SPECIFICATIONS AND GUIDELINES FOR THE OPERATION OF EGOS MOORED BUOYS

Revision 1.2

Issued by the European Group on Ocean Stations

Introduction

This document provides basic guidance for the design and operation of moored buoys maintained within the EGOS programme

The document is divided into two sections; Section A contains the minimum specifications recommended for all moored weather buoys within EGOS and Section B details the specifications currently in use for EGOS moored buoys

Data from the network of moored buoys falling within the EGOS programme should meet the requirements of the World Meteorological Organisation (WMO). In particular meteorological and oceanographic measurements derived from EGOS moored buoys should comply with the specifications given in WMO Publication No 8 – '*Guide to Meteorological Instruments and Methods of Observation*'. As far as possible the observed data should represent the environment undisturbed by the presence of the buoy. Such data are necessary for weather forecasting, numerical modelling and climatological purposes.

SECTION A

Minimum Specifications

1. Data Requirements

Data derived from EGOS moored buoys shall include as many as possible of the following parameters:

- Wind Speed
- Wind Gust
- Wind Direction
- Air Pressure
- Air Temperature
- Sea Surface Temperature
- Humidity
- Significant Wave Height
- Wave Period

2. Data Accuracy, Resolution and Range

The accuracy, range and resolution of data measurements should comply with the following minimum specifications;

Variable	Requirements		
	Range	**Resolution**	**Mean Error**
Wind Speed (including gust)	0-150kn	1kn	±2kn < 40kn ±5% > 40 kn
Wind Direction	0-360^0	1^0	±10^0
Air Pressure	900-1050hPa	0.2hPa	±0.5hPa
Air Temperature	-20^0 to +40^{0}C	0.1^{0}C	±0.2^{0}C
Sea Surface Temperature	-5^0 to +25^{0}C	0.1^{0}C	±0.2^{0}C
Relative Humidity	38-100%	1%	±5% < 85% ±3% > 85%
Dew-Point	-20^0 to +40^{0}C	0.1^{0}C	±0.4^{0}C
Wave Height	±10m rel MSL	0.1m	±10% (or ±20cm if greater)
Wave Period	0-20 sec	0.1 sec	±5% (or ±0.5 sec if greater)

Note....The mean errors stated in the table refer to the mean errors of the measuring system (sensors, interface and data processor). Errors due to an exposure unrepresentative of the undisturbed atmosphere are excluded

3. Data Transmission

Data must be transmitted onto the GTS within a short time of the observation

If using satellite for data transmission the transmitter must have the appropriate certification required by the satellite authority

The location of the buoy must be transmitted either within the body of the data stream or by another method

4. Battery Safety

When considering the safety of battery compartments the buoy manufacturers and operators are advised to take account of the design recommendations of the Data Buoy Co-operation Panel which is available at http://www.dbcp.noaa.gov/dbcp/safety.html

5. Buoy Markings

The yellow buoyancy section of the hull should be marked with two sets of black 0.3m high lettering. This buoy identification marking should be positioned on a vertical face clear of the water line, each set to be diametrically opposite the other. In accordance with the Technical Annexes to the Convention on the legal status of ODAS (Ocean Data Acquisition Systems) each buoy shall be assigned a unique identification number prefixed by the letters 'ODAS' and suffixed by letters indicating in abbreviated the national State (taken from the Table of Allocation of International Call Sign Series of the Radio Regulations promulgated by the International Telecommunication Union). e.g.

ODAS 23GB

(in this case 23 is the buoy's allocated number and GB is the national identification).

6. Radar Reflectors

The data buoy should have two multi-element radar reflectors each capable of giving a reflected signal equivalent to $6m^2$ of steel plate. The elements should be completely enclosed against ingress of water in a plastic housing.

The reflector shall produce radar echo at a range of at least 2 miles in accordance with the safety provisions of Ocean Data Acquisition Systems, Aids and Devices (ODAS) published by the International Maritime Organisation (IMO). The reflectors should be capable of withstanding a wind speed of 150 knots.

