# STEMM-CCS Instrumented Seabed Lander
## *Requirements Specification*

## 1. *Introduction*

An instrumented seabed lander is required for gathering various sub-sea environmental data as described in this specification document. The lander will form part of a suite of instrumentation required to support the EU Horizon 2020 project "Strategies for Environmental Monitoring of Marine Carbon Capture and Storage" (STEMM-CCS) that is to be carried out in the North Sea during 2017 to 2019.

Tendered proposals shall contain a **Basic Configuration** model and, if available, an optional upgraded model to the **Extended Configuration** described below.

## 2. *Scope*

The successful tenderer will deliver to NOC Southampton and demonstrate an integrated, fully functioning system in accordance with this specification. This will include:

a. Design and fabrication of the lander platform and its associated deployment and handling fixtures, e.g. lifting eyes, tie-down points, grab bars, and recovery system.
b. Sourcing and delivery of all sensors (except for those sensors provided by NOC in the Extended Configuration – see below).
c. Sourcing and delivery of data-logging systems for all sensors.
d. Sourcing and delivery of remote data transmission systems; satellite telemetry and acoustic modem pair. (Acoustic modem pair required for Extended Configuration only – see below)
e. Sourcing and delivery of electrical power source(s) and power distribution system(s).
f. Assembly of all components and full system integration.
g. Comprehensive testing of fully integrated system.
h. Demonstration of fully integrated system to be witnessed by client (acceptance test). This need not be in a full-depth sub-sea environment but should be in an 'immersed' environment. (NOC may be able to offer access to its immersion test tank for this purpose – this is a freshwater tank, 5 m long x 4 m wide x 4 m deep serviced by a 3.2 tonne overhead gantry crane). The acceptance test should include successful demonstration of acoustic and/or satellite data telemetry as appropriate.
i. Provision of calibration certificates for all sensors as appropriate.
j. Provision of pressure test certificates for all systems as appropriate (e.g. electronic housings, cable harnesses).
k. Provision of mechanical load test certificates for all lifting and securing points as appropriate.
l. Spares kits as appropriate.
m. Training on operation and maintenance of the lander system for NOC personnel (competent oceanographers and marine technicians).

Tenderers are also requested to provide:

n. A delivery plan.
o. A quality management plan.
p. Details of any post-sales support.

The tender will not include:

q. Deployment equipment, e.g. lifting wires, winches, cranes, etc.
r. Provision of satellite, e.g. Iridium, 'airtime'.

## *3. Statement of Requirements*

a. The lander system shall be able to be deployed from and recovered to an oceanographic research ship without the use of a remotely operated vehicle (ROV).
b. Nominal deployment depth will be 120 m.
c. Seabed water temperature is expected to be 7 – 8 °C.
d. Seabed currents are expected to be <0.51 m $s^{-1}$.
e. Seabed sediments at the intended deployment site comprise "clayey silty fine sand" with undrained shear strength of 5 – 25 kPa to a depth of up to 0.5 m. The sediment surface is generally flat and level.
f. The lander system will remain deployed and fully functioning for up to 16 months.
g. In design, consideration should be given to minimising the possibility of unintentional trawling.
h. The system shall operate as a standalone unit with sufficient on-board power and data storage capacity to remain fully functional for at least the minimum deployment period.
i. All gathered data will be stored in non-volatile memory on the lander for retrieval once the lander has been recovered.
j. It will be possible for all sensor clocks to be synchronised.
k. Additionally, key measurement parameters from the stored data (except for hydrophone data in the Basic Configuration) will be remotely telemetered to NOC at least once every 3 months throughout the full deployment duration. This may be achieved with pop-up beacons or similar system. A permanent surface expression (e.g. surface buoy) is not permitted.
l. As a minimum [**Basic Configuration**], the lander system will be equipped with sensors to gather the following parameters to the stated minimum specifications:

**i. Conductivity**

| | |
|---|---|
| Range: | 0 to 7 S/m |
| Accuracy: | ± 0.0003 S/m |
| Stability: | 0.0003 S/m per month |
| Resolution: | 0.00001 S/m |
| Sampling period: | Every 20 minutes |

**ii. Temperature**

Range: -5 to +35 °C
Accuracy: ± 0.002 °C
Stability: 0.0002 °C per month
Resolution: 0.0001 °C
Sampling period: Every 20 minutes

