature_Pnt' feature class further enhances the reporting and visualisation of SBF through a domain-based classification of the nature of the feature, based on the SIC's interpretation of available data (previously included as free-text only).

Newly discovered features which may be dangerous to navigation, and **charted features** which are found to be significantly changed, are to be reported to the AHO without delay by Hydrographic Note (F_05_51_AA217160). These should be consolidated in the SSDM for the final deliverable, including any subsequent revisions to position or least depth. Supporting spatial data may be provided with the Hydrographic Note, particularly when reporting multiple features; this may be in the form of an interim CSAR extract (coarser resolution permissible), floating point GeoTIFF, SSDM extract, shapefile(s) or CARIS HOB file.

This section provides definition of these concepts and quantifies the level of investigation and reporting of bathymetric features required for HIPP surveys. All features reported are to be reduced to LAT based on the final tidal model.

7.7.1 Limits of Variations Included

Where significant bathymetric features are found to lie within the specified project area, or up to a distance of 2 standard swaths (2 extra lines at general survey depth) outside the project area, then examination, delineation and delivery of such work is considered to be part of the work of this survey, and is not considered to be a variation (unless otherwise stated in the contract document).

Where an examination or investigation of either doubtful data or a shoal is specified and listed as part of the survey, the work required to determine the extent and least depth is not considered to be a variation.

7.7.2 Limits of Variations Excluded

Where significant bathymetric features are detected more than 2 standard swaths (i.e. 2 extra lines at general survey depth) outside the survey project area and the least depth and extent of such dangers requires them to be determined such work is deemed to be a variation and the work should be referred to the Authorised Officer before being undertaken.

7.7.3 Shoal and Significant Feature Examinations

Where significant features are either known to exist or their existence is doubtful and require further investigation, these features will be identified in the Survey Instruction. These features and those detected during the survey and identified as Reportable Features (RF) shall have their position and least depth determined by further examination such that Full Seafloor Coverage (FSC) is achieved and the least depth determined; or if not detected disproved in accordance with Section 7.8. No survey can be considered complete until all such shoals / features have been examined and any charted shoals that have not been located have been disproved. Definitive statements to this effect are to be made by the SIC in the Report of Survey and relevant SSDM feature classes.

7.7.4 Reportable Features (RF)

Reportable Features (RF) are a subset of the S-44 Significant Features that should be reported to the AHO and highlighted to cartographers. Reportable Features are to be fully investigated (additional lines sounded if required), examined (point data examined, least depth identified and designated to preserve their value on the final CUBE surface) and reported through the 'Seabed_Feature_Pnt' (Point) feature class of the SSDM. The level of effort warranted to investigate each Reportable Feature is to be controlled by the SIC taking into account the available resources, the likely use of the area (draught of vessels etc.), and the likely significance of the feature noting the general depths in the area. Reportable Features shall be discussed with the HIPP CR and the requirement for investigation agreed to prior to demobilisation.

When a feature is determined to be a Reportable Feature and warranting further investigation, the position, depth and extent of the feature is to be determined. The SIC is to investigate reportable features to the point that they are satisfied that the Least Depth has been found, including the collection and review of water column data over the feature. Full Seabed Coverage (FSC) is to be achieved over all Reportable Features.

Reportable Features are:

- All significant features in depths less than the reporting threshold specified in SI which will be determined based on the likely draught of vessels transiting the area to ensure navigational safety;
- Controlling depths over complex or sand wave areas;
- Specific features identified in the SI for investigation; and,
- Any other feature that should be depicted on a navigation chart as a shoal.

All Reportable Features are to be "Designated' or "Golden Soundings" and applied to the Final Bathymetric Gridded Surface so as to preserve the features depth and position.

Where controlling depths are used, an associated polygon in the 'Seabed_Feature_Ply' should define the region where this applies, with reference to the RF in the 'Remarks' field.

These Reportable Features are to be included in the Critical Soundings Layer (or equivalent) within the Level 2 data project, and in the 'Seabed_Feature_Pnt' (Point) feature class of the HIPP SSDM. The SIC may designate additional soundings if they feel it is warranted to truly define the shape of a Reportable Feature, in this case only the shoalest sounding need be reported as a shoal in the RF layer. Surveyed depth values and applied tide values should be stated at 2 DP in the SSDM. For each of these features, the SIC is to make definitive statement as to whether least depth has been found, the accuracy of the depth, and if appropriate, the reason for any difference to charted depth. The statement must also contain a recommendation on subsequent charting action. These statements and recommendations are to be contained within the HIPP SSDM 'Seabed_Feature_Pnt' (Point) attribute table. 3D images of the point data over the feature is to be provided and hyperlinked to the SSDM table. The traditional Shoal Summary spreadsheet is no longer required when the HIPP SSDM is provided with attribute tables fully completed.

Additional features that are not considered Reportable Features (such as those beyond the

Threshold Depth specified in the SI) may also be "Designated" to preserve their depth on the final surface and should be referenced in the Report of Survey. While not mandatory for reporting in the SSDM, the inclusion of such features in the SSDM will provide a more comprehensive seabed interpretation, and only require the pre-existing IOGP SSDM (v2) 'Seabed_Feature_Pnt' fields to be populated, not those added to facilitate RF/SCD reporting, such as screenshots and recommendations (refer to SPEC_03_33_BN32048462 HIPP Modified SSDM Data Dictionary).

On drying shoals the least depth is to be established by terrestrial observations whenever practical and reduced to tidal datum.

SSS should not be used for depth measurement, but to define areas requiring more detailed and accurate investigation.

7.7.5 Significant Charted Differences (SCD)

A chart comparison between the best scale official electronic navigational chart (AusENC), as provided in the GFI, and the reduced survey data is to be conducted and reported on in the 'Seabed_Feature_Pnt' (Point) feature class of the HIPP SSDM. The purpose of this is to aid the SIC in identifying and reporting anomalies or omissions in the published chart that are navigationally significant.

Significant Charted Differences may include:

- Charted shoals (a sounding circled by a contour) that are disproved, particularly where the sounding is a significant controlling depth;
- Charted soundings where the survey depth is different by >25% of charted depth; and
- Charted shoals that are relocated horizontally and/or have a revised least depth if not already included as a Reportable Feature.

The SIC must make a statement supporting the removal of all disproved charted features in the Report of Survey.

The official digital chart product AusENC, as provided in the GFI datapack, is to be used for all chart comparisons, as this is the most up-to-date official data source. The paper chart GeoTIFFs are not to be used as these are not updated as regularly and may exclude Notice to Mariners corrections, unless otherwise advised in the SI due to insufficient ENC coverage. The AusENC .000 files can be loaded into ArcGIS Pro 3.1 and later with appropriate symbology, or in ArcMap using the ESRI s57 Viewer toolbar (https://www.esri.com/en-us/arcgis/products/s57-viewer), provided all update files (.0xx) are in the same directory as the .000 base file; otherwise individual feature classes within the geodatabase can be accessed through standard GIS software packages. The IHO S-57 Object and Attribute Catalogue (www.s-57.com) can be used to gain a greater appreciation of data model.

7.8 Disproving Searches

Wrecks and 'doubtful' data requiring investigation will be identified in the Survey Instruction. Doubtful' data includes features thought to be unlikely from a study of the general seabed topography, or those whose position is not known with sufficient accuracy. These will be charted as Position Approximate (*PA*), Position Doubtful (*PD*), Existence Doubtful (*ED*), Sounding Doubtful (*SD*), Reported danger or soundings (*Rep*) or noted as *Discoloured Water*.

Many charted features shown as ‘doubtful’ data have been sourced from old navigation charts and the source and reliability are unknown. Reported dangers in the water for which the exact location is unknown may also be referred to as vigias.

If such features are located sufficiently within the defined survey area (>2.5 NM from edge), they can be considered disproved if the survey is conducted to HIPP 2, IHO Order 1a, HIPP 1 or higher order survey. However, if a bathymetric feature identified for investigation lies outside or along the edge of the defined survey area and is not detected, disproving searches are to be conducted using a detailed and systematic method in an attempt to clarify the existence, or not, of this feature, as per Section 7.8.1 and 7.9 below.

Upon completion of the survey, the SIC must make a definitive statement within the Report of Survey as to whether each identified wreck or ‘doubtful’ data exists and whether further investigation is required. If further investigation is still required, the SIC is to provide an explanation why this is the case and what course of action they believe should be undertaken to remove the data from the chart.

7.8.1 Extent of Area to be Searched

No empirical formula for defining the search area can cover all situations. For this reason, it is recommended that the search radius should be at least 3 times the estimated position uncertainty of the reported hazard (when provided). Unless specified in the Survey Instruction, high resolution MBES and/or SSS sweeps in two directions at right-angles should be conducted over the position with consideration given to extending the search area over a radius of at least 2.5NM.

7.9 Wreck Investigations

All wrecks located during the survey shall be fully investigated to determine position, orientation, extent and least depth. Survey track-lines are to be conducted as follows:

- One line centred over the major axis of the wreck with two parallel lines either side ensuring no data gaps exist between these lines.
- At least one line perpendicular to the major axis of the wreck and subsequent lines either side of this line ensuring the whole wreck is fully ensonified from this direction.

All investigation lines are to be run using survey parameters to maximise sounding density with water column data logged to enable post–processing of the water column to provide least depth if the real-time swath bathymetry did not digitise this feature.

Wreck data is highly important in determining historical knowledge and possible hazards. In addition to the collection of bathymetric and water-column data, investigation of wrecks could be conducted using a range of equipment and these should be considered in any tender response, including:

- **SSS**: Lines should aim to box in the wreck with the wreck positioned in the outer swath. At a minimum, lines shall be run parallel to the major axis of the wreck.
- **Magnetometer:** Magnetometers are important in determining whether a wreck which is not detectable by sonar, may be covered or remains as a debris field.
- **Drop camera or ROV:** Visual identification of key structural features or markings assist in identifying the actual wreck's origin.

Specific investigation requirements may be detailed in the SI.

The Contractor shall confirm in the ROS if the least depth of each wreck has been determined through analysis of the Water Column Data.

Any uncharted wreck detected during the survey, or any significant changes in depth of a charted wreck, should be reported to the AHO by means of a Hydrographic Note (F_05_51_AA217160) at the first available opportunity.

In addition to the final bathymetric surfaces for the whole survey area, a standalone extract of each wreck is also required to be rendered in the Ancillary Data Pack as per Section 11.5.6.

7.10 Passage Sounding

Passage sounding is required on all HIPP projects from the operating port, once systems are fully mobilised and calibrated, to the survey area on each transit and when proceeding from safe haven following weather avoidance. The objective of passage sounding is to increase the area coverage in low ZOC areas, assist in data collection for AusHydroid generation and analysing the hydroid model holistically.

Where possible, offsetting passage routes and overlapping MBES swaths, should be conducted to increase the width of data.

Passage sounding is to be reduced to LAT in depths < 200m using both a suitably generated predicted tide model and an AHO supplied *Passage Sounding HYDROID* model (which will be provided on contract award).

An analysis between the two surfaces is to be conducted and included as a surface difference layer.

Passage sounding data must:

- Comply with the HIPP-Passage standard,
- Be raw (Level 0),
- Fully processed (Level 2),
- Final Surfaces (Level 3),
- Reported via AHO Survey Summary Form (formerly AH68a)
- Rendered as a separate data pack to the main SI, inclusive of distinct projects and surfaces.

8 MISCELLANEOUS OBSERVATIONS

8.1 Aids to Navigation

Aids to navigation of interest to the AHO will be identified in the Survey Instruction and are to be checked and their position fixed in accordance with the accuracies in Table 6, and reported on in the ROS.

Aids to navigation that are found to be significantly displaced from the charted position, so as to be considered a danger to navigation, are to be reported to the AHO immediately via a Hydrographic Note (F_05_51_AA217160).

8.1.1 Fixing of Floating Navigational Marks

Floating navigational aids such as light floats, buoys and lightships are to be fixed in both their flood and ebb position to determine their range of movement with the mean position detailed in the ROS. If the range is significant to surface navigation noting the likely digital chart in be in use, this variation is to be shown on the digital products. The mooring positions may also be used to determine the mean position of the aid.

8.1.2 Characteristics

The characteristics of aids to navigation are to be checked in the field against the details on both the official navigation chart (ENC) and the relevant Admiralty List of Lights Vol K publication. Where possible, light arcs, flashing characteristics and colours are to be checked for all lit marks. Checked navigation marks are to be recorded in Annex K of the ROS.

Where characteristics differ from any of the published versions, the AHO is to be notified immediately via a Hydrographic Note (F_05_51_AA217160).

8.2 Conspicuous Objects

When checking the coastline, particular care is to be taken to detail beacons, flag-staffs, groynes and harbour developments and other significant features. A description of charted objects that no longer exist or are missing, must be tabulated in the ROS Annex G in the Charted Difference section and reflected in the digital products. Any conspicuous objects that would be relevant to the mariner, and that are not charted, are to be identified and captured in a photographic view (IAW Section 8.8).

When directed to do so in the SI, the Contractor is to:

- Fix and describe all objects conspicuous to the mariner, which are not already fixed, and check existing marks/features on charts and publications are positioned and described correctly, even though they may be a little inland;
- Measure and estimate the heights of all such features, some features can be described in general terms such as “Low red cliffs, 5 to 6 metres high;” and,
- Fix all islands, visible offshore dangers and obtain their heights, also fix adjacent floating marks (buoys not on chart).

Particular conspicuous objects may be specified in the Survey Instruction to be checked without the requirement for full delineation of the coastline.

8.3 Datum Line Delineation

8.3.1 Coastline Delineation

The coastline is the high water mark, or the line of mean water level where there is no appreciable tide or change in water level. When specified by the SI, the Contractor is to observe the coastline and record the following details in the provided database:

- Delineate and fix the coastline by the best methods available;
- Describe the composition of the beach between the low water line (drying line) and the high water line as well as above the high water line;
- Indicate established landing places along the coast;
- Fix and describe groynes, sewer outfalls and anything that might constitute a danger to landing; and
- Piers and jetties should also be fixed and a full description obtained, which should include type of structure, depths alongside, height of deck above the HW datum and facilities available.

Care must be taken to locate this line accurately, especially in areas with a large tidal range.

The Survey Instruction may also ask for either spot checks to be conducted to verify the uncertainty of the depicted coastline or the coastline to be surveyed by regular methods appropriate to the scale of survey and in accordance to the accuracy detailed in Table 6. The SMP is to detail the proposed solution for coastline determination when required in the SI.

8.3.2 Delineation of the Drying Line

When required by the SI and the survey area extends to the coast, the Contractor is to delineate the drying line where this can be determined. This is to include the drying line of the mainland, all islands and drying features (especially rocks). The best way to fix the drying line is by reduced soundings, however, it is important that the whole foreshore is sighted at least once during low water in order to detect features and dangers that may be a risk to surface navigation. Once fixed, it is good practice to delineate the drying line at low water using geodetic GNSS in kinematic mode instead of relying on lines of soundings that may be a considerable distance apart. Techniques such as LiDAR scanning, may be utilised to determine the drying line.

In some cases, the SI may nominate a depth contour to be delineated by MBES rather than the drying line; in these cases, the drying line will be obtained via other techniques independent of the SI requirement such as by the use of Satellite Derived Bathymetry or Bathymetric LiDAR.

8.4 Elevations and Overhead Clearances

All elevations and clearances must be referenced to a specific datum. In tidal waters, elevations are referenced to Mean High Water Springs (MHWS) or Mean Higher High Water (MHHW) and overhead clearances (e.g. bridges) are referenced to Highest Astronomical Tides (HAT). In non-tidal waters, elevations are referenced to the sounding datum.