7. Navigation Lamp

The data buoy shall have a navigation lamp giving an amber light. The illumination cycle shall produce a group of 5 flashes in a period of 10 seconds, followed by a pause of 10 seconds with no illumination.

The lamp is to be visible from at least 5 nautical miles in clear conditions, in accordance with safety provisions of Ocean Data Acquisition Systems, Aids and Devices (ODAS) published by International Maritime Organisation (IMO). It should be capable of withstanding a wind speed of 150 knots.

SECTION B

Current Specifications

The following recommendations and specifications are based upon the open ocean moored buoys designs developed in the UK by the Met Office, and which currently in use in Ireland, France and the UK. They should not be construed as precluding the development of other buoy designs.

1. Design and Operation Recommendations

1.1. Sensors

It is recommended that sensors should be capable of unattended operation in a marine environment for a period of at least 6 months. The recommended sensors for each observed variable are listed below, together with the recommended minimum specifications for their measurements:

- Atmospheric pressure: Digital Pressure Transducer

  The mean of 20 second averages taken over a 90 second period. (i.e. a rolling 20 second average, undated every second, the data used being that read after the 90 second period.)

- Air temperature (dry bulb): Platinum resistance thermometer

  The 10 second average taken at the observing time.

- Humidity: Electric hygrometric circuit element

  Instantaneous value taken at the observing time

- Wind speed: Cup anemometer, or Accoustic Sensor

  The average for the 10 minutes preceding the observing time.

- Wind Gust; Cup anemometer, or Accoustic Sensor

  The maximum wind speed with a duration of 3 seconds since the last automatic observation

- Wind direction: Wind vane / Accoustic Sensors

  As for wind speed.
  Averages should be based on unit vectors.

- Sea temperature: Platinum resistance thermometer element

  The 10 second average within the top 1m of the sea taken at the observing time.

- Significant Wave Height: Wave sensor

  Four times the RMS value of the water level above the average level of water surface over the period of observation, or

  the average height of the 1/3 highest waves (i.e. if all wave heights measured from the record are arranged in descending order, the 1/3 part, containing the highest waves should be taken and significant wave height is then computed as the average height of this part).

- Wave Period Wave sensor

  the average zero crossing wave period, obtained by dividing the duration of a record in seconds, by the number of times the wave trace passes through the mean water level in an upward direction.

All sensors or their housings should ideally be fitted with suitable quick-release clamps and have quick-release electrical connectors. The sensors should be calibrated before operational use. All sensors, with the exception of the wave sensor, should be duplicated.

In addition to reducing the potential data loss due to sensor failure, the duplication of sensors provide an opportunity to compare data thereby giving enhanced confidence in data quality.

1.2. Data Acquisition and Processing System

The Data Acquisition and Processing System should be duplicated and capable of:

- Unattended operation for a period of at least 18 months.
- Interfacing with all sensors listed in Section 4 and processing the data required by section 2 of this guidance.
- Interfacing with the Global Positioning Satellite (GPS) receiver and of processing and storing the data in accordance with the observation coding requirements.
- Controlling the timing of the data collection.
- Formatting the data into a suitable code.

The Data Acquisition and Processing System should also be capable of operating from a power supply of 13.0V ±1.5V DC and have an average current consumption not exceeding 14mA.

1.3. Data Transmission System

All the data from the Data Acquisition and Processing Systems should be transferred to the Data Collection Platform (DCP) System and transmitted to a ground station via the METEOSAT/GOES geo-stationary satellite system for onward transmission to the user. The data should be available to the user within 20 minutes of the observation hour i.e. between HH:50.00 and HH:10.00.

There should be two DCPs in each buoy system. Both DCPs should be connected to both Data Acquisition Systems

Each data acquisition system should be based upon a PC programmable data logger. The logger output is then converted to a unique Marine Automatic Weather Station (MAWS) code, within a programmable single board microcomputer, which takes position data directly from the GPS.