**iii. Depth**

Range: 0 – 200 m
Accuracy: ± 0.1% FS
Stability: 0.05% FS per year
Resolution: 0.002% FS
Sampling period: Every 20 minutes

**iv. Water current**

Type: Upward-looking ADCP
Range: 100 m
Accuracy: ± 1%, ± 0.5 cm/s
Velocity resolution: 0.1 cm/s
Velocity range: ± 10 m/s
Vertical resolution: 2 m
Sampling period: Every 20 minutes
NOTE: The upward-looking ADCP head should be mounted as close to the seabed as reasonably practicable to maximise near-seabed coverage.

**v. Underwater acoustics** (hydrophone)

Frequency range: 500 Hz – 50 kHz
Sensitivity: To be clearly specified in the tender.
Sampling frequency: 250 kHz
NOTE: For this **Basic Configuration**, acoustic data need not be included in telemetry nor acoustic modem transmissions; hydrophone may be self-logging only. The logging should be programmable to be either continuous for short deployments or, for example, 5 minutes every hour for longer deployments.

m. CTD and ADCP data to be sampled synchronously.

n. As an optional upgraded model [**Extended Configuration**], the lander system will be additionally equipped with the following:

**i. Underwater acoustics** (a second hydrophone positioned on the lander frame as far distant as reasonably possible from the first hydrophone specified in the Basic Configuration. **The two hydrophones must sample synchronously.**)
Frequency range: 500 Hz – 50 kHz
Sensitivity: To be clearly specified in the tender.
Sampling frequency: 250 kHz
NOTE: For this **Extended Configuration**, summary acoustic data (daily average spectra or similar) must be included in telemetry and acoustic modem transmissions in addition to being stored on the lander. The logging should be programmable to be either continuous for short deployments or, for example, 5 minutes every hour for longer deployments.

**ii. Additional third party sensor connectivity**
Provision shall be made for integration of the following sensors; these will be free-issued by NOC.

**1. Sea-Bird Scientific Deep SeapHOx**

This instrument comprises a Satlantic Deep SeaFET pH sensor and a Sea-Bird Electronics SBE 37-SMP-ODO MicroCAT CTD+DO sensor. Please refer to the data sheet provided in Appendix A and further documents at http://www.seabird.com/seaphox for full details.
Sampling: 20 measurements per hour
Energy requirement: It is expected that the SeapHOx on-board power will be sufficient for the full 16 month deployment.
Total data generated: 3745 bytes per hour

The following three sensors are NOC-built wet chemical sensors. These sensors do not have any on-board power but are in all other respects able to operate 'stand-alone'; measuring intervals are pre-programmed via the GUI during setup and all data is logged internally. Some data are required to be written to the sensors; please see section below on communication.

**2. NOC pH sensor**

Sampling: 1 measurement per hour
Energy requirement: 1371 J/hr = 4.39 kWh over 16 months
Total data generated: 80 bytes per measurement
Operating voltage: 12 V DC
Start-up inrush current: ~300 mA for 50 ms
Average current (measuring): 130 mA
Peak current: 145 mA
Stand-by current: 500 µA
Mounting orientation: vertical as depicted in Appendix B.
Please see Appendix B for physical dimensions.

### 3. NOC nitrate sensor

Sampling: 1 measurement every 3 hours (NOTE: a more frequent sampling interval may be chosen but the total number of samples per deployment (i.e. 3840 samples) won't be increased. For example, we may choose to sample every hour but only for the first 160 days – or some pro-rata combination thereof)
Energy requirement: 461 J/hr = 1.48 kWh over 16 months
Total data generated: 80 bytes per measurement
Operating voltage: 12 V DC
Start-up inrush current: ~300 mA for 50 ms
Average current (measuring): 200 mA
Peak current: 280 mA
Stand-by current: 500 µA
Mounting orientation: vertical as depicted in Appendix B.
Please see Appendix B for physical dimensions.