8.5 Nature of the Seabed

The nature of the seabed shall be determined by sampling or may be inferred from other sensors such as photographs from a Drop Camera or AUV or images from side scan sonar or sub-bottom profiler up to the depth required by local anchoring or trawling conditions. In sensitive areas such as marine reserves physical samples may not be allowed and instead a visual image should be taken such as with a Drop Camera.

Seabed samples are required to ground truth backscatter mosaics and identify significant changes in seabed textural area. The correlation of samples and backscatter intensity data should be detailed in the ROS and represent in the Seabed Textures layer of the SSDM.

Under normal circumstances sampling is not required in depths greater than 200m unless specified in the Survey Instruction. Samples have to be spaced according to the seabed geology and intended usage (i.e. anchoring). Any inference technique (e.g. Acoustic Seafloor Classification from multibeam echo sounder backscatter or side-scan sonar) must be ground-truthed by physical sampling, or use a standard catalogue developed for that specific sonar and vessel.

Seabed sample observations are to be conducted according to instructions provided in SP_03_32_R31777308 ‘Oceanographic Observations – Manual Logging – NHP’ and recorded using Form F_03_32_R31776865 and rendered digitally as a MS Excel (.xlsx) file along with any accompanying photographs and log sheets. In addition to be included rendered in the ‘Seabed_Sample’ feature class of the HIPP SSDM FGDB. Form F_03_32_R31776865 Field sample log should be used to facilitate classification at the point of collection.

Seabed sample photos should be taken whilst the sample is wet on deck and preliminary (in-field) interpretation made immediately, including sample composition code, relative sample composition (constituent percentages, to nearest 5%), associated Folk Classification and Munsell Colour.

If required in the Survey Instruction, a small portion (maximum 0.5 litres) of each seabed sample is to be retained and forwarded to Geoscience Australia for analysis. A copy of the field sample log must be provided with the samples.-A baseline sampling kit will be provided as GFM to each HIPP Panellist, and will be the responsibility of the Contractor to replace consumables and lost or damaged items. Procedures for handling samples are given in SP_06_51_R31777308. Samples are to be kept refrigerated (not frozen) whilst onboard the vessel and shipped in a fully sealed, portable insulated container to:

Attention: Director

Marine and Coastal Geoscience Section

Geoscience Australia

cnr Hindmarsh Drive and Jerrabombera Ave

Symonston

Canberra ACT 2601

Notification of dispatch of samples is to be made by email to GeoScience Australia at ausseabed@ga.gov.au and the AHO at hipp.ops@defence.gov.au. A digital copy of the seabed sample log and export of the SSDM layer is also to be provided with the dispatch email.

8.6 Freshwater Springs

The position of all freshwater springs shall to be fixed during normal survey operations and shown in the rendered digital dataset. The Survey Instruction will state if it is a requirement to obtain water samples to confirm the existence and composition of springs. If required by the SI a CTD profiler should be lowered over the freshwater spring to measure the seawater salinity profile and quantify the extent of freshwater dilution.

8.7 ADMIRALTY Sailing Directions (Pilots)

ADMIRALTY Sailing Directions (Pilots) publications shall be checked in the field for correctness and appropriate amendments are to be rendered with the Report of Survey. Care is to be taken when surveying near anchorages and harbor approaches to capture information that will be of value to seafarers when approaching these locations.

8.8 Photographic Views

Photographic views to support various publications, showing approaches to passages, navigational hazards and drying significant features, are to be rendered with the Report of Survey. Care is to be taken to show significant features when awash and dry if applicable. Oblique imagery at low tide is preferred, with additional imagery taken at high water desirable. Where practicable, panoramic views of a coastline to illustrate cliff lines and prominent features or to illustrate that certain charted features are not visible to the mariner are to be obtained in a similar fashion and rendered with the Report of Survey.

Where views are of drying or awash shipwrecks, comment should be made in the Report of Survey regarding the observed state of the wreck (i.e. intact, broken up, scattered remains etc) and an estimation of the height of the structure above the waterline.

Views are to be supported with metadata as follows, recorded in the 'Photographic_Views' feature class of the HIPP SSDM:

- GNSS position of camera
- Date and time
- Bearing and distance to a prominent charted feature (± 0.5°/± 0.1nm)
- Height of camera above sea level
- Height of tide at the time of capture
- Type of camera

8.9 Channels and Recommended Tracks

All leading lines and recommended tracks shall be sounded by MBES to a minimum width of ±1.5nm on either side of the centreline to achieve FBC such that all significant features are identified and least depths are found. If the track is found to be unsuitable, consideration shall be given to examining and recommending alternatives (consulting appropriate authorities where possible). Proposed new recommended tracks are to be sounded by MBES to ± 1.5nm.

All Two Way Routes, and Traffic Separation Zones are to be sounded by MBES to their charted width plus a minimum additional buffer of 500m on either side.

8.10 Geographic, Undersea Feature and Place Names

In general, names and spelling shall be accepted from the latest authoritative charts and maps of the area. The AHO maintains the Hydrographic and Undersea Feature Names (HUFN) database, which comprises place names shown on Australian nautical paper charts. Public access to this database is still in development; however names under the authority of the AHO are published in the Gazetteer of Australia: http//placenames.fsdf.org.au.

Within the territorial waters of Australia, jurisdiction for geographic names of features in legislated Coastal and Internal Waters (generally out to three nautical miles offshore) resides with the respective State or Territory geographic naming authorities. From the 3Nm limit out to 200Nm (EEZ) the AHO is the authority for processing proposals and adopting names in consultation with Federal, State and other statutory authorities. Within territorial waters outside Australia, the policy is to follow the names used by the country or state having sovereignty over the area.

In areas where there are no modern maps or charts, every endeavour shall be made to ascertain the correct names and spelling from local authorities. The source from which names have been obtained shall be included in the ROS. The surveyor may propose names of any newly located underwater features for which names cannot be discovered locally. The ROS shall indicate new names proposed and provide brief reasons for choosing them.

More information can be found at:
https://www.hydro.gov.au/factsheets/FS_Hydrographic_Surveying-Feature_name_proposals.pdf

8.11 Field Notes and Records

The following records are to be rendered with the ROS in digital form or scanned at 300dpi minimum for statutory archive requirements.

- Notebooks
- Tidal Curves
- Raw Working Graphics
- Field Forms
- Calibration Records
- Processing Logs

9 OCEANOGRAPHY and METEOROLOGICAL REQUIREMENTS

All required oceanographic and meteorological observations shall be detailed in the Survey Instruction. These may include temperature and salinity profiles, benthic habitat mapping, and deployment of oceanographic gliders, AUV, ARGO floats, buoys, radiosondes and similar scientific equipment.

Guidance will be provided in the Survey Instruction on the need to collect oceanographic and meteorological observations and samples. This will include sampling resolution, minimum data logging period, data format specifications, and transmission requirements (i.e. the need to transmit messages from sea in near real-time to BOM ensure timely assimilation into ocean and atmospheric forecast models – see later JJVV and BBXX message requirements).

9.1 Spatial and Temporal Metadata

As a general requirement all oceanographic and meteorological data must be tagged with position (latitude and longitude) on WGS84 and a Date-time.

Date-time should always be in UTC time, not local time, and where possible be coded in ISO8601 format like YYYY-MM-DDThh:mm:ss. Computer clocks on all instruments used should set to UTC time and the time checked prior to observations.

9.2 Data Format Requirements

All data should be submitted in either ASCII text format or a recognised readable format such as the netCDF format, .Excel .xlsx format or ASCII .CSV format. Data submitted in the netCDF format should follow the CF metadata standards (see http://cfconventions.org).

Where raw data comes from an instrument in a proprietary binary format it must be converted to a readable ASCII format prior to submission. Examples of acceptable data files and formats are given in document 'SPEC_03_33_BN16464067 Oceanographic Data Standards for HIPP'.

9.3 Instrument Configuration Requirements

Oceanographic instruments shall be configured such that all sensed data parameters are recorded. For example, with the Valeport SWiFT SVP if the 'automatic download mode' is used then only depth and sound speed will be recorded losing the valuable temperature profile data. Whereas if the Valeport SWiFT SVP is configured with the 'Valeport Data File (.vpd)' mode then depth, temperature and sound speed are recorded.

Sound velocity and CTD profiling instruments measure pressure to determine depth. Instruments should be configured to subtract the atmospheric pressure at the sea surface so that a pressure near zero decibar is measured at 0m depth. This configuration setting is usually named 'tare' or 'pressure tare'.

Most instruments measure data at a programmed rate. The sampling rate of the instrument in Hertz (Hz) should be indicated in the file header. Sampling at a fixed rate is termed 'continuous' mode, this is usually the default sampling mode. Sampling in continuous mode will generate a large amount of samples at not necessarily increasing depths due to the up/down motion of the vessel or the SVP/CTD probe. For example, 8Hz will give 8 samples every second and an irregular depth sequence.

Modern SVP or CTD instruments have a feature to configure sampling at fixed depth increments; or setting a start/stop depth and selectively recording the data on either the Up Cast or Down Cast. For example, the Valeport SWIFT SVP when set in 'smart mode' and set to record the Down Cast has these settings:

- Trigger Depth – controls the depth to start logging data e.g. 1.0m
- Depth Increment – controls the depth increment to record samples e.g. 0.5m
- Trigger Stop – senses when the instrument has started the Up cast (depth has decreased by a certain amount e.g. 1.0m) and stops recording.

Table 13 gives an example of some of the modes and settings available in the some of the Valeport instruments. The table is not exhaustive.

Table 144 – Modes and settings for Valeport SVP and CTD probes

Instrument	Mode name	Trigger depth	Depth increment	Trigger stop
Valeport SWIFT SVP	Smart mode	Y	Y	Y
Valeport SWIFT SVPplus	Smart mode	Y	Y	Y
Valeport rapid Pro	Rapid mode	Y	N	Y
Valeport MIDAS SVX2 CTD	Profiling mode	N	Y	N

It is strongly recommended, where the above control features are available, to configure SVP or CTD instruments to smart/rapid/profiling modes rather than the default continuous mode, provided this does not degrade the survey system accuracy. Data rendered from these modes is simpler to process compared to the flood/large amount of data from continuous mode which requires extraction of a monotonic depth sequence.

9.4 Expendable Bathy Thermograph (XBT) Probe

The Survey Instruction will detail the need to determine the temperature profile of the water column by XBT throughout the survey area and whilst on passage to the survey area. If specified in the Survey Instruction:

- In depths less than 200m and where significant oceanographic features are found, such as frontal boundaries, ocean currents, tidal streams in excess of 3kts, or in proximity to river or estuarine outflow, an XBT is to be launched 6 hourly, to supplement other sensors used to determine the temperature profile of the water column (i.e. CTD probe).
- In depths deeper than 200m, unless a CTD probe can be lowered to sufficient depth to exceed XBT, an XBT is to be launched every 6 hours.

If specified in the SI a low resolution copy of the XBT profile encoded as a WMO standard BATHY

(JJVV) message be emailed in near real-time to the BoM to aid weather and ocean forecasting. JJVV messages should be emailed to:

TO: cmss@bom.gov.au

CC: metoc.obs@defence.gov.au

Details of how to format the BATHY message email will be provided as GFI. A digital copy of the low resolution JJVV messages generated should be rendered along with the high resolution netCDF or *.edf XBT data files.

9.5 CTD probes

A CTD probe is capable of measuring a vertical profile of salinity, temperature and depth. A CTD probe has a cluster of 3 sensors: conductivity, temperature and pressure. Salinity is computed from the conductivity measurement compensated by temperature and pressure. The pressure measurement is converted to depth.

CTD probes are used in oceanographic surveys where a profile of temperature and salinity is required to study water masses and ocean circulation.

CTD probes may be lowered from a ship by a winch OR mounted on different types of platforms/instruments including:

- ARGO Floats
- AUV
- Ocean Gliders
- Mounted to the ship's hull continuously measuring Sea Surface Temperature (SST) and Sea Surface Salinity
- Another type of CTD is the Moving Vessel Profiler (MVP) which may be raised and lowered continuously while the ship is underway.

On oceanographic surveys CTD may be surrounded by an array of Niskin bottles referred to as a carousel or rosette (Figure 8). The sampling (Niskin) bottles close at predefined depths, triggered either manually or by a computer, and the water samples may subsequently be analysed further for biological and chemical parameters.

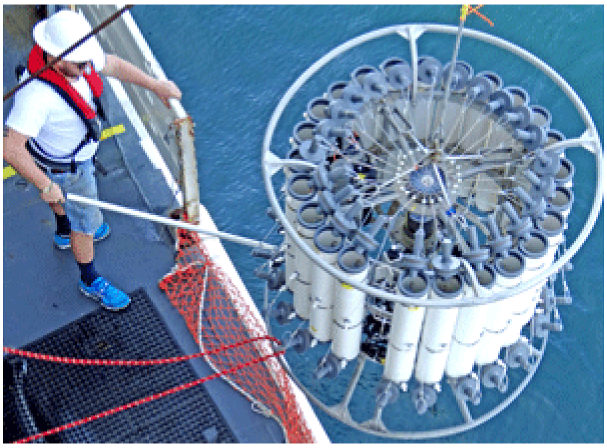


Figure 9 – CTD probe surrounded by a rosette of Niskin water sample bottles

If required by the Survey Instruction, a MVP, CTD, CTD with rosette sampler or Glider may be used to determine salinity. If a CTD with rosette sampler is used, the Contractor may claim Niskin bottles as a reimbursement expense. The required density of samples will be provided in the Survey Instruction.

The CTD sensors must be calibrated prior to the survey and any calibration certificates for the pressure, temperature and conductivity sensors rendered with survey data.

CTD data should be rendered in an ASCII format. The raw/source data should be submitted at full resolution with all sensor recordings (e.g. from MVP200 CTD instrument submit all *.raw and *.m1 profiles). An example of acceptable CTD data is given in MG Branch QMS document SPEC_03_33_BN16464067 'Oceanographic Data Standards for HIPP.'

9.6 Sound Velocity Probes

Please refer also to Section 7.4, specifically the key requirements in Section 7.4.2

Sound velocity probes measure a vertical profile of the speed of sound in-situ. The sound velocity probe will also have a pressure sensor attached to calculate depth and often a temperature sensor (thermistor) giving a temperature profile as well. As mentioned in Section 7.4.1 TOF probes are desirable.

Sound velocity probe data must be rendered in an ASCII format. The raw/source data should be submitted at full resolution with all sensor recordings (e.g. from Valeport Swift SVP submit all *.vp2 files).

An example of acceptable sound velocity probe data is given in MG Branch QMS document SPEC_03_33_BN16464067 'Oceanographic Data Standards for HIPP'.

9.7 Sea Surface Temperature (SST) and Sea Surface Salinity (SSS)

The sea surface temperature over the survey area is to be collected at a density (temporal) to determine the general trend of the survey area. At a minimum, sea surface temperature is to be measured concurrent with 6 hourly weather observations and other at-rest survey operations deemed appropriate by the SIC, such as when Secchi disc observations and seabed samples are undertaken. The ability to collect sea surface temperature at higher temporal resolution via extracting data from a hull mounted CTD or a dedicated infrared sensor is desirable.

SST and SSS data should be rendered in an ASCII format. The raw/source data should be submitted at full resolution with all sensor recordings. All readings must have UTC date-time and position – see Section 9.1 Spatial and Temporal metadata.

9.8 Water Clarity – Secchi Disc and Optical (Turbidity) Measurement

Water clarity and colour observations via Secchi disk or by optical instruments shall be conducted as detailed in the Survey Instruction.