The data from each of the two microcomputers are then united within two data combiners, the outputs of both then being passed to the two DCP satellite transmitters. Consequently each transmission contains data from both suites of sensors and both data acquisition systems.

Data are received at the European Space Operations Centre (ESOC) facility at Darmstadt from where they are forwarded to the National Met Service for data selection and recording into WMO F13-XI SHIP Code for retransmission on to the Global Telecommunications System (GTS)

The following requirements should be fulfilled:

- The manufacturer of the DCP shall be in possession of a current certificate from the appropriate satellite operating authority verifying that the design of the DCP has passed all the necessary performance tests required by the authority. (i.e. in accordance with the procedure stated in the DCP User's Guide, issued by ESOC).

- Each DCP shall bear a notice of certification together with a statement that the DCP meets this specification.

- Operation should be possible on all satellite channels from 402.0 MHz to 402.2 MHz.

- Transmission should be completely automatic at times specified and allocated by the satellite operating authority. Changes of transmission time-slot should be possible.

- Some indication should be provided to warn the operator that transmission is in progress e.g. a light emitting diode (LED),

- The RF transmission power level should be consistent with a data retrieval rate of greater then 95% via the buoy and satellite communication link.

- Transmitter timing should be accurate to within 15 seconds per year.
- The DCP should be suitable for mounting into a standard rack. All connectors should be mounted on the front panel of the DCP and where possible, internal electronic circuitry should be constructed as modules which plug into the unit.
- The units should be capable of operating from a power supply in the range +11V to +15V DC.
- The standby current consumption should not exceed 10 mA.

To enable the location of the buoy to be transmitted via the DCP each buoy should be fitted with two location systems; an Argos Platform Transmitter Terminal (PTT) and a GPS receiver (see also para 3.8)

1.4. Coding of Transmitted Data

Data transmitted by the buoy should be coded to meet the requirements of the communications system. An example of the code format currently in use by the UK Met Office is given at **Annex A**. The code is then converted to FM 13 ship code prior to use.

Under normal circumstances four sets of data are available every hour (two transmissions each containing data from both sensors). A selective process therefore has to be implemented. Normally the FM13 coded observation is made from sensor suite 1 data via transmission 1. However if the transmitter or data acquisition system or individual sensors in the sensor suite fail, the FM 13 message is compiled from the best available data.

1.5. Power Supply

The data buoy systems should normally be powered by lead acid gel batteries (in a sealed unit) and charged by solar panels. The units should be sealed against water ingress to a depth of 1 metre.

Accidents, occasionally fatal, have occurred due to explosions emanating from battery compartments and caused by the ignition of hydrogen and oxygen emitted from overcharged batteries. Batteries should be housed in their own stainless steel container which should ideally be located inside the steel hull of the buoy in order to minimise the consequences of an explosion. Brackets should be provided to hold batteries in place such that they will not move if inverted.

Note - When considering the safety of battery compartments safety operators and manufacturers of moored buoys are advised to take into account the design recommendations of the Data Buoy Co-operation Panel which are available at http://www.dbcp.noaa.gov/dbcp/safety.html

There should be sufficient capacity in the batteries to power all systems operationally for at least 4 months without recharge from the solar panels.

1.6. Hull and Superstructure

A schematic diagram of the hull and superstructure is attached at **Annex B**. It is recommended that the hull should be designed and constructed to fulfil the following criteria:

- The height should preferably not exceed 3.34m and the overall width should not exceed 3.0m, to enable it to be transported by road without the need for special precautions.
- The hull should be manufactured from a combination of mild steel and closed cell buoyancy material. The mild steel should be treated to ensure it is adequately protected, as appropriate, for continuous deployment in a marine environment. The buoyancy material should be protected against severe abrasion and damage. This should be achieved by a self coloured (yellow) elastomer material with properties equal to, or better than, the following:

  i. tensile strength 18MPa

  ii. elongation of 350%

  iii. split tear strength of 45kPa .