### 4. NOC phosphate sensor

Sampling: 1 measurement every 6 hours (NOTE: a more frequent sampling interval may be chosen but the total number of samples per deployment (i.e. 1920 samples) won't be increased. For example, we may choose to sample every hour but only for the first 80 days – or some pro-rata combination thereof)
Energy requirement: 388 J/hr = 1.24 kWh over 16 months
Total data generated: 80 bytes per measurement
Operating voltage: 12 V DC
Start-up inrush current: ~300 mA for 50 ms
Average current (measuring): 200 mA
Peak current: 280 mA
Stand-by current: 500 µA
Mounting orientation: vertical as depicted in Appendix B.
Please see Appendix B for physical dimensions.

## iii. Communication with NOC-built sensors (pH, nitrate and phosphate)

These notes apply equally to all three NOC sensors unless stated otherwise.

All NOC wet chemical sensors, regardless of chemistry, have identical support for RS232 communications; data type is ASCII or binary. The serial connection is made via a 6-way IE55 bulkhead connector (Teledyne IE55-1206-BCR). This same bulkhead connector also provides a connection for 12 V DC power.

The sensors can be configured via the GUI for any common serial port settings, but RS232 with 9600 baud, 8 data bits, 1 stop bit, no parity is the most common arrangement. The RS232 connection uses RX, TX, GND with no hardware handshaking.

Lander RTC time (typically in seconds since the Unix epoch) is to be written to all three sensors at least once during deployment to provide an offset value with local sensor clocks.

Salinity (PSU) and temperature (degrees C) data will need to be written to each sensor following each CTD measurement (every 20 minutes, see 3(l) above). It may be prudent to write further lander RTC times alongside these data.

The sensors will need to be polled by the lander periodically (suggest once per hour) to request new data for central storage and subsequent satellite/modem transmission. The dataset to be acquired from each sensor via the serial port is as follows:

- sensor name and/or serial number
- supply voltage (typically volts)/housing temperature (typically degrees C)
- measurement time (typically in seconds since the Unix epoch)
- measurement value (nitrate and phosphate typically in micromolar, pH typically in millipH)
- measurement quality (typically good or bad)
- measurement salinity (PSU)
- measurement temperature (degrees C)

o. In the **Extended Configuration**, stored data (including hydrophone data) will additionally be remotely interrogated and recovered as and when required via acoustic modem link with a suitably equipped surface vessel. In this configuration, the tendered proposal will therefore include an acoustic modem fitted to the lander and a compatible ship-side modem, e.g. dunker and deck unit.

p. To enable rapid turnaround of lander (in both Basic and Extended Configurations):
   i. Duplicates of battery pack(s) and all sensors (calibrated) are to be provided (except for those sensors free-issued by NOC).
   ii. Mounted battery pack(s) and all sensors to be readily accessible and easily replaced.

## *4. Timetable*

All deliverables to be completed by end June 2017. It is recognised that this is a tight deadline; if you think this is unrealistic, please indicate your best delivery date within Question PROJ6.2.

***Appendix A***

SEA-BIRD SCIENTIFIC

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# Deep SeapHOx™
## Ocean CT(D)-pH-DO Sensor

The Sea-Bird Scientific Deep SeapHOx™ combines the Satlantic Deep SeaFET ™pH sensor with the Sea-Bird Electronics SBE 37-SMP-ODO MicroCAT CTD+DO sensor. The Deep SeaFET adapts the MBARI/SIO/Honeywell Deep-Sea DuraFET technology to measure pH in a deep moored package. The Deep-Sea DuraFET technology was developed by Ken Johnson at MBARI and Todd Martz at SIO. The Deep SeapHOx™ allows for the integrated data collection of pH with the critical oceanographic and biological measurement of temperature, salinity, and oxygen. The integrated package also allows the SeaFET™ to take advantage of the SBE 37's pumped flow path and anti-fouling technology, extending deployment durations in some cases.

## Features

- Moored pH, Conductivity, Temperature, Pressure and Optical Dissolved Oxygen, at user-programmable 5-minute to 24-hour intervals.
- Integral pump.
- RS-232 or USB interface.
- Internal memory and batteries (can be powered externally).*
- Expendable anti-foulant devices, unique flow path, and pumping regimen for biofouling protection.
- SeaFETCom© Windows software package (setup, data upload, and data processing).
- Field-proven MicroCAT family, with more than 10,000 instruments deployed.
- Maximum depth 2000 m.