Water clarity may be estimated visually by the Secchi disc or by optical instruments using a light beam measuring backscatter, transmission of the beam or fluorescence of in-water particles hit by the beam. The degree of fluorescence at a particular wavelength (frequency) may be used to infer the mass concentration of chlorophyll (green planktonic matter). Other instruments can measure the intensity of ambient light at different frequencies e.g. the 'Satlantic' irradiance sensor measures down-welling irradiance intensity in uW/cm2 at 4 wavelengths.

The Secchi disc provides a simple integrated measure of visibility through the water column. Optical measurements provide a more detailed vertical profile of visibility (turbidity) and will indicate the presence of more/less turbid layers such as plankton.

Secchi disc observations are to be recorded on Form F_03_32_R31776867. Further guidance is provided in SP_03_32_R31777308 Oceanographic Observations – Manual Logging. Secchi disc observations are best taken at planned location(s)/times in the survey area to indicate the variation over time or tidal cycles etc. rather than random observations.

Optical sensors can sometimes be mounted as an extra sensor on SVP probes. For example the Valeport SWIFTPlus model is equipped with a dual nephelometer and optical backscatter sensor measuring Turbidity in NTU and backscatter (see example of a data file from the Valeport SWIFTPlus in document Oceanographic Data Standards for HIPP, AHO QMS BN16464067 in Annex A)

AUV or ocean gliders may also be equipped with optical sensors. For example, the Slocum G2 model ocean glider may be equipped with a dual beam 'SeaOwl' sensor capable of measuring volumetric backscatter intensity, concentration of chlorophyll and coloured dissolved organic matter (CDOM) and also a Satlantic irradiance sensor.

Calibration certificates for optical instruments should be rendered with the survey data return. Optical sensor data should be rendered in an ASCII format. The raw/source data should be submitted at full resolution with all sensor recordings

9.9 Bioluminescence

Bioluminescence observations shall be conducted at night as detailed in the Survey Instruction. Observations are to be recorded on Form F_03_32_R31776871. Further guidance is provided in SP_03_32_R31777308 Oceanographic Observations – Manual Logging.

The absence of bioluminescence is of equal importance to its presence and if no bioluminescence was observed the words 'Nil Bioluminescence' should be entered in the 'Comments' field of Form F_03_32_R31776871.

9.10 Water Sampling

The requirement to take water samples for analysis in conjunction with the bioluminescence observation will be detailed in the Survey Instruction.

If required, water samples are to be collected in support of the DST Environmental Signatures Program. Up to a maximum of 12 samples should be acquired on the vessel during any one swing. Samples should be collected using DST provided sampling kits and in accordance with the DST 'Plankton Sample Collection Procedures'. Sampling should occur across a spatial and temporal distribution within the survey area when bioluminescence has been observed.

Sampling is to occur no earlier than 2 hours after sunset, and at least 2 hours before sunrise. The sampling procedure is estimated to take 30 minutes. Specialist training for the sampling, recording and retention of sample data will be provided by DST prior to mobilisation.

Retained samples (1L water bottles) are to be kept refrigerated, and small filter paper for some samples will need to be kept frozen (approx. -20°C in a standard domestic freezer). Samples are to be shipped to DST or may be collected from the operational port by DST personnel arrangements are made through the AHO Client Representative.

9.11 Magnetometer Measurements

All charted or newly discovered magnetic anomalies are to be investigated using a magnetometer if required in the Survey Instruction in order to update the magnetic variations displayed on charts. These will be especially valuable in areas where isogonic lines run closely together, and a series of observations through the area will be of even greater value.

At a minimum, if time allows, and in waters in greater than 100m of suitable water depth, observations for magnetic variation are to be obtained using the following procedure:

- The ship should be steamed slowly in a wide octagon centred on the charted anomaly.
- The ship should be steadied on each heading for at least a minute before the observation to allow the sub-permanent magnetism resulting from the last course to disappear.
- The following simultaneous observations are to be logged and compared on each leg:
    - GNSS heading
    - magnetic heading

All records are to be rendered in the designated data pack.

9.12 ARGO Floats

ARGO floats are equipped with CTD sensor and sometimes an oxygen sensor and optical sensors.

Contractors may be required to deploy Argo Floats to support Commonwealth and National Science

(IMOS and CSIRO) collection priorities. Floats, deployment instructions and locations will be provided by the Commonwealth as GFM. The Contractor shall be responsible for the security and safety of all Argo floats until they are deployed as per the Survey Instruction. The requirement to deploy Argo floats will be detailed in the Survey Instruction.

Source/raw data in ASCII format along with the processed and quality controlled netCDF format should be rendered. Metadata in the netCDF format should follow the CF metadata standards and international standards from the global ARGO project.

9.13 Ocean Gliders

All ocean gliders are equipped with CTD sensor, altimeter and sometimes oxygen sensor and optical sensors (such as for turbidity or chlorophyll concentration measurements).

Contractors may be required to provide storage, launch and recovery of Gliders to support Commonwealth and National Science collection priorities. Gliders, deployment and recovery instructions and set up may be provided by the Commonwealth or approved Commonwealth Contractor as GFM. Glider operations can last from days to weeks and may form part of an overall survey plan or bespoke ocean data collection program. The Contractor shall be responsible for the security and safety of all Commonwealth provided Gliders whilst they are in their possession. The requirements to conduct Glider operations will be detailed in the Survey Instruction.

Source/raw data in ASCII format along with the processed and quality controlled netCDF format must be rendered. Metadata in the netCDF format file must follow the CF metadata standards and recognised national standards from the IMOS project. All data types observed by the glider must be rendered.

9.14 AUV

AUVs are often equipped with CTD sensors, altimeters and sometimes oxygen sensors, optical sensors, side scan sonar, ADCP and MBES. All data types observed by the AUV must be rendered.

Contractors may be required to provide storage, launch and recovery of AUV to support Commonwealth and National Science collection priorities. AUV, deployment and recovery instructions and set up may be provided by the Commonwealth or approved Commonwealth Contractor as GFM. Individual AUV operations can last from hours to days and may form part of an overall survey plan or bespoke ocean data collection program in conjunction with Glider operations. The requirements to conduct AUV operations for Commonwealth oceanographic priorities will be detailed in the Survey Instruction. Nothing in this paragraph prevents the Contractor from utilising an AUV to collect bathymetric data. If utilised as a platform for a MBES sensor, all MBES requirements must be met for the survey standard specified in the Survey Instruction.

Source/raw data in ASCII format along with the processed and quality controlled netCDF format must be rendered. Metadata in the netCDF format must follow the CF metadata standards and any other relevant oceanographic community standards.

9.15 Meteorological Observations

9.15.1 Automatic Weather Station (AWS) Data

Source (raw) meteorological data from AWS should be rendered in the Raw Data Pack in the Environmental/L0_Meteorological folder.

The survey may observe meteorological data from an Automatic Weather Station (AWS) either based on land at a fixed station or on a moving survey vessel.

For AWS on land the latitude, longitude and height above mean sea level of the station shall be supplied. For AWS on a moving survey vessel each observation must include latitude, longitude and UTC timestamp.

The height in metres of the AWS data sensors above the ground/land or if on a survey vessel above water level shall also be supplied.

10 PROCESSING BATHYMETRIC DATA

10.1 General Principles

Swath data is to be processed using a software package that uses a statistical method based on the uncertainty of the sounding and how closely it agrees with adjacent soundings (i.e. CUBE) to create a gridded Navigation Surface as the final survey surface. Only soundings that fall within the uncertainty requirements of the survey can contribute to the final gridded surface. Blunders, gross errors and systematic errors should be removed before CUBE processing.

For CUBE processing a TPU must be calculated for every depth and these values must be reflected in the full density data. If the TPU is smaller than the general spread of data on a flat seabed, then it is incorrect and should be adjusted. The magnitude of any tidal uncertainty variation within the survey area should be represented in the TPU values.

Non swath systems (i.e. SBES, satellite derived bathymetry) are to be processed using appropriate software packages. The software, processing methodology and processing quality control procedures are to be documented in the ROS.

10.2 Bathymetric Attributes

Raw data files (Level 0 data) for all sensors are to be recorded and supplied in proprietary sensor specific file formats. Options to record data relative to the ellipsoid and relative to the water line are to be enabled at all times so that the data may be processed relative to the Ellipsoid or LAT at a later date.

The full-density processed bathymetric point data (Level 2 data) should be provided in the relevant software package project structure and format, including the project files (e.g. '*.hips' or '*.project'). Where there is an interim processing package (e.g. QIMERA initial processing and further processing in CARIS) the interim solution should be supplied as Level 1 data. The processing software is to be nominated in the SMP and supplied format agreed to at the project Kick Off meeting. Files are to be full density with rejected soundings flagged but not removed. In addition to the software project file structure, full density processed point data is to be provided by line in a '.GSF' file format, and should match the data the data used to generate the final surfaces.

The final depth information from the survey should be a collection of CUBE statistical surfaces (Level 3 data). These grids must reflect the state of the seafloor at the time of the survey.

Bathymetry from other sources shall be submitted in a format readily understood and compatible with CARIS HIPS. These soundings should be delivered corrected for all offsets, sound velocity etc. and shall at a minimum contain the following attributes:

- Position
- Depth (2DP metres)
- Date and Time
- Tide Applied
- 95% statistical THU

- 95% statistical TVU

10.3 CUBE Specifications

When creating the CUBE surface the following parameters are to be used:

- A fixed capture radius of 0.707 x bin size shall be used. Bin/Grid size (resolution) is provided in Section 7.6

Table 155 – Cube Capture Radius

Bin Resolution	Capture Radius (m) at 2SD
0.5m	0.35
1m	0.71
2m	1.41
4m	2.83
8m	5.66
16m	11.31
32m	22.62
64m	45.25
128m	90.50

- Capture distance must be either not be used or be small enough not to affect the data (≤1%)

10.4 Outliers

When processing, the incorporation of noisy data or outliers into the final gridded solution may result in a surface that is shoaler or deeper than the sea floor. This is to be avoided, as underestimating the depth of water will result in economic loss due to restrictions on the draught of vessels that can operate in the area and overestimating can result in dangers to vessels. Similarly, all 'gross' noise such as noise at the transducer face must be removed (rejected) from the data as retention of this data may result in gross misinterpretation of the data by future users, and will create perception that the data has not been adequately reviewed.

Where the CUBE surface is honouring the seafloor correctly, outliers in relatively close proximity to the seafloor, need not be rejected from the full density (Level 2) data, however gross and systematic errors should be removed. Where outliers cause the CUBE surface to misrepresent the 'true' seafloor the final navigation surfaces will require editing using the methods described in Section 10.5 and 10.6. Full density (Level 2) data should reflect the CUBE surface.

10.5 CUBE Surface Editing

Where the CUBE surface does not represent the "true" seafloor with either the wrong hypothesis selected by the CUBE disambiguation engine or if there is no suitable hypothesis at the required depth then the CUBE surface will require the surveyor to intervene and correct the surface to generate a Navigation Surface using one of the following techniques:

- Reject soundings as necessary and re-CUBE the area to force the CUBE disambiguation to select the most correct hypothesis. The 'user nominate' hypothesis function in CARIS should not be used as any edits made using this method will be lost if the data is re-CUBEd.
- Select a Designated Sounding. See next section for guidance on selecting designated soundings.

10.6 CUBE Designated Soundings

Nautical surveying is focused on determining the depth of charted features to minimise the risk to seafarers. Processing algorithms such as CUBE provide a statistically robust method of modelling this depth. However, there are still cases where this method may fail to portray the least depth over a feature and it is necessary for the Contractor to select a "designated" sounding (also known as "golden" sounding) to override the gridded surface and force the model to recognise an estimated reliable least depth over a feature that is significantly shoaler the gridded surface.

To aid the Contractor in determining when the gridded surface should be overridden the following advice is provided.

All significant and reportable features need to have their depth confirmed against the point data to ensure the gridded solution agrees with the point data and that the least depth is reflected on the surface data. Reportable features are to be designated.

Point data not reflected on the CUBE surface shall be recovered by a designated sounding if the following guidelines are met:

1. All Reportable Features (RF) and controlling depths,
2. Is a Significant Bathymetric Feature (SBF), and
3. The difference between the gridded surface and reliable shoalest sounding is greater than:
    i. One-half of the allowable TVU in waters 0-20 meters
    ii. The allowable TVU in waters 20+ meters

If the dataset contains a large number of designated soundings, the SIC should consider a higher grid resolution for small areas of the survey to increase the grid accuracy and data processing efficiency. If large areas of the survey require higher grid resolutions, the SIC is to liaise with the Authorised Officer for guidance. All surfaces will be assessed against the rendered resolution, thus the density of sounding must be sufficient to meet the resolution requirements (9 soundings per bin) of the rendered grid resolution.

All Reportable Features are to be designated, and provided as a Critical Soundings Layer (or equivalent) with the Level 2 data, and in the 'Seabed Features' feature classes of the HIPP SSDM (as per Section 7.6.5).

10.7 Processing Quality Control

A robust and documented method of quality control is to be adopted and adhered to at all times during data processing. The SIC is responsible for the quality of data rendered with the ROS.

10.8 Reporting of Bathymetric Processing

The following information concerning the processing of bathymetric data is to be rendered with the ROS:

- Detailed description of all CUBE parameters that were used to create the surface
- A section explaining the calculation of the THU/TVU and TPU values for all soundings and CUBE nodes. How these were computed (including breakdown of errors and the vessel model used) and why the SIC thinks these values accurately represent the data.
- Any areas of unusually high uncertainty should be explained.
- Any spatial or temporal variation in THU should be explained including area boundaries and the typical values for the different areas.
- A full description of the method of determining if a least depth is found on a feature, and method of any shoal and wreck investigations undertaken
- List of Reportable Features, Significant Charted Differences, Wrecks and Obstructions are to be provided in the HIPP SSDM.

10.9 Processing and Storage

In accordance with clause 12.10.6 of the COD, all data is to be processed and stored either on the survey vessel during the course of the survey or at the Contractor’s premises in Australia. All data is to be stored by the Contractor until data has been validated by the Commonwealth. Once data is accepted, the Authorised Officer will notify the Contractor that this is the case and that all data is to be destroyed. A signed confirmation of destruction is to be provided to the Authorised Officer by the Contractor within 15 days of notification by the Authorised Officer, by means of a completed Statutory Declaration (Form F_03_33_BN21135221).

An audit of destruction may be conducted at the discretion of the Authorised Officer while the Contractor is engaged in the HIPP and up to 30 days on completion of engagement as a Contractor to the HIPP. Not having an audit conducted does not absolve the Contractor from their responsibility to have complied with this part.

10.10 Verification Failure – Repeating Work

Any survey tasks that fail final verification are to be rectified by the Contractor at the expense of the Contractor. Timings for the delivery of updated data shall be negotiated with the Commonwealth.

11 DELIVERABLES

11.1 Data Delivery

All data must be delivered to the AHO in the file scheme detailed in this SOR and provided as GFI. The AHO has adopted the AusSeabed Data Levels as follows:

- Level 0 – Raw data types for all sensors
- Level 1 – Georeferenced point data prior to any cleaning (this does not need to be preserved or delivered to the AHO unless Section 11.4.3 applies).
- Level 2 – Processed georeferenced point data including processing software project files
- Level 3 – Derived product data such as bathymetric surfaces, backscatter mosaics and SSDM geodatabase. Layout of final surfaces is to be agreed in advance with the Client Rep and surfaces should not in general exceed 15GB. This limit is a guide and may be adjusted in discussion with the CR, in advance of delivery provided the contractor has proven that the proposed surfaces will be manageable in th AHO software systems in use.