- The yellow buoyancy section of the hull should be marked in accordance with the requirements of Section A5
- The centre of the hull should contain a cylindrical mild steel well to house the equipment pod and should be protected, as appropriate, from the marine environment
- The well should be sealed against any water ingress at a depth of 20m by a hatch cover.
- The hatch cover should have “gland plates” through which equipment wires will pass. In addition the hatch cover should have fittings for an Argos box and antenna.
- The hull should have four lifting points, equally spaced around the hull at deck level, each capable of at least 15 tonnes SWL, to which the superstructure, with integral 15 tonne SWL lifting/holding down points can be bolted.
- The section of the hull below the well which houses the equipment pod should have four equally spaced "fins" and a circular "damping plate" and "foot", on which the buoy can stand. These should be manufactured from mild steel, protected to ensure minimal corrosion after 24 months at sea. (Minimal corrosion in this context means that any corrosion that is present after 24 months should not require extensive treatment to ensure the buoy's continued operation over its 10 year lifespan).
- The underside of the hull base should have a central mooring point with a SWL of at least 35 tonnes which should be capable of being replaced when worn.
- There should be two "cut-outs" in the wall of the foot, 180^0 apart, through which 1.5" open end link mooring chain can pass to prevent the buoy resting on the chain when the chain is attached to the mooring point. The depth of the foot should be sufficient to allow a 0.08m gap between the mooring point and any flat, level surface on which the buoy is placed.

- There should be protective material fitted around the wall of the foot acting as a fender to reduce shock loading should the foot be struck against a hard surface.
- All equipment within the buoy's hull should be mounted in a container sealed against any water ingress

It is recommended that the superstructure should be designed and constructed to fulfil the following criteria:

- The height should preferably not exceed 3.34m and the overall width should not exceed 3.0m, to enable it to be transported by road without the need for special precautions.
- The superstructure (including all component parts and fixings) should be manufactured from marine grade stainless-steel ("316 Stainless") .
- The superstructure should have four legs on which it can stand unsupported. The "feet" of the legs should be capable of being bolted into the four lifting points on the deck of the hull.
- Each foot of the superstructure should have an integral lifting/hold-down point proof tested to 15 tonnes.
- The superstructure's legs should form a truncated pyramid topped by a platform. The legs should be extended to form a 4 point lifting frame. The platform should be positioned approximately 2.1m above the top deck of the hull.
- The Proof Test for the lifting structure should be at least 15 tonnes and the 'Lifting Eye Plate' should be stamped with 'ODAS xx' (where xx is the ODAS number) and '15 t'.
- The superstructure should have a sensor ring 3m ± 0.01m outside diameter manufactured from seamless 0.025m (outside diameter) 10 gauge tube. This ring should be supported approximately 1.1m above the platform, and should be positioned centrally on the superstructure's axis.
- There should be a lifting point which may be integral with, or bolted on to, the lifting frame. It should be positioned at the top of the lifting frame, above the level of the sensor ring, and should not interfere with the exposure of the meteorological sensors.
- Access from the deck to the platform and sensor ring should be by two ladders, fitted on opposite sides of the platform. These ladders should be bolted in place as part of the superstructure assembly.
- A tube should be positioned centrally on the vertical axis of the superstructure of adequate length to guide and protect electrical cables passing between the equipment pod in the well of the hull and equipment located on the platform and sensor ring.
- Fixtures and fittings should be incorporated into the superstructure for such items as navigation lamp, radar reflector, solar panels etc.

