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## ABBREVIATIONS

| Abbreviation | Definition |
|---|---|
| ° | Degrees |
| AHRS | Attitude and Heading Reference System |
| BMS | Business Management System |
| CP | Cathodic Potential |
| DGPS | Differential Global Positioning System |
| DVL | Doppler Velocity Log |
| FLS | Forward Looking Sonar |
| Fwd | Forward |
| GPS | Global Positioning System |
| GMT | Greenwich Mean Time |
| HAUV | Hybrid Autonomous Underwater Vehicle |
| HD | High Definition |
| HIRA | Hazard Identification Risk Assessment |
| HMI | Human Machine Interface |
| HSEQ | Health, Safety, Environment & Quality |
| HVDC | High Voltage Direct Current |
| HWS | High Water Springs |
| Hz | Hertz |
| IHO | International Hydrographic Office |

| Abbreviation | Definition |
|---|---|
| INS | Inertial Navigation System |
| ISO | International Standards Organisation |
| KHz | Kilohertz |
| km | kilometre |
| m | metre |
| LAT | Lowest Astronomical Tide |
| LWS | Low Water Springs |
| MBES | Multi Beam Echo Sounder |
| OGGS | Offshore Gas Gathering System |
| PTW | Permit to Work |
| SPDC | Shell Petroleum Development Company |
| SoW | Scope of Work |
| SSS | Side Scan Sonar |
| STBD | Starboard |
| TBT | Toolbox Talk |
| UKHO | UK Hydrographic Office |
| UHF | Ultra-High Frequency |
| USBL | Ultrashort Baseline |
| UTC | Universal Co-ordinated Time |
| VHF | Very High Frequency |
| LARS | Launch and Recovery System |

## REFERENCE DOCUMENTS

| Ref No. | Document Title | Document Number |
|---|---|---|
| [101] | Management of Change Procedure | HS-PR-009 |
| [102] | Permit to Work System Isolation Requirements | HS-PR-015 |
| [103] | Risk Identification and Management Procedure | HS-PR-003 |
| [104] | Tool Box Talk | HS-FM-001 |
| [105 | HSE Plan | TBC |
| [106] | HAUV3 Mobilisation & Demobilisation Procedure | 23-0022-ENG-PR-001 |
| [107] | HAUV3 Operations Procedure | 23-0022-OPS-PR-001 |
| [108] | HAUV3 Launch and Recovery Procedure | 23-0022-OPS-PR-002 |
| [109] | HAUV3 Emergency Recovery Procedure | 23-0022-OPS-PR-003 |
| [110] | Project Execution Plan | FESL-SPDC-WEP-1909/2201 |

# 1 INTRODUCTION

Modus have been contracted by Fadfae Engineering Services to complete a subsea survey of the 251km 32" offshore gas gathering system (OGGS) pipeline from the RPA platform in EA field to the Bonny Land Fall. In addition to this, Modus will also complete the survey of 54km of EA field infield pipelines, and the 16" Bonga pipeline. The ultimate client for this project is Shell, and the project location will be offshore Nigeria.

The survey operations will be carried out using a Sabretooth HAUV operating in tethered mode. The vehicle will be launched from the vessel using an A-frame launch and recovery system (LARS).

## 1.1 SCOPE OF DOCUMENT

The purpose of this document is to provide a project specific, high-level overview of the organisation, structure, the chain of command and communication to be employed relating to project operations using the HAUV system. This document also outlines operating principles and parameters to be observed and the methodology to be employed in the execution of the survey scope.

Note that as well as adhering to the operating principles described in this document, the HAUV must always be operated in line with manufacturers recommendations.

This document should be read in conjunction with the HAUV Mobilisation/Demobilisation Procedure [106], the HAUV Operations Procedure [107], the HAUV3 Launch & Recovery Procedure [108] and the Project Execution Plan [110], as well as other related task specific and sensor specific documentation.

## 1.2 SCOPE OF WORK

The OGGS pipeline inspection survey will be divided into two main scopes:
**Work Pack 1**:

- The 251km 32" OGGS Pipeline System from RPA platform in EA field to the Bonny landfall, at water depths ranging from 20m (below Mean Sea Level) at the riser platform in EA field and 10m (below mean Sea Level) at the Bonny area respectively.
- 54km EA field infield pipelines within water depths ranging from 15m to 25m below Mean Sea Level.
- 4km along the Bonga Gas export line.