All Level 0, 2 and 3 data must be delivered to the AHO using the data schema supplied.

The final delivery of data to the AHO is through the HIPP Support System (HSS) Verification Environment, in Defence's Jetstream AWS. Requests for additional users or further onboarding training for new users are to be received by the AHO no later than 1 month prior to the agreed data delivery date. Delivery method and AWS details will be confirmed at a progress meeting prior to the delivery.

All files submitted to the HSS will be scanned by an antivirus software, any files that fail this scan will be identified to the Contractor who must supply a clean version of the file. No single file should exceed 195 GB, as this is unable to be processed by the AHO's antivirus software. Any file likely to exceed this size limit should be split. No zip files are to be uploaded to the HSS.

The Contractor is to ensure that any software temp folders, transfer folders or trash folders within processed files are wiped prior to delivery.

Where resupply of data is required, all survey reports and final survey data (such as Level 3 gridded products and SSDM file geodatabase) are to be marked with appropriate versioning as follows:

- **rA, rB** - Interim surfaces, geodatabase and reports for approval.
- **r0** – Final surfaces, geodatabase and reports supplied at Milestone 4b.
- **r1, r2** – Revised versions of Final Surfaces, geodatabases and reports supplied during verification post MS4b if required.

Raw (Level 0) and Project (Level 2) data may be overwritten without modifying the filename however, the Contractor is to be provide the CR with details of files modified so that the synchronisation can be confirmed.

11.2 Finalised Surfaces

11.2.1 Final Gridded Survey Data

Upon completion of all editing, the CUBE surface is to be finalised. Care must be taken to ensure that all edits, designated soundings and selected hypothesis are correctly applied.

The standard deviation and the uncertainty of each node must be less than the depth accuracy allowance for the survey order. The only exception will be on steep slopes. The uncertainty value in the finalised surface shall be the greater of either the Uncertainty (TVU) or the Standard Deviation (scaled to 95%).

The finalised surface(s) shall be clearly named (by survey area / sub-area etc.) and referenced in the ROS. Final surfaces are to use the following naming convention:

- SIxxxx_SA_SSS_cXm_DDD_OO_Final_rX where
    1. xxxx = survey number
    2. SA = Sub Area (A1, B3, XL = Cross lines, WA = whole area)
    3. SSS = System (MBE = MBES, ALB = LiDAR, SDB etc)
    4. s = Surface Type (c = CUBE, s = SDTP, b = Backscatter)
    5. Xm = resolution in metres
    6. DDD = Vertical datum (LAT, ELL, MSL)
    7. OO – Survey Order (1a, 1b, H1 – HIPP 1)
    8. Status – Final or Prelim
    9. r = revision
    10. X = revision number.
- For example SI1004_A1_MBE_c1m_LAT_1a_Final_r1

11.2.2 30m Backscatter Surface

A Level 3 (L3) backscatter mosaic generated at 30m bin resolution is required to be rendered with each survey, named as per above using “b” for surface type (backscatter),

e.g. SIXXXX_WA_MBE_Final_b30m_r0

11.3 Custody and Security of Data

The SIC must ensure that there are positive measures in force to ensure the safe custody of all original and processed survey data (including field records), and that there is a place of safety that the data can be taken to should the compartments on board or on-shore processing offices be threatened by fire, flood or other damage.

The Contractor shall have a pro-active cyber security policy to safeguard data from cyber theft or manipulation.

11.4 Interim Deliverables

To support project management and planning, the following interim deliverables are required, via the HIPP Support System (HSS) Operating Environment, in Defence's Jetstream AWS.

11.4.1 Seabed Survey Data Model (SSDM) Extracts

The SSDM is designed as both a project management tool and final deliverable, and should be populated throughout the project as planning is conducted and data acquired. To ensure relevant data is provided in a consistent and readily usable spatial format, extracts of the SSDM are to be provided as detailed below.

- Two weeks prior to Kick-Off Meeting
  - HIPP_SSDMextract_SIXXXX_EPSG9990_YYYMMDD_SMP_rX.gdb, containing the following feature classes:
    - Barometric Sensors
    - Current Meters
    - Tide Gauges
    - Geodetic Control
    - Proposed Survey Run Lines
    - Survey Keysheet (Sub Areas)
    - Tide Model
- Upon provision of the initial Pre-Acquisition Report (PAR) and subsequent update as required
  - HIPP_SSDMextract_SIXXXX_EPSG9990_YYYMMDD_PAR_rX.gdb, containing the following feature classes:
    - Barometric Sensors
    - Current Meters
    - Tide Gauges
    - Survey Keysheet (Sub Areas)
- Upon submission of data in support of Interim Tides Pack Milestone 4a
  - HIPP_SSDMextract_SIXXXX_EPSG9990_YYYMMDD_MS4a_rX.gdb, containing the following feature classes:
    - Barometric Sensors
    - Current Meters
    - GNSS Tide Buoys
    - Tide Gauges
    - Geodetic Control
    - Survey Equipment Limits
    - Survey Keysheet (Sub Areas)
    - Tide Model
- Further extracts may be relevant to support Client Representative enquires or Hydrographic Note submissions, and provided at the Surveyor-in-Charge's discretion by email.

11.4.2 Interim Tides and Geodetics Data Pack

As per Section 5.3.3, An interim Tides and Geodetics Data Pack is to be submitted to the AHO for approval prior to the final data being reduced to datum. This deliverable shall consist of a draft copy of the report at 11.5.5, consisting of a complete copy of all tidal analysis, datum calculations, tide reductions, supporting documents, proposed sounding datum, tide reduction model (CARIS ZDF file or Qimera Tide Strategy) and MS4a SSDM Extract as per Section 11.4.1.

If data has been collected to support the generation of a Survey Hydroid model for a hydroid reduction, this interim deliverable must be supplied prior to final demobilisation. Further requirements for deliverables at MS4a when utilising a hydroid model include:

- A Survey Hydroid model developed from all hydroid data points collected in support of the survey.
- Any relevant QC checks on the interim hydroid data points and model that the contractor is in a position to deliver at that time. At a minimum, these QC checks shall include the comparison between crosslines reduced by traditional means and the interim hydroid. To further support AHO QC, GSFs of the crosslines rendered through each means of reduction are to be supplied with the pack.
- Commentary from the SIC on the declared accuracy of the hydroid data points and the real life accuracies represented in the QC checks supplied.

11.4.3 Interim Surfaces

All interim surfaces are to use the naming convention detailed at Section 11.2.1 (replacing 'Final' with 'Prelim') and versioning as per Section 11.1. It is acknowledged that interim surfaces and images may contain artefacts and further processing is required; however, the intent is to demonstrate data coverage and density.

11.4.3.1 *Rolling Coverage Review*

To expedite demobilisation approvals, once data collection and preliminary cleaning is completed for each survey block, these should be provided to the CR in CSAR or GeoTIFF format at the appropriate final surface resolution for review, Surfaces should include depth, density and preliminary uncertainty (preferably using Standard Deviation). Subsequent revisions may be provided as further cleaning or in-fills are conducted.

11.4.3.2 *Demobilisation (MS3)*

Prior to demobilisation approval, high resolution gridded bathymetry surface(s), or equivalent georeferenced gridded images (GeoTIFF), with supporting uncertainty and density information are to be provided as proof that the survey data collection requirements have been met. If using CARIS HIPS, this should be a SDTP surface (final deliverable remains CUBE). Likewise, interim backscatter images are to be provided to demonstrate coverage achieved.

11.5 Final Data Packs

Data must be provided to the AHO in the following data packs:

- Survey Reports Data Pack
- Raw Data Pack (Level 0 Data)
- Processed Data Pack (Level 2 Data)
- Gridded Data Pack (Level 3 Data)
- Tides and Geodetics Data Pack
- Ancillary Data Pack
- HIPP Contractor Data Pack

These data packs have been refined to optimise data delivery in a cloud environment and facilitate the use of the modified HIPP SSDM FGDB. Further details are provided below and included in an overview at Enclosure 1. A template folder structure will be provided as GFI.

11.5.1 Survey Reports Data Pack

- Pre-Acquisition Report (with any Appendices)
- Hydrographic Notes
- Progress Reports
- Report of Survey (ROS)
- Project Management documentation (including safety documentation, personnel list, copy of final Survey Instruction and Survey Management Plan)
- Quality Assurance documentation
    - Calibration certificates for all hydrographic, meteorological and oceanographic sensors
    - All calibration and validation reports - including MBES patch test, position validation and final integrated verification reports (and LiDAR equivalents), and any other tests not included in the Pre-Acquisition Report
    - Crossline reports
    - THU and TVU analysis
    - Vessel Configuration Report / Vessel Files
        - Proprietary formats, e.g. DB file (Qinsy), HVF (CARIS)
        - Summary reports, e.g. PDF (Qinsy), XML (CARIS), or screenshots
    - Copies of all acquisition and processing logs (in native format e.g. MS Excel)
    - QAX check outputs (QCJSON, screenshots)

11.5.2 Raw Data Pack

- **Level 0 (Raw) Hydrographic Data** (organised by sensor or vessel)
    - L0 Raw MBES data (propriety format) containing full backscatter records
    - L0 Raw LiDAR data (propriety format) including intensity and waveform data
    - L0 Raw Backscatter data *(if collected separately to bathymetric data)*
    - L0 Raw Heave data

- L0 Raw Side Scan Sonar data
- L0 Raw Sub Bottom Profiler data
- L0 Raw Water Column Data
- *Any other raw sensor data not included elsewhere in these data packs*

- **Level 0 (Raw) Environmental Data**, in proprietary sensor format(s)
  - L0 Raw Conductivity Temperature Depth (CTD) Profile data
  - L0 Raw Magnetic Observation data
  - L0 Raw Meteorological data
    - Automatic Weather Station (AWS) data, including details of sensor make/model
  - L0 Raw Sea Surface Temperature data, where collected separately to SVP/CTD casts, including details of sensor make/model
  - L0 Raw Sound Velocity Profile data, and any other associated sensor data
  - L0 XBT profiles
- **Level 0 (Raw) Aerial Imagery**
  - L0 Raw Aerial Imagery, at acquisition resolution

11.5.3 Processed Data Pack

- **Level 1 (Interim Processed) Point/Project Hydrographic Data** (When applicable)
  - L1 full density data where an interim processing package has been used,
    - e.g. data has been partially processed in QPS Qimera, but final processing (data cleaning) has been completed in CARIS HIPS. In this case QPS Qimera projects would be supplied as Level 1 data. If no data cleaning was conducted in HIPS the Qimera project would be Level 2 data.
- **Level 2 (Processed) Point/Project Hydrographic Data**
  - L2 full density processed point sounding data in processing software format, including project files and critical soundings layer (or equivalent)
    - e.g. CARIS HIPS HDCS data and '.hips' files, or QPS Qimera QPD data and '.project' files (or equivalent)
  - L2 full density processed point data exported to GSF format, including backscatter data
  - L2 processed, classified and colourised (RGB) LiDAR point data, including intensity and waveform data in LAS 1.4 format
  - L2 Final Backscatter data project
  - L2 Processed Side Scan Sonar data, including project files
  - L2 Processed Water Column Data, including project files
  - Final Sub Bottom Profiling outputs in SEG-Y format or equivalent (if required)
  - Final tide model/strategy, as used in the processing project
    - i.e. CARIS ZDF and related TID files (or equivalent QPS tide strategy)
    - *all other tidal data is to be included in the Tides and Geodetics Data Pack*
- **Level 2 (Processed) Environmental Data**

  - Final SVP data (combined file), as used by the processing project
  - L2 Processed Magnetic Observation data
  - L2 Processed Meteorological data
    - Digital copies of any BBXX messages generated
- **Level 2 Orthorectified Aerial Images**
  - 5cm resolution orthorectified GeoTIFF images (or resolution as agreed with AHO)
  - Orthorectification DEM

11.5.4 Gridded Data Pack

- **Level 3 (Gridded) Hydrographic Data**
  - L3 Gridded Final Survey Data (FSD) is required in CSAR CUBE format (CSAR format required as this is the format in use by the AHO Charting process):
    - These surfaces are to be finalised with critical/designated soundings (or equivalent) applied.
    - These surfaces are to be at the resolution listed in Table 9 (Section 7.6) or as defined in the SI.
    - The following additional formats are to be generated from the FSD:
      - BAG files, corresponding to each CSAR surface (to enable the exchange of FSD with other government agencies who do not accept CSAR format).
      - 32-bit floating point multi layered GeoTIFF with depth, density and uncertainty layers (to enable QAX QC checking)
      - Qimera Dynamic Surfaces (SD) if processed in Qimera.
  - L3 Mosaics of Backscatter or Reflectivity data, and of Side Scan Sonar data (if used)
    - Side Scan Sonar to be provided as separate mosaic if used
    - Floating point GeoTIFF containing X,Y,I information
    - XYI ASCII file
- Level 3 Aerial Mosaics
  - L3 Aerial Mosaics:
    - Combined 50cm resolution ECW, using 1km tiles (or as agreed with AHO)
    - Index to be included in SSDM ‘Survey_Equipment_Limits’ feature class

11.5.5 Tides and Geodetics Data Pack

11.5.5.1 *Geodetic Data*

- **Geodetics Report:** A comprehensive report to cover the geodetic field work, observations, processing and results achieved. This report should include details on how survey marks were positioned during the course of the survey, include the source (i.e. authority) of all survey marks used, and mention any marks which no longer exist. Provide a diagram depicting the surveys marks in relation to sounding datum. Provide a chartlet of geodetic stations visited or deployed. Supporting geospatial data is to be recorded in the ‘Geodetic_Control’ features class of the HIPP SSDM FGDB.

- L0 Raw GNSS data from ashore geodetic observations, in proprietary sensor format(s) and RINEX 2.11 (or Higher) format.
- L2 Processed GNSS data, RINEX 2.11 (or Higher) format or equivalent
- Final AUSPOS reports for each occupation
- Forms:
  - GNSS Survey Field Sheets for each occupation (Form F_03_32_R31793214) – to be rendered as individual MS Word documents. One GNSS session per form.
  - Survey Mark Station Summary (Form F_03_32_R31793216) – to be rendered as individual MS Word documents.

11.5.5.2 *Tidal Data*

- **Tides Report**: A comprehensive report to cover the tidal field work, observations, processing, tidal reductions, sounding datum calculations and tidal model.
  - Provide a chartlet of all tidal infrastructure (including GNSS buoys, tide staff and current meters) and the final tidal model. Supporting geospatial data is to be recorded in the relevant features classes of the HIPP SSDM FGDB (‘Current_Meters’, ‘GNSS_Tide_Buoys’, ‘Tide_Gauges’ and ‘Tide_Model’).
  - Tabulate results (mean and standard deviation of differences) of comparison between survey instruments and reference instruments (standard port tide gauge and BOM weather station) during mobilisation and demobilisation. Provide time series plots of differences between survey and reference instruments at mobilisation and demobilisation. Use a suitable vertical scale to allow qualitative assessment of differences. Supply an assessment of the suitability of using the various instruments on the survey instruments.
  - Provide time series plots of differences between GNSS tide buoys and bottom mounted tide gauges at all tide gauge locations in the survey area. Apply a suitable vertical scale to allow qualitative assessment of the differences. Tabulate results (mean and standard deviation of differences) of comparison between GNSS tide buoys and BMTG data.
  - Provide linear regression plot of data collected concurrently by the GNSS buoy and BMTG at each tide gauge site.
  - Provide description with details of tidal analysis including
    - (i) software used
    - (ii) Method of inference of constituents
    - (iii) Method of inclusion of Sa and Ssa constituents
    - (iv) Method for dealing with mean sea level anomaly
    - (v) Plots of observations, tide predictions and residuals
    - (vi) Statistics for mean and standard deviation of residuals
    - (vii) Assessment of tidal analysis results.
  - Provide a diagram of Tidal Levels at each tide gauge or tide station.