* The instrument MUST carry internal batteries; external power may extend the deployment duration depending on the sampling regime.

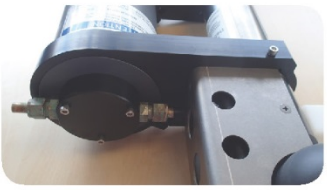
## Components

- pH sensor is an ion selective field effect transistor type adapted for high pressure operation.
- Unique internal-field conductivity cell permits use of expendable anti-foulant devices, for long-term bio-fouling protection.
- Aged and pressure-protected thermistor has a long history of exceptional accuracy and stability.
- Strain-gauge pressure sensor with temperature compensation is available in 6 ranges.
- Oxygen sensor is field-proven, individually calibrated SBE 63 Optical Dissolved Oxygen sensor.
- Pump runs for each sample, providing improved pH, conductivity, and oxygen response, bio-fouling protection, and correlation of CTD and oxygen measurements.

www.seabird.com sales@seabird.com +1 425-643-9866

SBE Sea-Bird Electronics

## Deep SeapHOx™



SeaFET connected to MicroCAT pumped flow path exhaust port

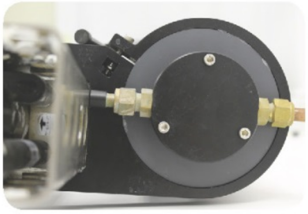
## Options

- RS-232 or USB interface
- Wire mounting clamp and guide or brackets for mounting to a flat surface

## Measurement

| | |
|---|---|
| Conductivity | 0 to 7 S/m (0 to 70 mS/cm) |
| Temperature | -5 to 45 °C |
| Pressure | 0 to 20 / 100 / 350 / 600 / 1000 / 2000 m (meters of deployment depth capability) |
| Dissolved Oxygen | 120% of surface saturation in all natural waters (fresh and salt) |
| pH | 6.5 - 9.0 pH |

## Initial Accuracy



| | |
|---|---|
| Conductivity | ± 0.0003 S/m (0.003 mS/cm) |
| Temperature | ± 0.002 °C (-5 to to 35 °C); ± 0.01 °C (35 °C to 45 °C) |
| Pressure | ± 0.1% of full scale range |
| Dissolved Oxygen | larger of ± 3 µmol/kg (0.07 ml/L, 0.1 mg/L) or ± 2% |
| pH | 0.02 pH |

## Typical Stability

| | |
|---|---|
| Conductivity | 0.0003 S/m (0.003 mS/cm) per month |
| Temperature | 0.0002 °C per month |
| Pressure | 0.05% of full scale range per year |
| Dissolved Oxygen | sample-based drift < 1 µmol/kg/100,000 samples (20 °C) |
| pH | 0.003 pH/month |

## Resolution

| | |
|---|---|
| Conductivity | 0.00001 S/m (0.0001 mS/cm) |
| Temperature | 0.0001 °C |
| Pressure | 0.002% of full scale range |
| Dissolved Oxygen | 0.2 µmol/kg |
| pH | 0.004 pH |

| | |
|---|---|
| Memory Capacity | 4 GB |
| System Depth Rating | 2000 m |
| System Dimensions | 55.88 cm x 28.25 cm x 12.90 cm (Height does not include 3.56 cm end cap)<br>22" x 11.12" x 5.08" (Height does not include 1.4" end cap) |