Detailed surveys will also be conducted for the following:

- Side valve protection structures of H-Block and K-Block tie-in at KP 151.060 and KP 219.000.
- Hot-tap tees at KP 163.065 and KP 230.150.
- Concrete blocks used for pipeline stabilization located on top of the 32" OGGS line at KP 253.000.
- 10.75" Texaco pipeline (KP 52.422)
- 12.75" Texaco pipeline (KP 64.479)
- 18" Texaco pipeline (KP 68.141)
- NITEL Cable (KP 92.236)
- 36" Agip pipeline (KP 137.390)
- 12" Agip pipeline (KP 137.569)
- 24" Forcados Yokri Spurline (KP 2.152) across the 18" pipeline SYMP to DP-A pipeline.

**Work Pack 2**:

- Seven (7) free span segments (totalling 115km) along the 32" OGGS pipeline from RPA platform in EA field to the Bonny Landfall, at water depth ranging from 20m and 15m (below Mean Sea Level).

Additionally, a non-contact cathodic protection inspection shall be performed along pipelines. Survey data collection for all pipelines and infrastructure will include:

- Determination of any free span length and height.
- Identification of debris, obstacles, scarring (trawl, anchor), damage, and any active sedimentary and scour processes.
- Assessment of the stability conditions of subsea structures.
- Evaluation of potential dangers of pollution or hazards to shipping or fishing activities