- Provide evidence of settings used in post-processing software for GNSS Tide Buoy observations, including:
  - antenna model & height
  - base station details, model, height and coordinates
- Describe the method used to smooth and correlate tide buoy data with tide gauge data.
- Describe the application of tidal observations to reduce soundings.
- Reduced levels must be provided (Form F_03_32_BN49671211 Record of Tidal Observations) for each station, and state clearly the value of Sounding Datum established, referred to benchmarks, the ellipsoid and MSL.
- Give an estimate of the uncertainty of the tidal/tidal stream observations with particular reference, but not limited to:
  - (i) The effects of the weather on data quality.
  - (ii) Tide buoy error in measuring sea levels
  - (iii) Tide gauge error in the conversion of pressure to depth
  - (iv) The stability of bottom mounted tide gauges
- Provide a comment on the tide gauge/tide staff comparison and how the final tidal model was applied. Supply an estimate for the error in the datum determination.

- Levelling data/records (Form F_03_32_BN49664941) – to be rendered in MS Excel format
- L0 Raw observed tidal data, in proprietary sensor format(s)
- L2 Processed tidal data (datum offsets applied if used)
- L0 Raw tidal stream (current meter) data, in proprietary sensor format(s)
- L2 Processed tidal stream (current meter) data
- L0 Raw GNSS tide buoy data in proprietary sensor format(s), and RINEX v2.11 or higher
- L2 Processed GNSS tide buoy data, in *.pos or equivalent format
- Results of 25hrs tide staff/tide gauge or 75 hrs GNSS tide buoy/tide gauge comparison
- L0 Raw Barometric data
- Forms:
  - Summary of Checks of Automatic Tide Gauges (Form F_03_32_AA1010884)
  - Summary document detailing tide gauge make, model, serial number, deployment details and location, calibration date and time (Form F_03_32_AA1010884) - to be rendered in MS Excel format
  - Summary documents detailing make, model, serial number, deployment details and location, calibration date and time for current meters and barometers.
  - Scanned copies of all field records
- The final Survey Hydroid model as approved by the AHO.
- All QC checks on the hydroid data points and model. These QC checks shall include the comparison between crosslines reduced by traditional means and the hydroid. To further support AHO QC, GSFs of the crosslines rendered through each means of reduction are to be supplied with the pack.
- Any correspondence regarding tidal datum (*all other correspondence should be in the HIPP*

Contractor Data Pack)

11.5.6 Ancillary Data Pack

- Forms:
  - Bioluminescence observations (Form F_03_32_R31776871)
  - Seabed Samples (Form F_03_32_R31776871)
  - Secchi Disc observations (Form F_03_32_R31776867)
  - Deployment records for deployed sensors not otherwise reported in Tidal Data, e.g. turbidity sensor
  - Scanned copies of all field records
- HIPP SSDM (GIS):
  - HIPP SSDM File Geodatabase (HIPP_SSDM_SI_10xx_EPSG9990.gdb)
  - Layer files for feature datasets within the HIPP SSDM FGDB
  - Project file (e.g. ESRI ArcGIS Map Document '*.mxd' or ArcGIS Pro Project '*.aprx')
    - Should be a single project for the survey, with multiple layers and layer groups as required
- Plot of seabed texture (PDF or GeoPDF)
- Images:
  - Photographic views
  - Seabed sample photos (one per sample, wet on deck) and imagery from drop camera – to be rendered as JPEG files
  - Screenshots of Reportable Features
  - Significant Charted Differences
- Wrecks
  - Standalone package of data for each wreck, including:
    - L2 MBES Data Project including point data of wreck investigation lines;
    - Highest resolution CSAR of wreck (0.25m or better) and surrounding seafloor out to a minimum of 100m, ensuring coverage includes any debris field and scouring;
    - Floating point GeoTIFF of wreck, to same extent and resolution as CSAR; and
    - Screenshots of wrecks surveyed, including overhead view of wreck (to same extent of CSAR/GeoTIFF) and 3D views from the direction of: bow, beam and stern; showing dimensions where possible, with consistent vertical exaggeration and colour map. Screen captures of all angles are not required where the remnants do not support meaningful images. Screenshots should include capture of least depth, and position in decimal degrees.
- Miscellaneous (as required):
  - Coastline delineation data (raw and processed data)
  - Supporting data for positioning of any conspicuous objects
  - Supporting data for positioning or characteristics confirmation of any navigational aid

11.5.7 HIPP Contractor Data Pack

- Copies of any pertinent correspondence with the AHO, not including reports rendered in Survey Reports Data Pack
- Any additional information considered necessary to provide not catered for in above data packs. This should be used sparingly, and the contents thereof referenced in the Report of Survey

11.5.8 NRS Survey Required Data Packs

Where possible Data Packs are to follow the standard HIPP layout and file structure, however only data and folders needed to support the data collected as part of the NRS survey need to be supplied, nil returns are not required.

The following data packs are to be supplied for each NRS site;

- Raw Data Pack (Level 0 Raw Data)
    - L0 raw data for all sensors used to survey NRS
- Processed Data Pack (Level 2 Data)
    - L2 full density processed data in processing data format.
    - L2 Backscatter data project
- Gridded Data Pack (Level 3 FSD Data) – surfaces to be supplied reduced to LAT and GRS80 Ellipsoid
    - L3 FSD
        - CUBE Surface
        - BAG Files
        - GEOTIFF images
- Tides and Geodetic Data Pack
    - Tides and Geodetic data used to conduct NRS Survey, (maybe included in SI data pack if data relates to SI as well)
    - Include Tidal analysis, Tidal reduction, Datum transfer information and GNSS Tide Buoy observations
- Survey Reports Data Pack
    - AHO Survey Summary Form (formerly AH68a) is to be supplied – one per NRS Site
    - The following ROS Annexes (which can be the same for all sites):
        - Annex A – Delivered Documents and Data – as required to support NRS Survey dataset
        - Annex B – Pre-Acquisition Reports – SI PAR or dedicated PAR required to support NRS Survey
        - Annex D – Survey Uncertainty Report – as required to support NRS Survey; and:
            - A definitive statement on density achieved and IHO Order achieved
            - A Crossline Analysis Report
            - Inclusion of QAX Compatible GEOTIFFs and analysis for:

  - Depth
  - Uncertainty
  - Density
- Annex E – Geodetic Data Pack Report – as required to support NRS Survey
- Annex F – Tidal Data Pack Report – as required to support NRS Survey

12 DIGITAL DATA

The Contractor is to ensure that all digital data is easily discoverable within the abovementioned Data Packs. Data is to be rendered in the following formats in the supplied file structure scheme.

12.1 Acoustic Bathymetric Data

12.1.1 Raw Data – Level 0

All raw bathymetric data is to be rendered in its proprietary sensor format. No corrections are to be applied but gross errors are to be removed. Full backscatter data is to be supplied.

12.1.2 Processed Data – Level 1

Only required where interim processed bathymetric data is transferred to another package for final processing. The interim processed bathymetric data is to be rendered in its proprietary format as Level 1 data. This may occur when the workflow contains an interim processing package where the data does not represent fully the data used to generate Level 3 data and products.

12.1.3 Processed Data – Level 2

Level 2 bathymetric data must represent fully processed (cleaned) data used to generate Level 3 data and products.

Full-density processed acoustic bathymetry is to be rendered in processing software format with accompanying project files (e.g. CARIS HIPS/SIPS project or QPS Qimera/FMGT project). In addition, processed point data is to be supplied by line as full density GSF data. These GSF files and projects may be used during verification of the final CSAR surfaces, and hence must represent or be an export of the final processed data used to generate these surfaces.

Bathymetry from other sources shall be submitted in a format readily understood and compatible with CARIS HIPS. These soundings should be delivered corrected for all offsets, sound velocity etc.

The data shall at a minimum contain the following attributes:

- Position (+/-DDD.DDDDDDDD)
- Depth (DDDD.DD)
- Date and Time (DD:MM:YYYY HH:MM:SS)
- Tide Applied
- 95% statistical THU
- 95% statistical TVU

12.1.4 Finalised Gridded Dataset – Level 3

The final depth information from the survey should be a collection of bathymetric grids (usually CUBE surfaces for MBES data). These grids must be at the resolutions described at Table 10 or as specified in the SI, such as to reflect the state of the seafloor at the time of the survey and adequately display seafloor features.

Final Survey Data should be rendered consisting of as few finalised surfaces as practical, but no more than 10GB per surface - i.e. adjacent data acquisition blocks should be combined based on the survey quality achieved and depth bands as per Table 10.

Where multiple grid resolutions are required, each should be rendered as separate surfaces - i.e. multi-resolution grids are not to be used.

The CUBE surface is to contain the following **mandatory** standard layers (attributes):

- **Depth** – the final accepted depth value at each node after competing hypotheses have been disambiguated
- **Uncertainty** – the final uncertainty associated with each nodal depth
- **Hypothesis Count** – the number of hypotheses at each node
- **Hypothesis Strength** - The uncertainty associated with the selection of the correct hypothesis by the disambiguation engine
- **Density** – number of soundings that contribute to that node
- **Node_Std_Dev** - standard deviation of the soundings that contributed to the current grid node at the 95% CI

The CUBE surface may also contain the following additional desirable layers (attributes):

- **Deep** - deepest sounding from the set of soundings that contribute to a node
- **Mean** - sample mean of the set of soundings that contribute to a node
- **Shoal** - shoalest sounding from the set of soundings that contribute to a node
- **Std_Dev** - Standard Deviation of soundings that contributed to the selected hypothesis at the 95% CI

The finalised bathymetric grid is to be provided in both CARIS CSAR and BAG formats. A Metadata form will be provided in the GFI and section nominated for the HIPP Contract to complete must be fully populated.

Additionally, a Density GeoTIFF is to be rendered, as a 32-bit scalar, unsigned integer surface.

12.2 Airborne LiDAR Bathymetry (ALB) Data

12.2.1 Raw Data – Level 0

- Raw LiDAR data files, plus
- Waveform data

12.2.2 Processed Data – Level 1

- Processed Point data in system propriety software

12.2.3 Processed Data – Level 2

- Classified LiDAR point data in LAS 1.4 format
  - Bathymetric LiDAR
  - Topographic LiDAR

12.2.4 Finalised Gridded Dataset – Level 3

- Aerial Images and Reflectivity Tiles and Mosaics – ECW format (resolution 0.5m (water)/0.2m (topo) and 4m (water)/1m (topo) respectively) or as specified in SI.
- Bathymetric surfaces (Datum - sounding datum) – CARIS CSAR format (Shoal Depth True Position (SDTP) surface resolution 3m or as specified in SI)

12.3 Backscatter and Other Feature Detection Data

12.3.1 Raw Data – Level 0

Level 0 backscatter and other feature detection system (e.g. side-scan sonar, synthetic aperture sonar or similar) files are to be delivered in proprietary formats or in XTF format.

To allow post-processing of the backscatter the following raw data is to be rendered:

- Backscatter Intensity
- Source Level
- Pulse Length
- Transmit Beam Patterns
- Receive Beam Patterns
- Receiver Time Varying Gain Functions
- Path Length Attenuation Characteristics, (Spherical spreading and absorption co-efficient)
- Seabed Grazing Angle

12.3.2 Processed Data – Level 2

Level 2 processed backscatter data is to be rendered in GSF format, and is to include all project files.

12.3.3 Final Survey Data – Gridded Datasets – Level 3

Level 3 backscatter mosaics are to be delivered with resolution and extent as per the corresponding bathymetric surface as floating point 32-bit GeoTIFFs with backscatter values.

In addition to a combined mosaic as per backscatter data, data from non-bathymetric feature detection system (e.g. side-scan sonar, synthetic aperture sonar or similar) is also to be rendered as individual run-line mosaics, with resolutions as per Table 9 for the survey order specified.

12.4 Ancillary Geospatial Data – HIPP Seabed Survey Data Model (SSDM)

Digital Seabed Texture Data is to be supplied using the latest modified HIPP Seabed Survey Data Model (SSDM) File Geodatabase (FGDB) schema. This has been based on the IOGP SSDM (v2) and modified/extended as required to meet the data requirements of the HIPP and integration with existing systems at the AHO. A template geodatabase and layer files will be provided in the GFI. Seabed texture symbology is detailed in the IOGP SSDM (v2) documentation and associated ArcGIS style file.

The MG Branch QMS document SPEC_03_33_BN32048462 'HIPP Modified SSDM Data Dictionary' provides guidance on the expected SSDM contents, data formats and symbology codes, and should be referred to when populating and reviewing the SSDM. It also details the changes made from the IOGP SSDM (v2).

The Coordinate Reference System for the HIPP SSDM FGDB is **EPSG:9990 (ITRF2020)**. This is a geographic Coordinate Reference System, and allows for consistency across data deliverables and ease of integration (as per SOR Section 5.2). Projected coordinates are not to be used. Likewise, only a single HIPP SSDM FGDB should be rendered with each survey (i.e. not sub-divided by UTM zones).

Fields not required have been removed from the template HIPP SSDM FGDB, hence all remaining fields are to be populated for each record and no NULL values are expected, with the exception of the 'Remarks' field which is to be populated as required. All metadata (ISO 19115) is to be populated and must include geospatial information.

No modifications are to be made by Contractors to the schema or domains of the HIPP SSDM to ensure this can be integrated into an enterprise dataset.

The HIPP SSDM FGDB contains the following feature datasets and feature classes:

- Charted Features
  - Coastline Anomalies, Conspicuous Objects, Navigational Aids and Photographic Views
  - Marine Aquaculture sites
  - Wrecks and Obstructions
- Deployed Equipment
  - Barometric Sensors
  - Current Meters
  - GNSS Tide Buoys and Tide Gauges
- Environmental Samples
  - Bioluminescence
  - Seabed Samples
  - Sound Velocity (TS Dip) Samples
  - Video Track
  - Water Clarity Observations
  - Water Samples
- Seabed Features (texture layers)
  - Seabed Features – Points (incorporating the former Reportable Features and Significant Charted Differences feature classes)
  - Seabed Features – Lines (Arc)
  - Seabed Features – Polygons
  - Primary Sediment Polygons (Seabed Texture)
- Survey Measurements
  - Geodetic Control
  - Survey Run/Track Lines
  - Survey Equipment Limits
  - Survey Sub Areas / Data Acquisition Blocks (Keysheet)
  - Survey Uncertainty
  - Tide Model

The HIPP SSDM FGDB allows imagery and reports to be linked to the spatial data of relevant feature classes (using the DATA_URL, IMAGE_URL, PHOTO_URL, REPORT_URL or similar fields as appropriate). Hyperlinks are to be compatible with ArcGIS Pro, and should reference files and images in the final file structure. Relative hyperlinks as used by ArcMap are no longer required.

12.5 Sound Velocity Profiles

Raw sound velocity data is to be rendered in proprietary sensor format(s) as per MG Branch QMS document SPEC_03_33_BN16464067 'Oceanographic Data Standards for HIPP'. Processed sound velocity data is also to be rendered, as comma delimited text files (i.e. MS Excel or CSV files), with an accompanying image of the profile linked to the SSDM 'TSdip_Samples' feature class.