It is recommended that the combined hull and superstructure assembly should designed and constructed to fulfill the following criteria;

- The total weight of the hull and superstructure should not exceed 3.0 tonnes.
- The buoy should be designed so that all external sensors and equipment can be changed at sea in wind strengths up to and including force 5 on the Beaufort scale, with a sea/swell wave of amplitude up to 2.5 metres and period greater than 8 seconds.
- Te hull and superstructure should be designed to survive the severe sea conditions that occur on average once in 50 years in the EGOS area. It should be capable of unattended operation at sea for a period of at least 24 months and have a total life in excess of 10 years with appropriate routine maintenance.
- The assembled structure, fully loaded with operational equipment, should be capable of being towed at seven knots or more without the superstructure being submerged.
- With the buoy fully equipped (with a 0.5 tonne payload), with no mooring attached and in still water conditions, the height of the sensor ring should ideally be between 3.8m and 4.5m above the water surface.
- The complete buoy (excluding equipment) should be self righting in still water when tilted at an angle greater then 90^0 from the vertical with a 0.1 tonne weight attached to the sensor ring.
- The complete buoy should remain stable (i.e. it will not topple over) when standing on a flat surface that is inclined at an angle of 30^0 to the horizontal.
- The damping ratio of the buoy to pitch and roll should not be less than 0.6 when displaced in still water neglecting the effect of the mooring system.
- The buoy should be designed to have a reserve buoyancy of at least 5 tonnes above still water level. This should allow the buoy to support the full weight of its entire mooring equipment without the deck level becoming submerged.
- The buoy should be designed to support 1 tonne of moorings in still water conditions, with a "step-on" deck provided at approximately 0.2m ±0.05m above the still water level.

1.7. Moorings

In water depths of 30 to 100 metres all chain mooring is used with a subsurface float where appropriate.

Moorings used in deeper water are an inverse catenary type with a 1 tonne reserve buoyancy sub-surface float and an acoustic release. A schematic diagram of the type of deep water mooring commonly used is attached at example of **Annex C**.

1.8. Location Systems

The position of moored buoys should be monitored to determine the location of the meteorological data collection site, and to enable the buoy to be tracked should it go adrift.

Being moored the nominal location of the buoy is known, at least within the catenary mooring, but unwarranted interference does occasionally result in a buoy being set adrift.

To enable the location of the buoy to be transmitted via the DCP it is recommended that two GPS location systems be fitted to the buoy and an independent Argos Platform Transmitter Terminal (PTT),

1.8.1. Platform Transmitter Terminal (PTT)

The buoy's location is monitored by measuring the Doppler shift on the carrier frequency of the signal transmitted from the Platform Transmitter Terminal (PTT) fitted to the buoy. Each measurement made via the satellite corresponds to a field of possible solutions. This field takes the form of a cone with the satellite at its apex. The altitude of the satellite is known, therefore the buoy's position can be calculated from the intersection of several of these cones, each cone corresponding to a separate, successive measurement. The calculation will yield two results; one of these is the required solution, the other its image. The ambiguity can be resolved by reference to previous positions and range of possible speeds etc. The PTT will be powered from the data buoy system batteries but it should also have an independent supply to maintain it in operation for at least one year.

The general requirements for the PTT are as follows:

- The PTT manufacturer should be in possession of a current certificate from Service Argos verifying that the PTT design, offered against this specification, has passed all the necessary performance tests required by that authority.
- The PTT should have a notice of certification together with a statement that the PTT meets the original specification.
- The operating frequency should be 401.650MHz ±1.2kHz.
- Transmission should be completely automatic at times specified and allocated by the system operating authority.
- The RF power output should be adjustable in the range 30dBm to 33dBm into an impedance of 50Ω.
- The input voltage should be between +12V and +15V DC.
- The maximum standby current should not exceed 3.0mA.
- The PTT should be programmed with the Project/Customer Identification Number by the supplier and should be capable of accepting up to 32

bytes of serial binary data or up to 32 bytes of RS232 data: both in increments of 4.

- The PTT should be capable of being housed in a container sealed against any water ingress along with its back up battery supply.
- The PTT antenna should be a low profile type approved by Service Argos and tuned to 401.650MHz.
- The antenna should be capable of withstanding a wind loading of 150 kn.