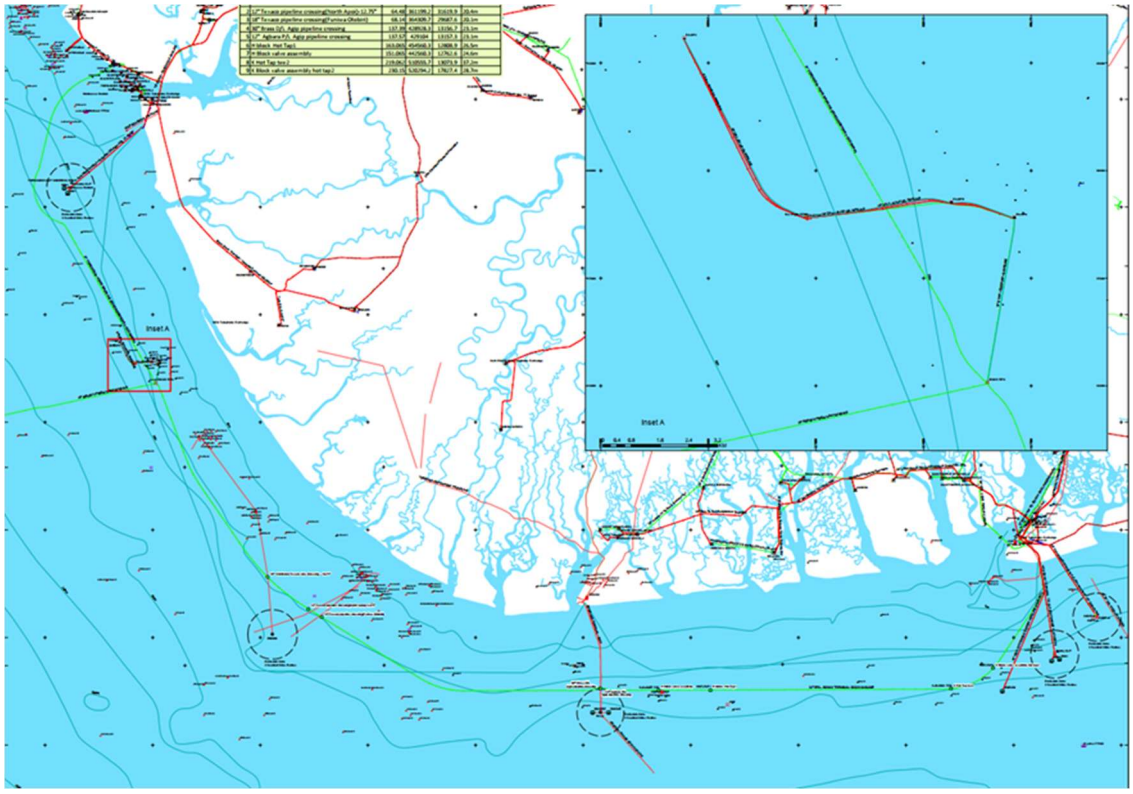

**Figure 1: Full EA Field & OGGS Pipeline Survey Route**

### 1.2.1 MBES SURVEY

Multibeam data is to be acquired along the centre of the pipeline route to provide full seabed coverage with feature resolution to at least meet IHO S44 Special Order Surveys.
The HAUV will have a dual head R2Sonic 2024 MBES installed. The system will be operated at a frequency of nominally 400kHz and triggered at 10Hz. The flying altitude will be circa 2m along the centre line, and the vehicle will fly at a target speed of 2-4km/hr, subject to tidal stream. As the vehicle will be operated in tethered mode, this will allow the operator to monitor and adjust acquisition parameters in real time. Some examples of achievable data densities and resolution based on acquisition parameters across the survey sites are presented in Table 1. The parameters are per line, per head. There will be at least 100% data overlap for the majority of the site, which will be doubled again where swaths from each head overlap, e.g. over the RPL.

| Flying Height (m) | Sector Angle (°) | DH Swath Width (m) | Data Density (hits/0.3m bin) | Along Track Beam Footprint (m) | Across Track Beam Footprint (m) | Overlap between heads (m) |
|---|---|---|---|---|---|---|
| 2 | 110 | 17 | 20 | 0.03 | 0.02 | 3 |
| 4 | 100 | 25 | 12 | 0.07 | 0.04 | 4 |
| 6 | 90 | 28 | 10 | 0.10 | 0.06 | 5 |
| 8 | 80 | 30 | 10 | 0.14 | 0.08 | 5 |
| 10 | 80 | 38 | 7 | 0.17 | 0.09 | 6 |

**Table 1: Indicative MBES Data Density and Coverage Examples**

### 1.2.2 SSS SURVEY

Sidescan data is to be acquired along the wing lines of the pipeline route to provide ensonification of the seabed over the width of the corridor to provide full seabed coverage with feature resolution to at least meet IHO S44 Special Order Surveys.
The narrow survey corridor allows utilisation of the highest frequency 1600KHz VHF band of the Edgetech 2205 to provide the best possible image definition. The 1600kHz band has a maximum operating range of 35m. With a line spacing of 20m we will still be able to achieve full overlap of the centreline from the wing lines at the minimum altitude of 2m, whilst the nadir gap will remain outside the survey corridor when flying at the maximum altitude of 10m.

### 1.2.3 FIGS CP SURVEY

For collection of cathodic protection data, Modus will be using the FiGS CP sensor to conduct the survey. The FiGS CP survey is a specialised technique used to assess the effectiveness and integrity of cathodic protection systems on buried or submerged structures such as pipelines. FiGS stands for Field Gradient Sensor, and it is designed to measure the electric field gradients in the soil or water surrounding a cathodically protected structure. This information helps determine the distribution of the protective coating and identify areas of potential corrosion or inadequate protection.

The electric field gradient measurements are used to create a detailed map of the electric field around the structure. The raw data will be issued to Fadfae and will be analysed by the onboard Fadfae Survey team to identify areas with unusual electric field patterns, which may indicate issues such as coating defects, inadequate protection, or potential corrosion hotspots. With the assistance of the Force Technology onshore analysis team the Fadfae Survey team will generate a comprehensive report detailing the findings of the survey. The report will include maps, graphs and data tables that illustrate the distribution of the CP current and highlight any areas of concern to the end client, Shell.

# 2 HSEQ

## 2.1 HSEQ General

All work described within this document shall be performed in accordance with requirements given in the MODUS Business Management System (BMS) which is accredited in line with ISO:9001, ISO:14001 and OSHAS:45001 Standards.
All relevant documents for the project relating to this subject are referenced in the Reference Documents table and should be read in conjunction with this procedure. Any additional task related safety awareness that needs to be highlighted will be addressed in the body of this document.

## 2.2 Risk Assessments

All offshore operations will be executed in compliance with the Health and Safety Plan, [105], but also in accordance with the Risk Identification & Management Procedure [103].
The Modus specific Risk Assessment shall identify the risks associated with specific elements of Modus operational activities. The Risk Assessment also identifies the controls required, which also consider the different human behaviour traits that are exhibited performing the same task under different conditions. Risk Assessment shall be completed by the Team Leader/Chairman and a minimum of two experienced personnel in the activity to be assessed.