Many SVP and CTD profilers do not have an integrated GPS sensor, therefore the latitude and longitude (position) of each profile must be accurately reflected by the geometry of each record in the SSDM 'TSdip Sample' feature class. Subsequent processing at AHO will match and merge the position information with the raw SVP/CTD data file. For a precise and automated match the exact filename with extension (e.g. *.vp2, *.txt) must be included in the SAMPLE_NAME field of the 'TSdip Sample' feature class.

EXpendable BaThythermograph (XBT) should be rendered in ASCII or netCDF format depending on the type of XBT data recorder used.

- The Turo-Devil and Turo Quoll XBT recording system produce high resolution source data in netCDF format, while the Sippican Mk21 XBT recording system produces data in ASCII format (*.edf files) through export from recorded binary files (*.rdf files). The export from .rdf to .edf format with the Sippican mk21 software shall be done on ship prior to data rendering.
- The Turo Devil/Quoll XBT recording system also generates low resolution JJVV messages from the high resolution data. A digital copy of any low resolution JJVV messages should also be supplied.

12.6 Tidal Data

Raw tidal data is to be rendered in proprietary sensor format(s). Processed tidal data is to be rendered as comma delimited text files (i.e. MS Excel or CSV files). Any spreadsheet used to reduce tides to datum should be provided in full to all for full checking of the tidal reductions. This data is to be rendered together with all deployment records, logging parameters and metadata. The minimum metadata to be supplied with each file is as per ICSM Tide Gauge Detail Form.

Data is to be recorded using the following format:

Raw Data: DD/MM/YYYY HH:MM:SS XXX.XXX

Processed Data: Date, Time, Raw Observed Tide (m), Pressure (psi) raw, Pressure (psi) corrected, Corrected Observed Tide (m), Reduced Tide (m)

(DD:MM:YYYY, HH:MM:SS, DDD.DD, PPPP.PP, PPPP.PP,DDD.DD, DDD.DD)

The position of all tide gauges are to be recorded in the 'Tide_Gauges' feature class of the HIPP

SSDM FGDB.

12.7 Tidal Stream (Current Meter) Data

Raw tidal stream data for each instrument or bin is to be rendered in proprietary sensor format(s). Processed tidal stream data is to be rendered as a comma delimited format (i.e. MS Excel or CSV files) with the following attributes:

- Date and time (UTC)
- Latitude and Longitude
- Depth of instrument/ bin (if ADCP)
- Velocity East, Velocity North, Velocity Vertical (where available), Errors for each beam (where available), Magnitude and Direction, Pitch, Roll, Temperature

The following metadata is to be supplied with all tidal stream records:

- File Name
- Position of Instrument
- Start and End Date and Time (UTC) of Deployment
- Equipment Details (Make, Model, Type Serial Number)
- Frequency, Bin Size (if applicable) and Depth of Water at the deployment site
- Height of instrument above the seabed
- Local Variable parameters
    - Magnetic Variation
    - Mean Water Density
    - Barometric Pressure

Specify units for all measurements.

If the ADCP can record tidal heights this is also to be rendered as a separate record (tab in MS Excel spreadsheet, or separate comma delimited file).

The position of all current meters are to be recorded in the 'Current_Meters' feature class of the HIPP SSDM FGDB.

12.8 Digital Photographs

Photographic views must be saved using as high a resolution as possible (≥ 300dpi), preferably in RAW or TIFF format. Images must not to be manipulated in any way. Metadata requirements are detailed at Section 8.8.

Seabed sample photos should be rendered as JPEG files, taken whilst the sample is wet on deck. The best, most representative photo for that sample should be rendered.

Aerial imagery collected during LiDAR surveys is to be rendered in ECW or GeoTIFF format.

12.9 Bioluminescence and Water Clarity (Secchi Disc) Observations

Bioluminescence observations are to be rendered on Form F_03_32_R31776871 and Secchi disc observations on Form F_03_32_R31776867.

12.10 Field Notes and Forms

All field notes and forms are to be scanned (300dpi) and saved as a PDF. All forms are to be signed before scanning. Forms should not be modified from their template, as these are designed to integrate into existing databases and processes. Modifications to the forms should be suggested to the Authorised Officer for consideration and incorporation into future surveys.

12.11 Reports

All reports are to be rendered in PDF format. Supporting spreadsheets should be provided in MS Excel format.

13 REPORTS

13.1 Tasking Statement

Tasking for survey operations will be via a Tasking Statement. It will provide all details required for the Contractor to bid for the survey work and will contain two enclosures:

- Survey Instruction; and,
- Quoting Template.

The Survey Instructions will contain all the survey and technical requirements for the survey. The Quoting Template will be used to provide a response to the Tasking Statement for the survey task.

The successful tenderer shall then be required to fulfil all survey tasks within this Survey Instruction within the agreed time frame.

13.2 Survey Pre-Acquisition Report

A survey Pre-Acquisition Report is to be submitted and endorsed by the Authorised Officer before sounding operations commence. The Contractor accepts all risks if sounding operations are commenced before endorsement of the Pre-Acquisition report by the Commonwealth.

The Pre-Acquisition Report is to contain all calibration and validations results conducted within this phase. The main report document is to be completed as a summary of the below sections, and all supporting documents such as calibration certification, survey check forms, software outputs are to be collated in appropriate appendices folders to accompany the PAR.

The Pre-Acquisition Report is to follow the structure outlined in the following sections. The Title Page layout should be based along on the following example:

Survey Instruction Number/Title of Survey (Project Name)

Contract Number

Surveyed by (Name of Company & Surveyor-in-Charge)

Surveyed for the Australian Hydrographic Office

(Australian Geospatial-Intelligence Organisation)

Inclusive Dates

SURVEY PRE-ACQUISITION REPORT

Version

Date of Report

Introduction. The introduction should include an overview of the procedures conducted for the installation and calibration of equipment that comprise the survey system in use.

- **Background and Outline of Events** – A narrative giving an overview and timeline for the set-to-work of the survey platform(s).

- **Platform(s)** – A description of, and justification for, the survey platforms chosen to undertake the survey.
- **Geodetic Control** – Provide the geodetic parameters for the control survey, station diagrams and descriptions outlining the geodetic control utilised for the survey.

Equipment. Provide a summary of equipment that comprises the survey system as installed on the survey platforms, including all relevant offsets and calibrations.

- Hardware – A summary of the hardware relating to data acquisition including manufacturer, model and serial number is to be tabulated.
- Software – A summary of the acquisition and processing software, including version numbers is to be tabulated.
- Sensor mounting systems – A description of the mounting system utilised for data acquisition is to be provided, e.g. pole mount, gondola, moon pool etc.
- Sensor offsets – The measurement method and results for the dimension control that determine the relationship between the measurement sensors and the platform CRP are to be provided. Sensor offsets may be annexed to the report.
- MRU Heading Checks.

Underway calibrations. The checks and calibrations of platform when underway are to be outlined. These shall include:

- SBES Calibrations (if deployed)
- Draught, Settlement and Squat
- Primary & Secondary positioning comparison
- Static Position Test – Method undertaken and results detailing the statistical reliability of both the horizontal and vertical position of the point used during the test.
- Patch Test – When MBES is used the method undertaken, and results of the patch test for the pitch, roll and heading bias are to be calculated and rendered.
- Reference Surface/Dynamic Bathymetric Repeatability Test – difference statistics between manoeuvring lines and the reference surface are to include; beam number; mean, maximum and minimum differences and standard deviation.
- Feature Detection – The ability of the survey system to meet the feature detection criteria of the specified HIPP order are to be demonstrated.
- SSS – Feature Detection Confidence Check
- Backscatter – confirm acquisition of valid backscatter data and ability to process / review data quality during acquisition.
- Water Column – provide evidence of ability to acquire and process water column data as required in the SI / SOR.
- Level 2 Project data of all Patch Test areas to be provided to CR if on vessel
- GSF Data – provide GSF data, reduced to survey datum, for all underway calibrations.

Land Access. A summary of all communications and permissions with Indigenous authorities and land owners, IAW Section 3.7 of this document.

All calibration and validation reports, digital files and plots which have been used to validate the system at any time of mobilisation are to be provided in the Pre-Acquisition Report (PAR) or supporting appendices. The PAR and supporting appendices are to be updated for any change in the survey set up during the survey period. The PAR and supporting appendices are to be re-submitted during the final delivery as part of the survey reports pack.

Supporting spatial data is to be submitted in the SSDM format as per Section 11.4.1.

13.3 Progress Reports

The progress reporting timeline and level shall be tailored to suit the length and complexity of the survey. This timeline shall be agreed by all parties during the contract negotiation phase. At a minimum, monthly progress reports shall be required.

13.3.1 Daily Reporting

AHO request inclusion in standard company daily progress reporting or online progress monitoring sites. Emails should be cc to hipp.ops@defence.gov.au and the relevant Client Representative's email as advised.

13.3.2 Weekly Reports

A weekly progress report is to be emailed to the AHO (no later than close of business every Tuesday afternoon), informing the status of ongoing fieldwork and the completion of milestones. This report allows the Contractor to highlight issues and discuss any variations and the plan for the next week. In addition, the Contractor is to upload a CSAR, or GeoTIFF with depth, density and uncertainty layers (multilayered or individual layers), file showing the survey coverage achieved to date. A weekly processing report is required during the processing phase.

A mobilisation plan should be provided two weeks prior to mobilisation in company format.

Weekly reporting it to commence with mobilisation.

The weekly report is to be succinct and shall include:

- Brief narrative of the state of the survey including the past week's activities and progress of planned activities
- The plan for the next week
- Issues or points for discussion (e.g. weather, defects)
- Progress towards all key deliverables for the survey
- Project Statistics:
    - One graphic of coverage, with SI pink boundaries and sub blocks shown. Two or more chartlets if the SI area is large enough to require this.
    - Area sounded - Percentage completed (in relation to sub blocks and whole area)
    - Linear Line Miles sounded

  - Time on task in days (including a breakdown of days lost to weather/equipment failure)
  - Milestone list, including original dates, dates achieved or dates expected, and highlighting if Milestones are at risk.
  - Updated personnel list, including past, present and future rotations with actual/planned dates, and including personnel supporting from ashore.
  - Number of Level 1 AHSCP Certified Surveyors on-board during reporting period
  - Number of Level 2 AHSCP Certified Surveyors on-board during reporting period
  - Equipment mobilised / deployed (Including serial numbers and calibration dates), date of deployment, time deployed, expected date of recovery.
  - WHS Statistics / issues
- CSAR surfaces or equivalent georeferenced gridded image at the resolution defined in the SI if data transfer rates allow (or as high a resolution as possible) are to be uploaded to the HSS Operating Environment, in Defence's Jetstream AWS.
- Progress towards achievement of Australian Industry Capability (AIC).

13.3.3 Demobilisation Report

Two weeks prior to the expected completion of data collection the SIC is to forward by email a demobilisation plan including timeline for the supply of coverage surfaces / images, plan for post survey system checks and equipment recovery plan for approval by the Authorising Officer.

On completion of all fieldwork the following information is to be included in a separate Demobilisation Report. This report will be linked to the permission to demobilise and be approved prior to the recovery of any tidal infrastructure.

- Linear Line Miles Sounded – NM
- Area Surveyed – NM^2
- Days on task (mobilisation to de-mobilisation) – Days
- Summary of down time
- Status of all SI requirements
- Results of post survey checks
- Interim Crossline comparison results
- Status of recovered tide gauges and current meters and confirmation that required datasets have been collected
- Interim tide buoy analysis / plots to provide assurance of acceptable quality GNSS data
- Number of Level 1 AHSCP Certified Surveyors utilised, including their phase(s) and role(s)
- Number of Level 2 AHSCP Certified Surveyors utilised, including their phase(s) and role(s)
- Number of sub-contracted hydrographic companies utilised
- A statement from the SIC that all survey key data collection requirements have been met.

Interim gridded high resolution surface(s) showing all surveys areas are complete and containing depth, density and uncertainty information are also to be provided as per Section 11.4.3.

13.4 Report of Survey

The ROS is a comprehensive report that conveys a full summary of the results obtained, the methods employed, the decisions made, difficulties encountered and shortcomings of the survey. The ROS shall contain a positive statement by the Contractor of the completeness of the survey.

The Title of the Report is to be consistent with that of the contract and other rendered data and be based on the following example:

Survey Instruction Number/Title of Survey (Project Name)

Contract Number

Surveyed by (Name of Company & Surveyor-in-Charge)

Surveyed for the Australian Hydrographic Office

(Australian Geospatial-Intelligence Organisation)

Inclusive Dates

REPORT OF SURVEY

Version

Date of Report

The Title section should also include an A4 size chartlet depicting the completed survey area. This chartlet should appear immediately after the Title Page and is to include sufficient topographic and geographic detail to be readily understandable without reference to any other source.

The ROS should be in two or three parts:

- Part 1 (Descriptive)
- Part 2 (Technical Annexes)
- Part 3 (Oceanographic and Science Annexes) *(only necessary if these observations are specified in the Survey Instruction)*

Emphasis within Part 1 should be placed on the analysis of achieved accuracies and whether the specifications called for in the Survey Instruction, this documents and IHO Publication S44 have been met. Part 2 contains the necessary technical information to support opinions expressed in Part 1. Part 3 is a standalone section that should contain enough information for recipient to effectively use the data collected for oceanographic and scientific purposes.

A digital version of the report should be rendered to the AHO.

The ROS is to be based along the following guidelines:

13.4.1 Part 1 – Descriptive

13.4.1.1 *Introduction*

Give start and finish dates. Remark on the scope of the survey, any particular difficulties encountered plus any non-surveying activities which interrupted the progress of the survey.

Give a general statement on the weather, including the seasonal climate and variations experienced. Comments on weather are essential when surveying unstable, critical areas which require optimum hydrodynamic conditions to determine the absolute minimum depth over each feature. Comments are also required on how the weather affected the quality of data - e.g. vessel motion, stability of nav-aid in storms, etc.

Provide a general overview and statement regarding the performance of the platforms deployed and their respective Hydrographic Survey Systems.

Comment on any extraneous activities (e.g. commercial fishing) which affected the conduct of the survey. Mention whether the strength of the tidal stream caused any particular difficulties. Mention any logistic problems.

Give an overall opinion of the completeness of the survey. Identify any areas which require further investigation. Include opinion of thoroughness of survey with regards to coverage, including line spacing as appropriate.

13.4.1.2 *Geodetic Control*

State the horizontal datum, projection, spheroid and grid used.

State how much existing geodetic control was used and briefly describe how any new control was established; give a general statement on the degree of uncertainty achieved.

Include a description of the GNSS observations for geodetic control. The description is to cover parameters, problems, solutions of any observations, either static or kinematic. A full description of geodetic observations is to be included in the Geodetic Data Pack.

13.4.1.3 *Digital Surveying System*

State the acquisition and processing components of the Hydrographic Survey System. Include any desktop or offline systems.

Briefly describe any difficulties experienced and venture an opinion of the effectiveness of the systems used.

13.4.1.4 *Position-Fixing Systems*

Briefly describe the types and operating modes of the systems used.

Give an opinion of the quality and reliability of the equipment.

13.4.1.5 *Bathymetry*

State the type of sensors used and the transmission frequencies, especially where multi-frequency sensors are used. State the results of squat and settlement trials conducted (if applicable) and how corrections for vessel squat were applied.

State the type of motion sensor used and give a brief summary of its performance.

Describe influencing factors that present in the data (e.g. artefacts caused by motion, SV consistency or system faults).

State how the survey was conducted including the sounding line direction, line spacing, height of AUV above seabed, height of UAV/aircraft and average speed of advance as applicable for the platform/sensor used. For shoal investigations, state the density of the soundings and the seabed footprint of the echo sounder beam. Give a general statement of how the bathymetry meets the standards of uncertainty required by the contract and note the uncertainty of soundings achieved. Detail those periods when the uncertainty standard was not achieved and explain why.