1.8.2. Global Positioning System (GPS) Receiver

If coded meteorological data are sent from a remote site, via a satellite link, to a ground station, for transmission via the GTS (Global Telecommunications System), the location from which the data is taken must be included in the coded message. The location data should be obtained via a GPS receiver and transmitted with the meteorological data via the DCP. The satellite navigation unit should fulfil the following:

- The location should be accurate to within 1 nautical mile in both latitude and longitude.
- The output should be in NMEA (US National Maritime Electronics Authority) RS232C format.
- The unit's operation should be completely automatic at predetermined times.
- The supply voltage should be between +12V and +15V DC and the operating current should not exceed 200mA.
- All interconnections should be suitable for use in a marine environment.
- The antenna should be capable of withstanding a wind loading of 150 kn.

1.9. Navigational Safety

Each buoy should be fitted with radar reflectors and Navigation lights as specified in Sections A 6 and A7.

2. Servicing

It is recommended that a servicing visit be made to each moored buoy at least every six months for a routine change of external sensors.

The upper moorings should be inspected every 12 months and the complete buoy changed every two years. Moorings should be changed at three yearly intervals.

3. General Design Recommendations

- Temperatures in the range -20^0C to $+50^0$C should cause no malfunction or deterioration of the buoy's equipment.
- All the buoy's equipment should be capable of storage in temperatures in the range -40^0C to $+70^0$C without deterioration or consequent malfunction.
- The equipment not exposed to external conditions should operate in relative humidities of up to 90%, non-condensing, without malfunction or deterioration of its performance.
- All equipment should be constructed to withstand the shock and vibration which can be expected in a normal ship-borne environment and whilst being transported by road.
- All external components should be suitable for use in a marine environment, in all forms of precipitation.
- The wiring harness and the locations at which it passes into the sealed hull should be sealed against water ingress.

ANNEX A

Open Ocean Buoy Message Format

05DDD	07DDD	10DDD	11DDD	12DDD	13DDD	14DDD	15DDD
18DDD	19DDD	22DDD	23DDD	35DDD	36DDD	50DDD	51DDD
52DDD	53DDD	70DDD	71DDD	72DDD	73DDD	74DDD	75DDD
76DDD	77DDD or 8DDDD or 9DDDD						

Address	Variable DDD	Decode	Notes	Default
05	Station Ident	xxx*		000
07	Wind dir	Deg (T)	10 min average	999
10	Wind speed	Kn	10 min average	999
11	Max gust	Kn	3 sec gust	999
12	Air Temp	Deg (C)	Average over 10s	999
13	Sea Temp	Deg (C)	Average over 10s	999
14	Humidity	%		000
15	Pressure	hpa	Average of 10s	999
18	Characteristic	a=0-8	See FM 13-vii 5appp	999
19	Tendency	hpa	See FM 13-vii 5appp	999
22	Time	Hr Min	GPS Ob Time	999
23	Time	Min Sec	GPS Ob Time	999
35	Wave Period	Sec	Over 17.5 min average	999
36	Sig Wave Ht	m	4xRMS 17.5 min average	999
50	Latitude	Deg	GPS Position	000
51	Latitude	+10 min	GPS Position	000
52	Longitude	Deg	GPS Position	000
53	Longitude	+10 min	GPS Position	000
70	Pod Humid	%		000
71	Flash Mon			500
72	Tx Counter			999
73	System Volts	Volts	System on load	999
74	A-D Ref		2.5V Source	999
75	Pod Temp	Deg (C)		999
76	Hull State		Sys'1 Higher Sys'2 Lower	500
77***	Current Used	Ah		
8****	'I' Discharge	mAh	max 9999mAh	77999
9****	'I' Charge	mAh	max 9999mAh	77999