## 2.3 Management of Change

For all Project related unplanned circumstances Management of Change Procedure [101] is the overarching tool but in the event of any unplanned circumstances which affect this procedure, then this procedure can be changed to ensure the safety and efficiency of the operation.

## 2.4 TOOLBOX Talks

Toolbox talks (TBT) [104] are always required at the start of each shift and/or during shift if required. TBT are identified within Procedure Task Plans.
Relevant operating procedures and associated risk assessments must be reviewed during the TBT.

## 2.5 Field Permits

Any field permits required to work on the survey sites will be arranged by Fadfae Engineering Services/SPDC.

# 3 ORGANISATION

The organisational organogram for the project can be seen below:

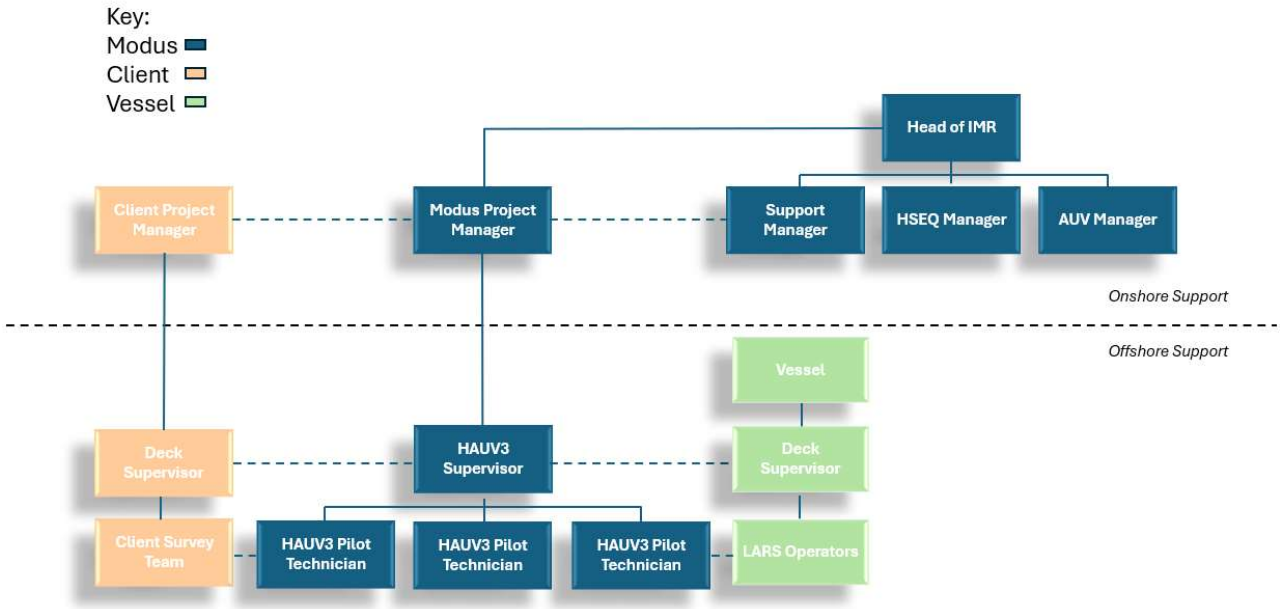


**Figure 2: Project Organogram**

During all operations, the HAUV3 Superintendent will be the primary point of contact and in overall command of the HAUV operations. The HAUV3 Superintendent with the HAUV3 Supervisor shall orchestrate the HAUV Operations and pass on instructions directly to the Pilot/Technicians. During operations, direct communications between the HAUV Supervisor, Client Surveyor and pilot boat skipper shall be maintained.

## 3.1 COMMUNICATION

The primary form of communication between all parties and the HAUV3 crew will be via Clear COMM's / VHF radios, UHF radios may be utilised if required as a secondary or backup means of communication. It is especially important that the emergency channels are agreed, communicated to relevant parties, and tested prior to the commencement of operations.

The vessel will have sufficient Wi-Fi on board to allow external communications back to the onshore support team when required.