For MBES operations state the logged format of the backscatter/water column and provide an overview of any processing that has taken place.

13.4.1.6 *Side Scan Sonar*

State the types of sonar used and the transmission frequencies.

Mention the type and frequency of confidence checks carried out (cross reference to details described in the Quality Assurance Data Pack). Include an opinion of the quality and reliability of the sonar equipment.

State the choice of sonar line direction, line spacing, sonar range, and mean speed of advance.

State the sector sweep adopted for hull-mounted sonars; give an estimate of the effective ranges achieved.

State the allowance made for side-scan sonar layback at the end of lines and whether or not an extra line was run outside the required survey area limits to achieve a full search.

Give an opinion of the thoroughness of the sonar coverage and a definitive statement of the extent and category of side-scan search achieved.

State the logged format of the backscatter and provide an overview of any processing that has taken place.

13.4.1.7 *Seabed Sampling*

Briefly describe the method of sampling used and mention any problems with the equipment or the recovery of seabed samples. State the sampling interval and any particular samples obtained from interesting features. Quote the number of samples retained (if any).

13.4.1.8 *Seabed Topography and Texture*

Give a description, which may include images, of the seabed topography of the surveyed area. Provide a statement in relation to all significant features, their nature and distribution throughout the survey area, including seabed characteristics and sediment types e.g. mud, silt, sand waves, gravel beds, rocky areas etc. State the reason if unable to investigate a shoal as thoroughly as desired and estimate the reliability of the least depth obtained; identify the extra work needed to ascertain the absolute least depth. Comment on the distribution of any sandwave areas. Include the orientation, distance between crests and maximum height trough to crest for each sandwave area. The limit of sandwave areas are to be shown on the Seabed Texture Layer, if rendered, or another accompanying tracing.

Give an opinion of the comparison with previous surveys and any doubts on the detection of all existing (charted) shoal depths, or recommendations for retaining previously surveyed depths. Comment on any movement of sand waves when compared with previous surveys.

13.4.1.9 *Tides and Sounding Datum*

State where each tidal station was sited, how sounding datum was established, and why the sounding datum was chosen. Explain any transfer of datum involved and the use of co-tidal models.

State the types of sea level recording equipment used and the periods of use.

Mention any tide gauge malfunctions and any difficulties in obtaining tide readings, such as impounding or surge.

Quote the standard port used for reference purposes.

Provide an opinion as to the uncertainty of:

- the method used to establish sounding datum; and
- the tidal reductions.

Provide an assessment of the results of the cross-line comparison analysis.

Give a brief outline of the methodology used to reduce depth data to the sounding datum.

13.4.1.10 *Tidal Streams*

State the location, time (UTC) and method where tidal stream observations were carried out.

State what analysis has been carried out. Give an opinion as to the uncertainty of the observations.

13.4.1.11 *Wrecks and Obstructions*

Briefly describe the method of investigating wrecks and obstructions.

Provide a general statement on details obtained from fishermen or others with local knowledge.

13.4.1.12 *Navigational Marks and Reports of Dangers*

State whether or not light sectors or buoys were checked in the survey area or on passage, referring (if necessary) to a more detailed description in Annex J.

Whenever possible, the authority responsible for establishing any new light or buoy should be quoted.

Describe how the position of each buoy was fixed on the flood and ebb and quote the spread of position about the final accepted mean.

Give an opinion on the uncertainty of the observations to determine light sectors and positions of buoys.

13.4.1.13 *Coastline, Topography and Conspicuous Objects*

State whether these features were fixed or checked in the field and, if so, by what method, or whether they were adopted from another source, which is to be specified.

State how heights were determined. Comment on any significant changes such as foreshore erosion or significant soft sediment build-up.

Comment on any new man-made facilities such as marinas or jetties (which are also to be included in amendments to Sailing Directions).

Remark on those objects considered to be conspicuous. Include these in amendments to Sailing Directions and in Annex J.

13.4.1.14 *Views, Publications and Ancillary Observations*

Remark on how views were observed. Remark as to whether charted names have been checked giving details of how this was done. Remark on any new names proposed. Comment should also be made as to whether amendments are required. Detailed information is to be included at Annex J.

Provide a general statement on the reliability of the information published in ALRS. Specific detail is to be included at Annex I.

Briefly outline any ancillary observations that were undertaken. These may include:

- Fresh water springs;
- Overfalls, eddies and tide rips (a marked up chart showing these, together with the validity of any previously reported observations is required);
- Leading lines;
- Measured distances;
- Photography;
- Transparency/water colour;
- Any special scientific observations requested by the contract (e.g. magnetic variation, bottom photography, ocean currents, water sampling); and
- Recommended tracks.

Give an opinion of the usefulness of leading lines, measured distances and recommended tracks and any recommendations for improving their direction and appearance.

13.4.1.15 *Miscellaneous*

Comment on any other facets of the execution and results of the survey which may be of value to AHO or of historic interest when reviewed in future years.

13.4.1.16 *Future Survey Guidance*

Comment on any particulars which may be useful for planning future surveys in the area.

13.4.1.17 *Report Sections and Annexes Rendered*

Provide a table with a 'Yes' or 'No' statement to positively identify which Report of Survey sections, as listed above, have been rendered. This enables a through muster of the report's content on receipt by the AHO.

In addition, a table with a 'Yes' or 'No' to positively identify which Report of Survey Technical Annexes as listed below have been rendered.

13.4.2 Part 2 – Technical Annexes

The list of annexes is given in the following table:

Table 16 – Report of Survey Technical Annexes

Annex	Description
A	Delivered Documents and Data
B	Pre-Acquisition Reports
C	Processing Report
D	Survey Uncertainty Report
E	Geodetic Data Pack Report
F	Tidal Data Pack Report
G	Reportable Features and Significant Charted Differences
H	Seabed Topography
I	Hydrographic Notes and Navigational Warning Signals
J	Views, Conspicuous Objects and Coastline
K	Publications and Ancillary Observations
L	Diary of Survey Activities
M	Personnel
N	Australian Industry Capability (AIC) Plan

13.4.2.1 *Annex A – Delivered Documents, and Data*

This Annex shall provide a list of all documents and data delivered. Individual file listings are not required, however the information provided should be such that the AHO verification staff and data management staff are able to easily and quickly assess the delivery status and efficiently verify the supplied data. The annex should include:

- A list of key documents provided,
- A summary of the final survey data (FSD) as approved by the SIC
- A list of data packs provided, with key components highlighted
- A copy of the file structure used, with a summary of number of file and data size in each pack the overall number of files and data size.
- A list of the data types provided with a brief description

This annex may be supported by an attached document or spreadsheet that provides a more detailed description of data and records provided.

13.4.2.2 *Annex B – Pre-Acquisition Report*

This Annex should contain a copy of the submitted Pre-Acquisition Report(s) as provided and approved at the mobilisation stage.

These reports should be as per Survey Pre-Acquisition Report.

13.4.2.3 *Annex C – Processing Report*

Include a detailed description on how the survey data was managed, including details on how the final project or database was produced. This annex provides concise technical detail in relation to the logging and processing systems employed, the data rendering format, and any other relevant detail.

This should include but not be limited to:

- Online and Offline Software. A description of the software, including main function and versions, used in the logging, processing and presentation of the survey data. Also list any upgrades to software that were made during the survey;
- System Performance. Give a summary on the software performance and a diary of defects; and
- Comments and details regarding the way in which all survey acquisition software was configured which effected the type of raw data recorded e.g. data included in the XTF file type, if data is recorded in geographic or projected format, the way the MRU logging software was configured, the way the SVP or MVP software was configured.
- Details of database / project name(s) (e.g. CARIS project);
- Parameters used in post processing, including
    - Heave compensation
    - Attitude correction
    - Product creation (i.e. bin size, vertical resolution, cube capture distance and cube hypothesis resolution algorithm (if used), CUBE filter settings);
- List of offsets applied in the software from the platforms ‘datum point’ for all sensors including a diagram;

- Details of any special configuration files or scripts that need to be loaded or amended in order of their application; and
- Digital versions of the digital vessel files / job configuration file used during the survey are to be rendered to allow for future checking if required.
- Details of any difficulties encountered in the processing of data and generation of the final reports.

13.4.2.4 *Annex D – Survey Uncertainty Report*

This Annex should provide a comprehensive discussion on the achieved survey uncertainties to support the claimed survey standards. It should include discussion on the following areas.

13.4.2.4.1 Position System Analysis

State the types of position fixing systems and operating modes used for the survey. List all calibration results (C-O). If using DGNSS/RTK/PPK, list the base/reference stations used. State the range and accuracies achieved. Comment on the method used to monitor and overall results of the post-processed 3D positional data.

Provide and comment on any dynamic positional checks that were conducted during the survey.

13.4.2.4.2 Crossline Analysis

Provide and comment on crossline comparison result and analysis including any repeated crossline results.

13.4.2.4.3 Sound Velocity Analysis

State the method of obtaining sound velocity (SV) measurements, if applicable, and provide a comment on the correlation between the SV employed by the sounder/post processed and variation of SV throughout the survey area. When mean sound velocities have been calculated from XBT observations, the consecutive numbers of the XBT observations and the assumed salinity values used must be included.

Provide a chartlet depicting the location of each profile. Supporting geospatial data is to be recorded in the 'TSdip_Sample' features class of the HIPP SSDM FGDB.

13.4.2.4.4 Reference Surface Comparisons

Provide and comment on all reference surface comparisons against National Reference Surface (NRS) or any other reference surface checks.

13.4.2.4.5 Surface Density Analysis

Provide sounding density analysis to support the claimed feature detection achieved in each area.

13.4.2.4.6 CUBE Uncertainly Analysis

Provide the inputs to the CUBE uncertainty calculation and analysis of the resultant TPU layer.

13.4.2.4.7 A-Posteriori Uncertainty Analysis

The survey area is to be divided into a series of closed polygons depicting the spatial variation in uncertainty (both THU and TVU) and provide a typical value for each area taking into account all error sources; these should usually match the final bathymetric surfaces rendered based on S-57 requirements. These are to be recorded in the 'Survey_Uncertainty' feature class of the HIPP SSDM FGDB, which includes the following attributes/fields:

- Corresponding grid cell size of final surface
- THU
    - THU Value (2DP)
    - Survey Order achieved
- TVU
    - TVU Value (2DP)
    - Survey Order achieved
- Coverage achieved
- Overall Survey Order achieved

Provide a table of the resultant TVU / THU values as calculated above.

Provide an A4 chartlet of the survey depicting all survey polygons and a hyperlink to the TVU/THU calculations.

The SIC is to make a definitive statement about the survey uncertainties and survey order achieved.

13.4.2.5 *Annex E - Geodetic Data Pack Report*

This is a copy of the approved Geodetics Report as detailed at 11.3.5 and submitted for Milestone 4a, as approved at payment of MS 4a.

13.4.2.6 *Annex F – Tidal Data Pack Report*

This is a copy of the approved Tidal Report as detailed at Section 11.3.5 and submitted for Milestone 4a, as approved at payment of MS 4a.

13.4.2.7 *Annex G – Significant Bathymetric Features and Wrecks*

Information contained in this Annex should provide a summary of the approach taken to identifying, investigating and ensuring the least depths are obtained on all bathymetric features reported on in the SSDM. The SIC should use the annex to highlight features worth of additional comment within this annex.

Reportable Features and Significant Charted Differences are to be compiled based on extracted spatial data loaded into the 'Seabed_Feature_Pnt' feature class of the HIPP SSDM FGDB with appropriate categorisation and attribution. This feature class replaces the previously separate 'Reportable_Features' and 'Significant_Charted_Differences' feature classes, and the tabular/spreadsheet format of the historical 'Shoal Summary'.

This information is used for decision making during chart compilation and in determining achievement of feature detection requirements, thus requiring the SIC to provide a positive comment on whether least depth over the shoal has been found and any subsequent charting action that should be considered, in particular the removing or relocating of charted features. Words like ‘delete’, ‘relocate’ or ‘insert’ should be utilised to describe actions for charted shoals. It is through this section and associated SSDM feature class that the SIC can make direct charting recommendations to the cartographer who is updating the chart.

Charted features that have been disproved can only be removed from the chart on the recommendation of a CPHS1, submission of a bathymetric surface alone is not enough to remove a charted feature. Features highlighted in the SI should be commented on individually, other isolated features which vary significantly from what is charted should be commented on by the SIC, however in complex areas the SIC may utilise control depths and recommend the survey data replace all charted information.

An image of the shoal showing the soundings that contribute to the least depth from a 3D viewer such as Fledermaus or CARIS is to be provided for each shoal, this image must also capture position and depth information for the designated sounding, see Figure 11.

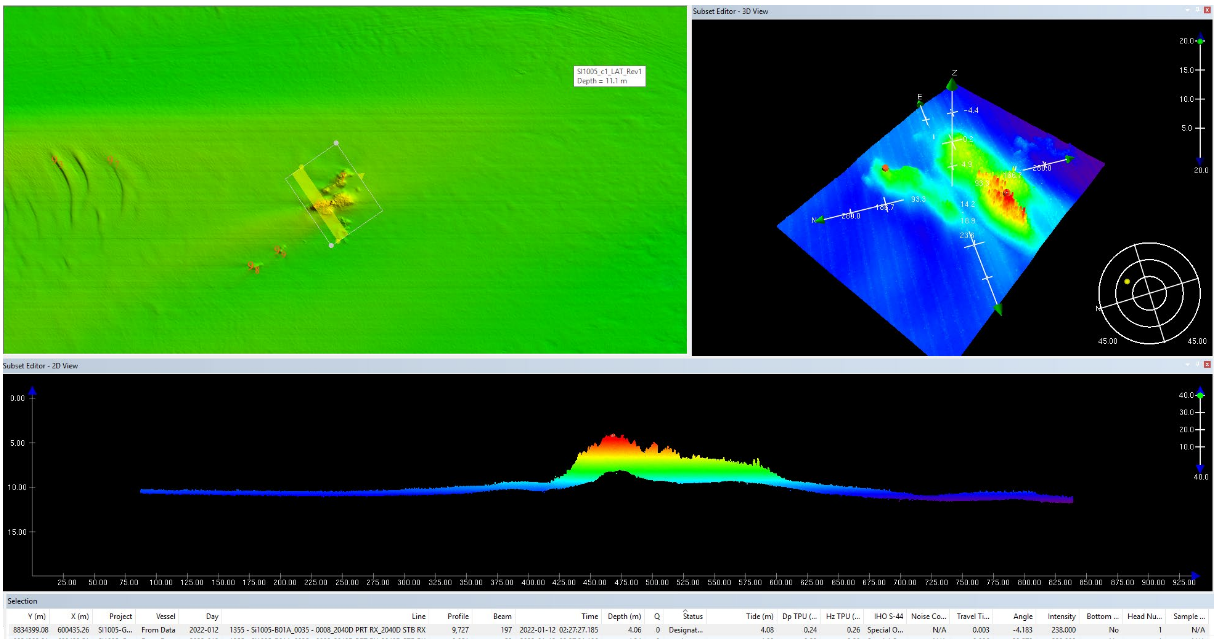


Figure 10 – 3D image of shoal

The ‘Seabed_Feature_Pnt’ (Point) feature class attributes include:

- Designation (RF, SCD, other SBF), RF to take priority in reporting
- Charted Depth
- Surveyed Depth
- Feature Description
- Feature Dimensions
- Examination results and charting (or further survey) recommendations

- Survey method (how the depth / height was determined e.g. MBES, SBES, WCD, low water inspection)
- Water Column Data line reference (shoalest point)
- Hyperlink to screenshot of shoal
- Hyperlink to any Hydrographic Note (if sent)

Further details and specific field information are provided in MG Branch QMS document SPEC_03_33_BN32048462 'HIPP Modified SSDM Data Dictionary.'