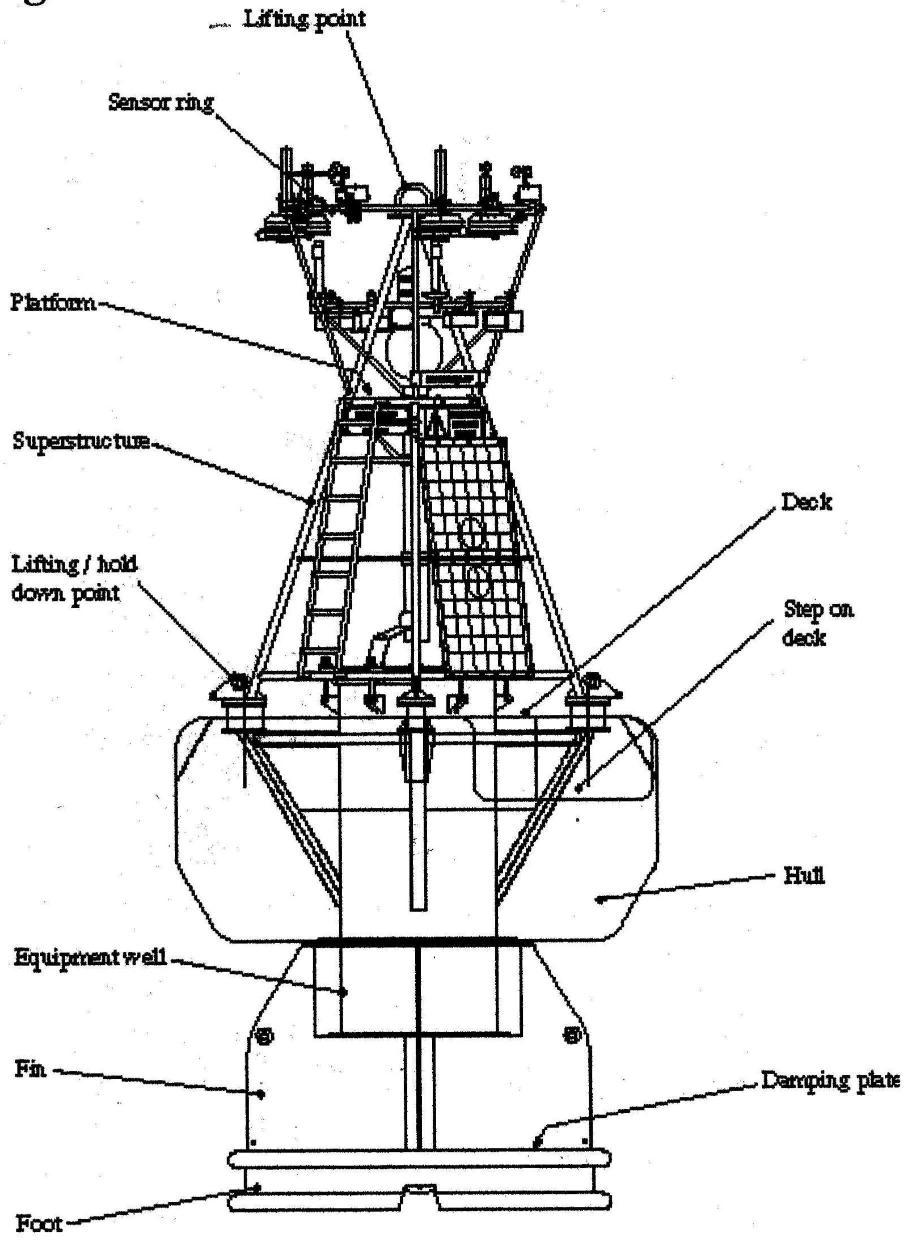
* xxx refers to the electronics pod (pod), and system number eg. 271 is pod '27' system '1', 272 is pod 27 system '2'