In case of an emergency or an urgent requirement, there will be a dedicated onshore Duty Manager who will always be accessible by mobile phone. The Duty Manager role will rotate around the onshore management team on a weekly basis, and the dedicated individual will be clearly communicated to the offshore team

# 4 PROJECT EQUIPMENT

## 4.1 HAUV3 GENERAL SPECIFICATION

The HAUV3 is a hybrid ROV/AUV with deep water capability, long excursion range and 360° manoeuvrability with 6 degrees of freedom. HAUV3 is ideal for autonomous and tethered inspection and maintenance of subsea installations and offshore survey work.

| | |
|---|---|
| **Max Length** | 4.3 m |
| **Max Width** | 1.7 m |
| **Max Height** | 1.4 m |
| **Mass** | 1200 kg excl. payload |
| **Mass (including survey equipment)** | 1580kg |

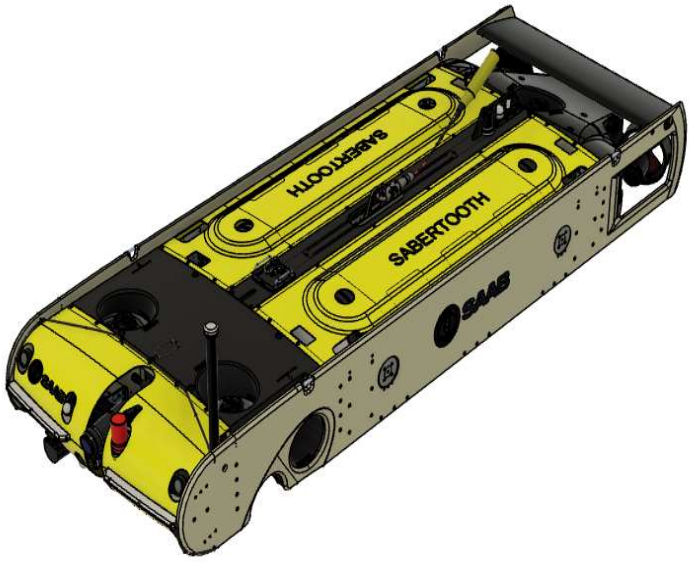


Table 2: MODUS HAUV3

## 4.2 SURVEY EQUIPMENT SPREAD

HAUV3 will be installed with a pre-determined set of standard and project specific survey equipment. All systems will be mobilised and calibrated using industry standard techniques. The calibrations will be performed at the start of project by Fadfae. When operational, online systems will be monitored and logged ensuring data quality by Fadfae.

### 4.2.1 STANDARD HAUV3 EQUIPMENT

The standard, permanently installed, HAUV3 Equipment are as follow:

- **Positioning** – SprintNav 500
- **Surface Comms** – WLAN
- **Wireless Comms** – Novatel OEM 729 GNSS
- **Acoustics Comms –** Sonardyne AvTrak 6 with Sonardyne ROVNAV 6G dunker c/w 100m cable
- **Cameras** – Axis Q1614 IP HD; Bowtech Explorer low light Camera; Fisheye Camera & Rear Camera
- **Flood Lights** – 4x Bowtech
- **OAS** – Imaginex 881L
- **Misc** – Valeport UV-SVP; Valeport MiniIPS, Iridium GPS position Tracker, RJE emergency locator pinger

#### 4.2.2 ADDITIONAL HAUV3 PROJECT SPECIFIC SENSORS

- **MBES** – MBES Dual Head R2Sonic 2024
- **Edgetech 2205 –** SSS & SBP for AUV supplied with topside software
- **Depth Sensor** – Valeport Mini IPS
- **TSS660** – Pipeline Tracker
- **Gemini720s** – Imaging Sonar
- **Applied Acoustics 1329A Micro Beacon –** To be used with Exail GAPs M7 USBL system. Fadfae supplied.

### 4.3 NAVIGATION AND DATA ACQUISITION SOFTWARE

The HAUV has the capability to have EIVA Naviscan installed on its on-board computer, but this will not be used to manage, visualise and provide real-time QC of sonar data acquisition as the Fadfae Survey team are responsible for this.
All navigation systems are interfaced into the vehicle's HMI software from where all vehicle piloting is controlled.
The online components of the system (NaviPac and NaviScan) shall be installed on the Fadfae online survey PCs, interfaced with all topside and HAUV mounted senor data including:

- GNSS data
- HAUV INS data (Sonardyne LNAV)
- Positioning systems including both raw GPS, GPS aided INS positions, USBL and USBL aided INS positions.
- Depth/Pressure sensors
- MBES data
- Sound velocity sensors

The Edgetech 2205 comes with its own acquisition software called Discovery, a copy of this will be supplied during mobilisation. This is used to tune and record the sidescan and sub-bottom data.