Data gathered as part of a low water inspection, coastlining and survey operations are to be compared against the most recent edition of the Electronic Nautical Charts (ENCs) which cover the survey area, provided as GFI. Checks should also be conducted against the deconflicted bathymetric surface, also provided as GFI, to identify any significant discrepancies compared to historical data (noting that the chart may also comprise data derived from manuscript data not necessarily reflected in the deconflicted surface). Where charted features are found to be in error, the SIC is to provide a firm charting recommendation. If the charted difference is linked to a RF discovered during the survey it is to be cross-referenced.

Wrecks and Obstructions. Provide a detailed description of the methods used (e.g. WCD, diving or wire sweeping) to investigate wrecks and obstructions. Comment on any problems encountered with obtaining the least depths. Describe any disproving searches conducted in accordance with Section 7.7 'Disproving Searches'. Provide details of the areas considered for each disproving search. The locations and basic details of any wreck or obstruction are to be included in the 'Wrecks_and_Obstructions' feature class of the HIPP SSDM FGDB, and summarised in this Annex.

An A4 chartlet depicting all Reportable Features is to be rendered with the ROS.

13.4.2.8 *Annex H – Seabed Topography*

Seabed Texture Layer. Provide a chartlet of the seabed texture layer. Provide a statement in relation to all significant features, their nature and distribution throughout the survey area. Comment on any difficulties experienced in interpreting SSS/backscatter mosaics and ground truthing. Comment on the distribution of sand wave areas. Include the movement (from previous surveys), orientation, distance between crest and maximum height from trough to crest for each sand wave area.

The supporting digital data should be contained in relevant feature classes of the HIPP SSDM FGDB ('Sediment_Primary_Ply', 'Seabed_Feature_Pnt', Seabed_Feature_Arc' and 'Seabed_Feature_Ply').

13.4.2.9 *Annex I - Hydrographic Notes and Navigational Warning Signals*

List all reports of dangers and provide a hyperlink to any Hydrographic Note raised.

13.4.2.10 *Annex J – Views, Conspicuous Objects and Coastline*

Provide a table of any conspicuous objects that have not been checked in the field or charted objects that no longer exist.

Provide details on the method and accuracy of all surveyed coastlines.

13.4.2.11 *Annex K – Publications and Ancillary Observations*

Sailing Directions. Render amendments in accordance with Section 8.7 ‘Amendments to Sailing Directions’. Give recommendations for pilotage through the survey area (if appropriate). All charted names should be checked in so far as this is possible. List separately any proposed new names, with full explanation of the reasoning behind the need to name the feature and the selection of the proposed name.

Conspicuous Objects. Identify any new conspicuous objects pertinent to mariners, or any charted conspicuous objects that no longer exist. The locations and basic details of any conspicuous objects not charted or relocated are to be included in the ‘Conspicuous_Objects’ feature class of the HIPP SSDM FGDB, and summarised in this Annex.

Radio Signals Amendments. List amendments for the appropriate ALRS Volume.

Ancillary/Miscellaneous Observations. Provide details in as clear and concise a format as possible (preferably tabular).

Provide a chartlet of all Aids to Navigation, Conspicuous Objects and Ancillary Observations (including delineation of the coastline).

13.4.2.12 *Annex L – Diary of Survey Activities*

List all **significant** events (with dates) which have influenced the conduct of the survey. These may include:

- Establishing control
- Pre-survey checks/calibrations
- Start of fieldwork
- Post-survey activities
- Significant Downtime

13.4.2.13 *Annex M - Personnel*

Provide a list of all key personnel and their role in the survey, with dates of their involvement. This list is to contain a specimen signature and initial for each person for comparison against entries made in processing logs and other documentation. Original file is to be stored in the Survey Reports Data Pack > Project Management folder.

13.4.2.14 *Annex N – Australian Industry Capability (AIC) Plan and/or Australian Industry Activities (AIA) Schedule*

Provide an explanation of the progress made towards, or achievement of, the commitments made in your AIC Plan and/or AIA Schedule during the Term of the Official Order for this Survey. Address each section of the Plan or Schedule where applicable. Where possible provide evidence of achievement.

13.4.3 Part 3 – Oceanographic and Meteorological Annexes

13.4.3.1 *Introduction*

Provide a summary of the data collected including results and issues.

13.4.3.2 *Oceanographic Data*

List all oceanographic data types collected including equipment used, processing software (and versions), parameters and filters used in processing, issues and lessons learnt. Provide a hyperlink to raw and processed data, and a chartlet depicting the variation in the data over the survey area (if applicable). The locations and basic details of oceanographic observations are to be included in the relevant feature classes of the HIPP SSDM FGDB e.g. 'TSdip_sample', 'Water_Clarity_Obs' and 'Water_Sample' and 'Bioluminescence'.

If JJVV messages are emailed to BoM (cmss@bom.gov.au) report a list of observation date-times (UTC) of all JJVV messages sent to BoM.

Provide details on the software and version used to record 6-hourly weather observations.

If BBXX or UUBB messages are emailed to BoM (cmss@bom.gov.au) report a list of observation date-times (UTC) of all BBXX or UUBB messages sent to BoM.

13.5 AHO Survey Summary Form

Certain survey activity, such as passage sounding, NRS Survey and independent feature/shoal/wreck investigations not connected to the main Pink Chart Area, may not warrant comprehensive reporting as per Section 13.4, and if specified in the Survey Instruction abbreviated reporting via the AHO Survey Summary Form (formerly AH68a) is to be used.

The Survey Summary Form is also to be used when establishing a National Reference Surface, as per Section 7.3.

While the Survey Summary form outline the minimum survey metadata to be provided, further detail and supporting information is to be provided to support the survey order and any other claims made. As a minimum, the following Annexes are to be rendered with a Survey Summary Form:

- Annex A – Delivered Documents, and Data (SOR Section 13.4.2.1)
- Annex B – Pre-Acquisition Report (SOR Section 13.4.2.2)
- Annex C – Processing Report (SOR Section 13.4.2.3)
- Annex D – Survey Uncertainty Report (SOR Section 13.4.2.4)
    - Inclusion of:
        - Definitive statement on density achieved and IHO Order achieved
        - Crossline Analysis Report
        - Inclusion of QAX Compatible GEOTIFFs and analysis for:
            - Depth
            - Uncertainty
            - Density

- Annex E – Geodetic Data Pack Report
    - As required to support Survey Task
- Annex F – Tidal Data Pack Report
    - As required to support Survey Task
- Annex I – Hydrographic Notes and Navigational Warning Signals (SOR Section 13.4.2.9I)
    - Inclusive of any submitted Hydro Notes

14 Government Furnished Material (GFM)

The following GFM are to be used during survey operations and/or when indicated in the Survey Instruction.

14.1 Forms and Documents

14.1.1 AHO (MG Branch) Forms

Relevant GFM forms are listed in the following Table:

Table 17 – List of GFM Forms and Documents

Form ID	Form Title
General	
F_05_51_AA217160	Hydrographic Note
F_05_51_AA217163	AHO Survey Summary Form (formerly AH68a)
F_03_33_BN21135221	GFM Destruction Certificate (Statutory Declaration)
Geodesy	
F_03_32_R31793214	Geodetic GPS Survey Field Sheet
F_03_32_R31793216	Survey Mark Station Summary
Tides	
F_03_32_BN49664941	Levelling Observations
F_03_32_AA1010884	ICSM – Tide Gauge Survey Instructions and Forms
F_03_32_AA1010884	Summary of Check of Automatic Tide Gauges
F_03_32_BN52151554	Transfer of Sounding Datum (Semi-Diurnal Tides)
F_03_32_BN49671211	Record of Tidal Observations
F_03_32_R31793216	Survey Mark Station Summary
Oceanography	
F_03_32_R31776871	Bioluminescence Observations (MS Excel form)
F_03_32_R31776867	Secchi Disc Observations (MS Excel form)
F_03_32_R31776865	Seabed Sample Observations (MS Excel form)

14.1.2 AHO (MG Branch) Reference Documents

The following AHO (MG Branch) Quality Management System Documents provide supplementary information to this SOR:

Table 18 – List of relevant MG Branch QMS Documents

Document	Description
General	
SPEC_03_33_BN32048462 'HIPP Modified SSDM Data Dictionary'	Explanation of feature datasets, feature classes and respective fields contained within the HIPP SSDM FGDB, including clarification of required inputs.
Oceanography	
SP_03_32_R31777308 'Oceanographic Observations – Manual Logging'	Instructions to users for recording oceanographic observations in appropriate formats for populating in the SSDM
SPEC_03_33_BN16464067 'Oceanographic Data Standards for HIPP'	Oceanographic Data Standards for HIPP

14.2 Government Furnished Material

14.2.1 Government Furnished Equipment

Government Furnished Equipment (physical GFM) is listed below:

Table 19 – List of GFE

Equipment	Description
Seabed data collection pack (for use when retaining samples for provision to Geoscience Australia)	For equipment list required refer to SP_03_32_R31777308.
Munsell soil colour booklet	Booklet with colour chips to estimate Munsell colour code of seabed samples. Issued to each Panel member once upon joining panel. *Refer to SP_03_32_R31777308.*
Forel-Ule water colour scale	A4 plastic laminated card with Forel-Ule colour scale chips (21). Used to visually estimate seawater colour during Secchi disc observation. *Refer to SP_03_32_R31777308.*
Survey mark plaques	Metal survey mark plaques stamped with unique identifier and permanently fixed into solid base material for geodetic positioning.
Bioluminescence water sampling equipment	Water sample collection and retention bottles (provided as required).

14.2.2 Government Furnished Information

Government Furnished Information (digital GFI) is listed below:

Table 2020 – List of GFI

GFI Data Pack	Containing spatial data and supporting documentation as detailed in SP_03_32_BN13478213 GFI Explanatory Notes and Data Dictionary. This includes: • A geospatial database with layers depicting the survey area, tidal deployment locations and other features described in the SI • An ESRI Map Document and layer file associated with the above. • Copies of the published ENC hydrographic charts (including database of ENC features) • Historical geodetic Station Summaries • Reports on shipwrecks within the survey area • Graphic depicting the survey area (Pink Chart)
Seabed Survey Data Model (SSDM)	HIPP Seabed Survey Data Model (SSDM). Based on the IOGP SSDM (V2). Original documentation can be downloaded from: https://www.iogp.org/geomatics, with HIPP modifications detailed in SPEC_03_33_BN32048462. A template file geodatabase is provided as GFI.
Data Rendering File Structure Template	Zipped folder containing the data pack and top level folder structure to be used for data rendering.

14.3 Software and Other Tools

14.3.1 AusTides

The Contractor is to obtain and maintain a copy of the AusTides software (released annually in October with updates promulgated in the fortnightly Australian Notices to Mariners and published online at http://www.hydro.gov.au/prodserv/publications/ausTides/tides-patches.htm). When required for planning purposes or for the preliminary reduction of soundings, tidal predictions can be exported from AusTides for all primary and published secondary ports. Only tidal predictions that have not been published in AusTides (where relevant) and harmonic constituent data (as required) will be provided as GFI.

14.3.2 Quality Assurance Tool (QAX)

QAX is an open-source project, jointly steered by AusSeabed, the United States of America National Oceanic and Atmospheric Administration's Office of Coast Survey (NOAA OCS), and the University of New Hampshire's Center for Coastal and Ocean Mapping (UNH CCOM). The latest version of QAX is available on the AusSeabed GitHub (https://github.com/ausseabed/qax).

QAX facilitates quality assurance (QA) of multibeam echosounder (MBES) data. It provides an efficient workflow for checking MBES data. The tool standardises QA outputs and assists the technician to perform a robust QA of data.

Three plug-in tools are available through the QAX user interface that facilitate the QA checks:

- MATE – performing checks on raw data, and logs results to a QAJSON file (Optional for HIPP)
- MBESGC – performing grid checks against IHO or HIPP survey orders (Required for HIPP)
- FinderGC – performing grid checks to identify holidays and erroneous data (desirable for HIPP)

QAX must be used for HIPP surveys as the primary qualifier in relation to key data quality factors for MBES bathymetric surfaces. At a minimum each supplied bathymetric surface for Milestone 3 and Milestone 5 must include supply of QAX output, this includes the Surface Report and the associated folder files outputs.

Enclosure 1 to HIPP SOR

Data Delivery Folder Structure (outline)

- SI_10xx
  - Survey_Reports_Data_Pack
    - Hydrographic_Notes
    - Pre-Acquisition_Report
    - Progress_Reports
    - Project_Mgmt
    - Quality_Assurance
      - Acquisition_Logs
      - Calibration_Certificates
      - Calibrations_and_Validations
      - Crossline_Reports
      - Processing_Logs
      - QAX_Checks
      - Surface_QC_Reports
      - THU_TVU_Analysis
      - Vessel_Config_Reports
    - Report_of_Survey
  - Processed_Data_Pack
    - Environmental
      - Final_SVP_Data
      - L2_Magnetic
      - L2_Meterological
    - Hydrographic
      - FMGT
      - HIPS
      - L1_Interim_Processed_Data
      - L2_GSF_Export
      - L2_LAS_Export
      - L2_SBP
      - Qimera
    - Orthorectificed_Aerial_Imagery
      - L2_Aerial_Imagery
      - L2_Video
  - Raw_Data_Pack
    - Environmental
      - L0_CTD
      - L0_Magnetic
      - L0_Meteorological
      - L0_SST
      - L0_SV
        - [Device]
        - XBT
    - Hydrographic
      - L0_[sensor]
      - L0_Backscatter
      - L0_Heave
      - L0_LiDAR
      - L0_MBES
      - L0_SBES
      - L0_SBP
      - L0_SSS
      - L0_WCD
    - Imagery
      - L0_Aerial_Imagery
      - L0_Video
  - Gridded_Data_Pack
    - Aerial
      - L3_Aerial_Mosaics
    - Hydrographic
      - L3_Gridded_Bathy
        - BAG
        - CSAR
        - GEOTIFF
      - L3_Mosaics

- Tides_Geodetics_Data_Pack
  - AUSPOS_Reports
  - Correspondence
  - Forms
  - Geodetic_Report
  - Levelling
  - Processed_Data
    - L2_CM
    - L2_GNSS_Ashore
    - L2_GNSS_Buoy
    - L2_TG
  - Raw_Data
    - L0_BA
    - L0_CM
    - L0_GNSS_Ashore
    - L0_GNSS_Buoy
    - L0_TG
  - Tide_Report

- HIPP_Contractor
  - Additional_Information
  - Correspondence

- Ancillary_Data_Pack
  - HIPP_SSDM
    - r0
      - HIPP_SSDM_SI10XX_EPSG9000_YYYYMMDD_V3.gdb
      - Layer_files
      - Project
  - Images
    - Photographic_Views
    - Reportable_Features
    - Seabed_Photos
    - Significant_Charted_Differences
  - MetOcean_Forms
    - Scanned_Field_Records
  - Miscellaneous
    - Coastline_Delineation
    - Conspicuous_Objects
    - Navigational_Aids
  - Seabed_Texture
  - Wrecks
    - Wreck_Name
      - Floating_Point_GeoTIFF
      - Gridded_Data
      - Miscellaneous
      - Point_Cloud
      - Screenshots