*** primary cell powered systems- total current used

**** hourly current charge or discharge

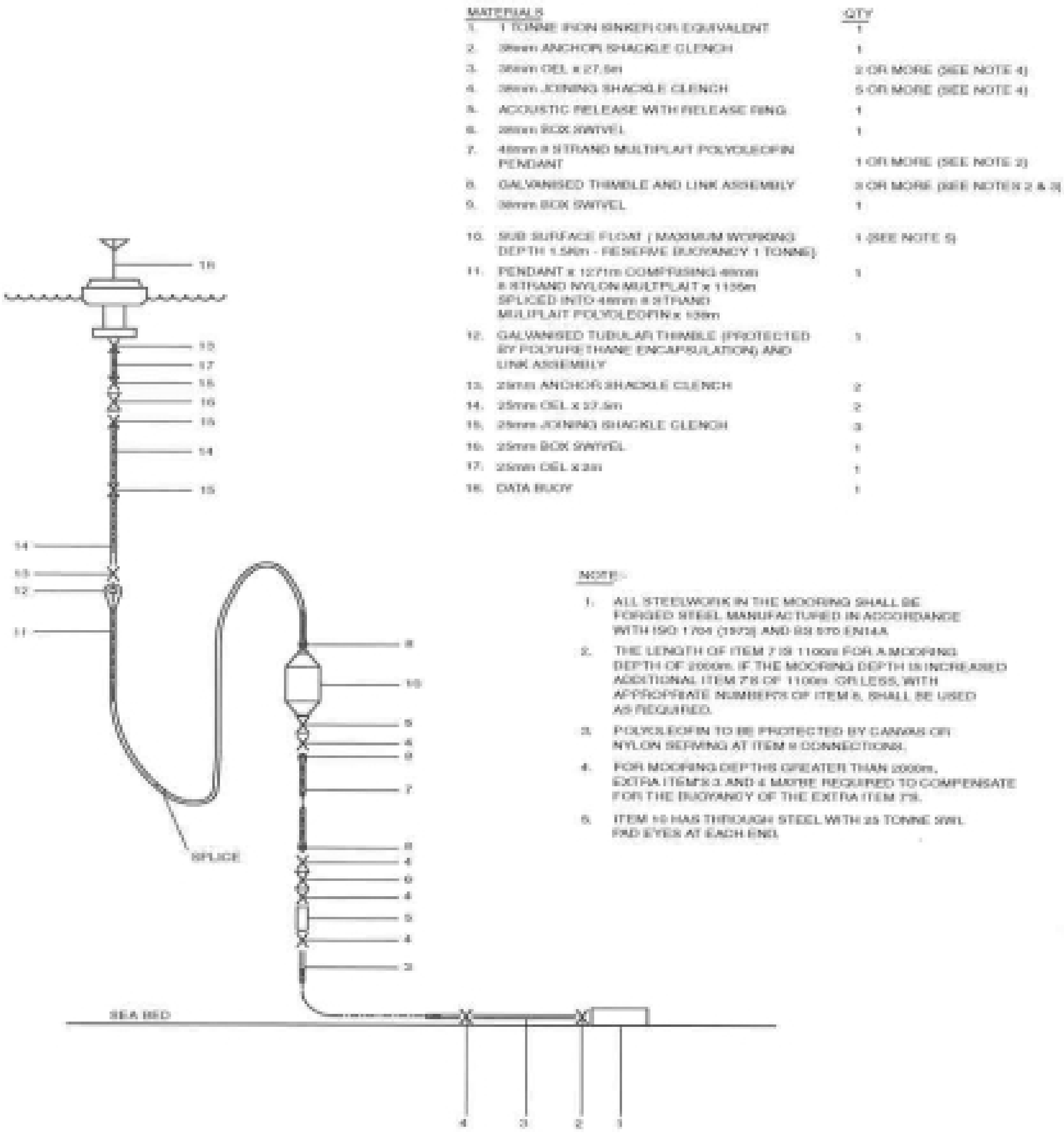
Annex B

Hull and Superstructure Diagram



ANNEX C

Deeper Water Moorings - Inverse Catenary Type



MOORING DEPTH UP TO 6000m