### 4.4 LAUNCH AND RECOVERY

The HAUV will be launched and recovered from the vessel using an A-frame LARS and a subsea garage, the garage is to be fitted with 2 off USBL beacons to monitor heading changes.

The launch and recovery of the vehicle is covered in more detail in the HAUV3 Launch & Recovery Procedure [108].

# 5 SUBSEA OPERATIONS

## 5.1 GENERAL SUBSEA OPERATIONS

The HAUV and vessel are to be operated in line with normal manufacturers operating guidelines, within the normal capabilities of the system and at the discretion of the HAUV Supervisor/Vessel Master.

During project preparation, the work scope has been assessed confirming that it can be performed safely and successfully, with specific consideration given to the implications of emergency scenarios.

Weather conditions are a key consideration for all subsea operations and particularly in the case of shallow water operations where the HAUV will be operating near the surface. Not only is weather and sea state a key consideration, as always, from a safety perspective, but it will also have a very significant impact on data quality. If it is deemed by the HAUV3 Superintendent or HAUV3 Supervisor that subsea conditions impede (or are likely to impede) the safe operation of the system or acquisition of satisfactory quality data, the HAUV will not be launched, or survey operations will pause to recover the vehicle.

## 5.2 EMERGENCY AND CONTINGENCY PROCEDURES

Contingency procedures for recovery of HAUV3 are included in the Emergency Recovery Procedure [109]. In the event of an emergency situation with the HAUV, the Vessel Master and the HAUV3 Superintendent shall be informed by the HAUV Supervisor.

No emergency or contingency procedures shall be put into operation until all relevant parties have agreed on the course of action and the necessary risk assessments have been put in place along with any risk mitigation measures required.

# 6 SURVEY CONTROL

## 6.1 OFFSET SIGN CONVENTION

Unless specified otherwise, all offsets given here are as per EIVA axis and sign conventions i.e.:

- The x axis runs laterally from port to starboard
- The y axis runs longitudinally, from stern to bow
- The z axis runs vertically downwards

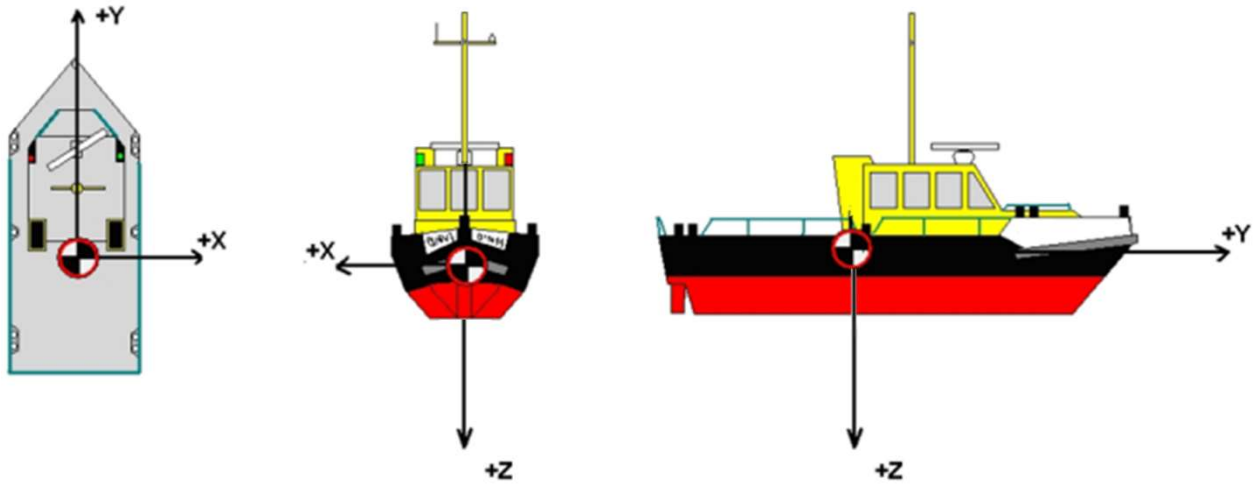


**Figure 3: Axis and Sign Conventions**

## 6.2 ROTATION SIGN CONVENTIONS

EIVA software (and many other systems) uses the following convention. This is the standard convention to be used:

- bow up = + (positive)
- starboard down = + (positive)
- heave up = + (positive)

## 6.3 SURVEY UNITS

The following survey units will be used during the project:

- Linear units will be expressed in metres [m]
- Angular units will be expressed in degrees (°)
- Frequency units are expressed in hertz (Hz)
- Temperature units will be expressed in degrees Celsius (°C)

### 6.4 TIME

The vessel will maintain GMT for operation which will be used for record keeping during the project, including the DPRs.

Internal time tagging and synchronization uses UTC.

## 7 MOBILISATION AND CALIBRATIONS

Project specific sensors will be mobilised on to the vehicle upon its arrival in country, Fadfae are responsible for supplying the dual head R2Sonic, TSS660 and FIGS. Equipment will be mobilised as efficiently as possible, installed as per the Modus/Fadfae standard operating procedures and respective equipment manuals.

A Dimensional control survey will need to be undertaken once all sensors have been fitted to the vehicle, to ensure the accuracy and reliability of all collected data.

The calibration of the dual head MBES system and verification of the TSS660 system will need to be completed offshore, prior to the commencement of the survey scope, at a suitable location.

All mobilisation and calibration activities will be conducted in accordance with Modus & Fadfae standard operating procedures. Only once complete will operations commence. A mobilisation and calibration report will be completed after completion of the offshore calibrations by Fadfae.

# 8 OFFSHORE SURVEY OPERATIONS

## 8.1 ONLINE SURVEY OPERATIONS

The Fadfae survey team shall be responsible for ensuring that the applicable survey procedures are adhered to, covering but not limited to the following tasks:

- Ensuring all pre-survey checklists are fully completed, including confirming reception of all raw data feeds
- Monitoring and QC of all incoming survey data
- Ensuring the correct pipeline parameters are entered into the Teledyne DeepView prior to starting survey
- Ensuring video recording and overlays are correct for the operational task
- The formal recording of all survey operations and events as they occur, through the use of the Survey Logbook.
- Ensuring all pertinent survey data is logged, including HAUV positional and sensor data during survey operations
- Ensuring that project survey requirements are fully understood and communicated to all dependent parties
- Maintaining communication with all departments as to ongoing and upcoming operations

Modus offshore crew are not responsible for the survey operations but must integrate well with the Fadfae survey team to ensure a harmonious effort during offshore operations. Modus will operate the HAUV allowing the collection and interpretation of raw data by the Fadfae survey team. If the Survey Lead deems it necessary to carry out additional passes and collect further data, the Modus team adhere to these requests.

# 9 DATA PROCESSING

Data that is collected during survey operations from the HAUV is classified as raw data.
It is the responsibility of Fadfae's survey team to process the raw data in accordance with their own Data Processing procedures and determine sensor offsets and calibration parameters to be applied to the data during post processing.
Processing steps depend on the project type and the nature of the data, but typically include the following:

- Raw data quality check.
- QC of vessel / vehicle position.
- Smooth vehicle position (if necessary).
- Application of tidal data.
- Clean soundings.
- Digitising the asset location based on exposures and tracking data.
- Final QC of all data including comparisons with previous survey results and comparison with results from other sensors
- Export data to required format for further processing or reporting.

### 9.1.1 RAW QUALITY CHECK

The raw data will be initially checked by the Modus Offshore Crew and the Fadfae Survey Lead at the start of the project during vehicle wet testing and the daily prior starting the days tasks. This will ensure all sensors are behaving as expected, and the data quality is acceptable.
Update rates are extremely important for some systems when carrying out a multibeam survey and will need to be checked by Fadfae to ensure that they are adequate for the scope. If required, the update rates can be adjusted by the Modus Offshore Crew.
Other checks will be more visual (and subjective). For instance, where sensor data are noisy, inconsistent or where the values do not fall within the expected range, the reason for this should be investigated by the Fadfae survey team.
Results that contain anomalous data will be reported to the Fadfae Project Surveyor and Modus HAUV3 Superintendent in order to investigate options to improve the quality of the data.
Any changes to the setup will be recorded to the data processing log and in the handover notes.