PROVOR-DO – 33-16-006_UTI

USER MANUAL

Z.I de KERANDRE - RUE GUTENBERG

56700 HENNEBONT - FRANCE

Telephone: +33 (0)2 97 36 10 12 Fax: +33 (0)2 97 36 55 17
Web : http://www.nke.fr - E-mail : info.instrumentation@nke.fr

USER MANUAL

DOC33-16-006 du 26 / 03 / 12 rev.4

DATE	REVISION	OBJET	Auteur
11/10/10	0	Création	JS
02/12/10	1	MAJ en code 33-16	SL
23/05/11	2	Correction unité acquisition en dérive	JS
27/06/11	3	Drift phase CTD Messages precisions	JS
26/03/12	4	Aquisition of TCPhase instead of dissolved oxygen Concentration (Argos messages modification)	JS

WHITE PAGE / PAGE BLANCHE

1 INTRODUCTION

PROVOR-DO is a subsurface profiling float developed jointly by IFREMER and MARTEC Group. Since January 1st, 2009 **nke** has integrated profiling floats activity and is now in charge of PROVOR-DO manufacturing and development in industrial partnership with IFREMER.

The PROVOR-DO float described in this manual is designed for the ARGO Program. This international program will be a major component of the Global Ocean Observing System (GOOS). An array of 3,000 free-drifting profiling floats is planned for deployment in 2004. These floats will measure the temperature and salinity of the upper 2,000 meters of the ocean, allowing continuous monitoring of the ocean's climate.

All Argo measurements will be relayed and made publicly available within hours after collection. The data will provide a quantitative description of the evolving state of the upper ocean and the patterns of ocean climate variability, including heat and freshwater storage and transport. It is expected that ARGO data will be used for initialization of ocean and coupled forecast models, and for dynamic model testing. A primary focus of Argo is seasonal to decadal climate variability and predictability.

After launch, PROVOR-DO's mission consists of a repeating cycle of descent, submerged drift, ascent and data transmission. During these cycles, PROVOR-DO dynamically controls its buoyancy with a hydraulic system. This hydraulic system adjusts the density of the float causing it to descend, ascend or hover at a constant depth in the ocean. The user selects the depth at which the system drifts between descent and ascent profiles. PROVOR-DO continually samples the pressure at this drift depth and maintains that depth within approximately 30m.

After the submerged drift portion of a cycle, the float proceeds to the depth at which the ascending profile is to begin. The ascent profile starting depth (typically the ARGO-selected depth of 2,000m) is not necessarily the same as the drift depth.

During its mission, PROVOR-DO collects measurements of four parameters - salinity, temperature, depth and dissolved oxygen (CTDO) - and saves them in its memory. These measurements can be made during the float descent (descent profile), during the submerged drift period (Lagrangian operation) and during the ascent (ascent profile).

After each ascent, PROVOR-DO transmits its saved data to the satellites of the Argos system. The volume of data is reduced using a compression algorithm in order to reduce the time needed for transmission. The Argos system calculates the float's position during its stay on the sea surface.

This manual describes the PROVOR-DO float, how to use it and safety precautions to be observed during handling.

Please read this manual carefully to ensure that PROVOR-DO functions as intended.

Overview of the present manual's contents:

- Chapter 2 contains the instructions necessary for the personnel in charge of the deployment
- Chapter 3 describes the components of PROVOR-DO; it is intended for those who want a more in-depth understanding of PROVOR-DO
- Chapter 4 describes the mission of PROVOR-DO
- Chapter 5 describes the various parameters
- Chapter 6 describes the various ARGOS messages
- Chapter 7 presents the technical specifications
- Chapter 8 provides explanations about the operation of PROVOR-DO
- Chapter 9 specifies the elements of the constraints limited to the transport of Lithium batteries.

2 OPERATING INSTRUCTIONS

The following instructions tell you how to handle, configure, test and launch the PROVOR-DO float. Please read these instructions carefully and follow them closely to ensure your PROVOR-DO float functions as intended.