SEA·BIRD SCIENTIFIC

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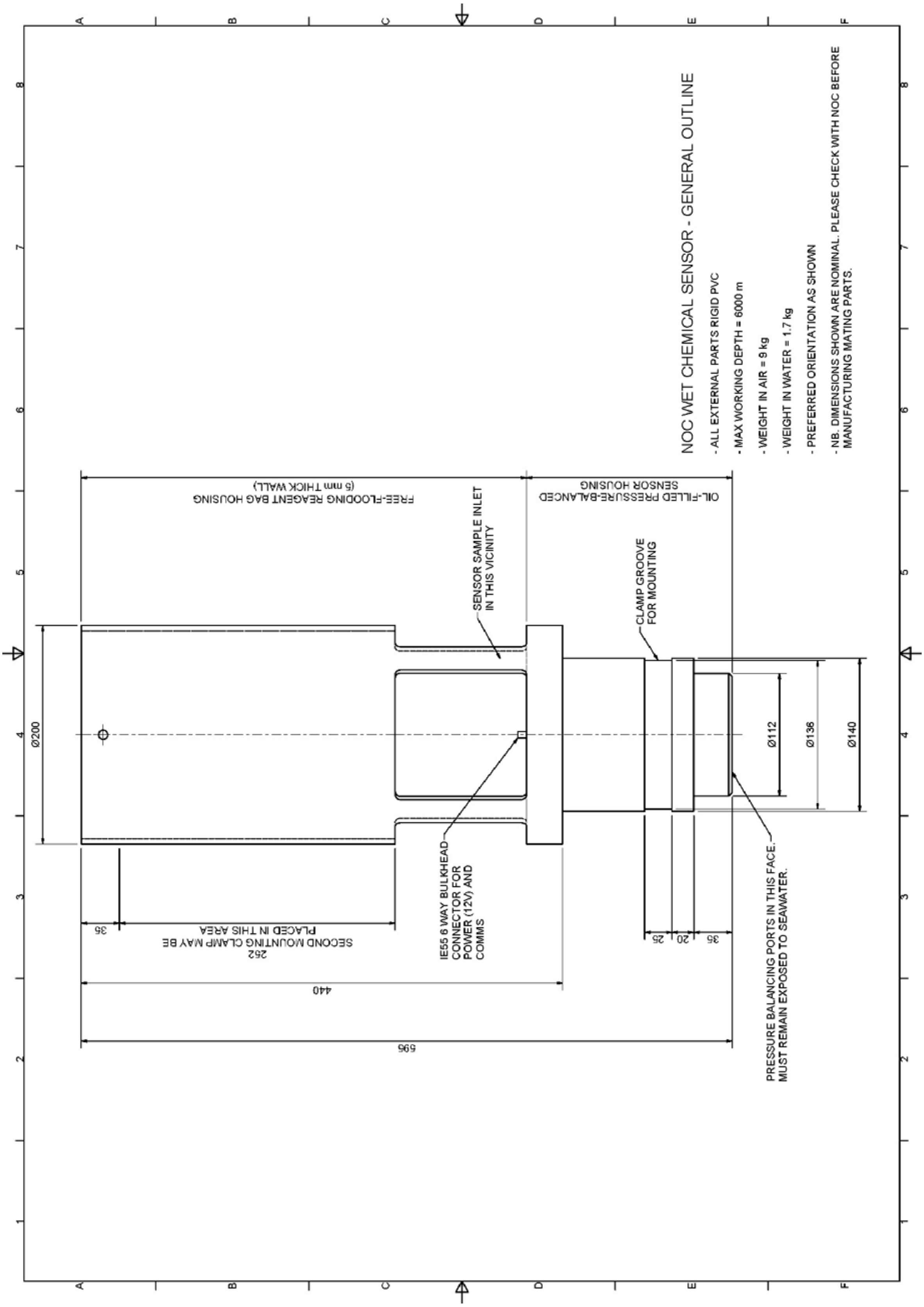
*Appendix B*



NOC WET CHEMICAL SENSOR - GENERAL OUTLINE
- ALL EXTERNAL PARTS RIGID PVC
- MAX WORKING DEPTH = 6000 m
- WEIGHT IN AIR = 9 kg
- WEIGHT IN WATER = 1.7 kg
- PREFERRED ORIENTATION AS SHOWN
- NB. DIMENSIONS SHOWN ARE NOMINAL. PLEASE CHECK WITH NOC BEFORE MANUFACTURING MATING PARTS.
FREE-FLOODING REAGENT BAG HOUSING (6 mm THICK WALL)
OIL-FILLED PRESSURE-BALANCED SENSOR HOUSING
SENSOR SAMPLE INLET IN THIS VICINITY
CLAMP GROOVE FOR MOUNTING
IE55 6 WAY BULKHEAD CONNECTOR FOR POWER (12V) AND COMMS
PRESSURE BALANCING PORTS IN THIS FACE. MUST REMAIN EXPOSED TO SEAWATER.
252
SECOND MOUNTING CLAMP MAY BE PLACED IN THIS AREA
35
440
596
25
20
35
Ø200
Ø112
Ø136
Ø140