2.1 Handling Precautions

PROVOR-DO is designed to withstand submersion at great depths for long periods of time (up to five years). This remarkable specification in oceanographic instrumentation is possible thanks to the protection of the casing by an anti-corrosion coating. This coating is sensitive to impact. Damage to the coating can accelerate the corrosion process.

NOTE: Take precautions to preserve the anti-corrosion coating during handling. Remove the float from its packing only when absolutely necessary.

NOTE: Regulations state that PROVOR-DO must not be switched on during transport.

2.2 Acceptance Tests

Immediately upon receipt of the PROVOR-DO float, you should test it to confirm that it is complete, correctly configured and has not been damaged in shipment. If your PROVOR-DO float fails any of the following tests, you should contact **nke electronics**.

2.2.1 Inventory

The following items should be supplied with your PROVOR-DO float:

- The present user manual.
- A test sheet.

NOTE: Disassembly of the float voids the warranty.

Check that all of the above items are present. If any are missing, contact **nke**.

2.2.2 Physical Inspection

Upon the opening of the transport casing, visually inspect the float's general condition: Inspect the transport container for dents, damage, signs of impact or other signs that the float has been mishandled during shipping.

Inspect the CTD sensor, antenna, hull, housing around the lower bladder for dents or any other signs of damage

NOTE: Ensure the magnet is in place against the hull (on ON/OFF position).

2.3 Default Parameters

Notwithstanding special instructions given to NKE during the PROVOR-DO preparation stage, the following set of parameters is applied: **section 5. page 24**

If these parameters are not appropriate, the user can change them himself by following the instructions.

2.3.1 ARGO Identification

The user is responsible for contacting the AIC in order to obtain the WMO number which will identify the PROVOR-DO's mission

2.3.2 Decoding

The CORIOLIS project team (IFREMER) is able to assist the teams that use PROVOR-DO for data processing

2.4 Launching

Following is what you should do to launch the PROVOR-DO float.

2.4.1 *Test the Float and arm the mission*

Before you take PROVOR-DO on deck for deployment, we recommend that you repeat all of the tests described in **section 2.5.8 page 15**. This will ensure that the float is functioning and configured correctly and maximize the probability of success of your experiment.

IMPORTANT: Before launching the float, you must arm the mission by issuing the !AR command:

!AR

PROVOR-DO will respond:

<AR ON>

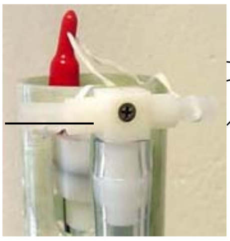
Put the magnet on the float (ON/OFF position).

NOTE: Once the mission is armed, the next time you will attempt to communicate with the float upon magnet removal, you need to establish Bluetooth connection (see section 2.5.2 page 9) and press "ENTER" within 30 seconds in order to get the prompt].

2.4.2 *Remove protective plugs and magnet*

The pump system of the CTD sensor is sealed by 3 protective plugs. Remove these plugs from the sensor before launching.

CTD sensor



Protective plugs

Remove the magnet located near the top of the float (see Figure 1 – General view of PROVOR-DO float **page 17**). Retain the magnet for future use in case the float is recovered.

PROVOR-DO is now ready for launch.

To confirm that the magnet has been removed and that the float is ready for launch, 5 seconds after magnet removal, PROVOR CTS3.1 starts 5 valves actions. After 80s, the seabird pump is active. If you have water in the CTD, this water go out by the holes where was the protectives plugs. After 100 sec, floats starts 5 quick valve activations.

NOTE: Once the magnet has been removed, the PROVOR-DO float performs an initial test. Ensure that the CTD pump starts as explained above before placing the float in the water.

If your do not hear the valve running after 30 seconds, and you do not see the water after 90s, replace the magnet, connect the PC, and conduct the tests described in **section 2.5. page 9**. If these tests fail, contact **nke** technical support.

2.4.3 *Launch the Float*

NOTE: Keep the float in its protective packaging for as long as possible to guard against any nicks and scratches that could occur during handling. Handle the float carefully, using soft, non-abrasive materials only. Do not lay the float on the deployment vessel's unprotected deck. Use cardboard or cloth to protect it.

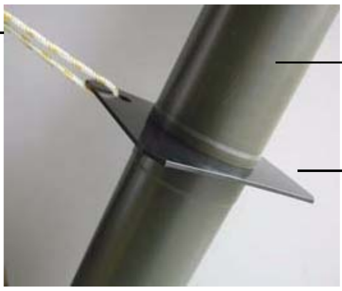
2.4.3.1 By hand

PROVOR-DO can be launched by hand from the deck from a height of 3 meters

2.4.3.2 Using a rope

The damping disk is already fastened on the tube (under the buoyancy foam).
It is possible to use the holes in the damping disk in order to handle and secure the float during deployment.

Put the rope in the hole according to the following photo:



After the launch, you may decide to wait alongside the float until it starts its descent, but this can take up to 3 hours depending on the float's buoyancy when it is placed in the water.

2.5 Checks prior to deployment

2.5.1 Necessary Equipment

The equipment required to check that PROVOR-DO is functioning correctly and to prepare it for the mission are:

(1) A PC.
The most convenient way of communicating with PROVOR-DO is with a PC in terminal emulation mode. Among other advantages, this allows storage of configuration parameters and commands. You can use any standard desktop or laptop computer. The PC must be equipped with a serial port (usually called COM1 or COM2).

(2) VT52 or VT100 terminal emulation software.
The Hyper Terminal emulation software can be used.

(3) A Bluetooth Dongle with drivers installed on the PC (BELKIN class 2 model is recommended).

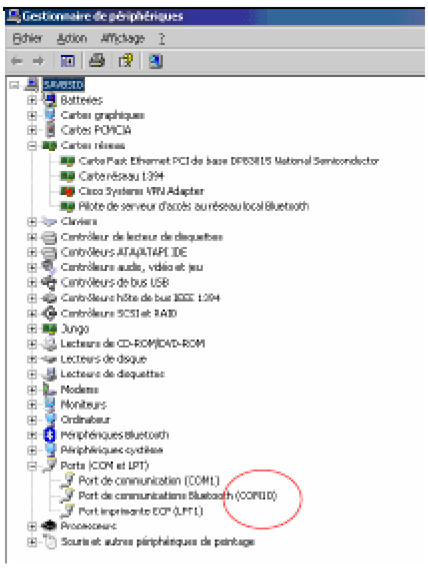
(4) An accurate time source.
This could be a wristwatch, a GPS receiver or the PC's internal clock. Some users use a GPS receiver connected to the PC to adjust the clock.

(5) An Argos test set.
This device receives Argos messages directly from the transmitter for test purposes (Goniometer, RMD02 receiver).

2.5.2 Connecting the PC

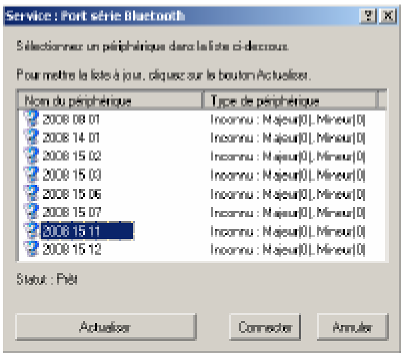
Make sure you check the following points before attempting a connection:

- ✓ Bluetooth key connected to the PC with the drivers installed
- ✓ Magnet present at the Bluetooth's power supply ILS (see Figure 1 – General view of PROVOR-DO float **page 17**)
- ✓ Start Hyperterminal after checking on which COM port the Bluetooth key is installed by going to: Control Panel->System-> click on Hardware tab->Device Manager as shown in the figure below:



- ✓ On the PC, run the following commands as shown in the figure below:
- ✓ Right click on the Bluetooth logo in the bottom right corner of the Desktop
- ✓ Select Quick Connect, Bluetooth Serial Port, then click on other devices

A window appears as shown in the figure below:

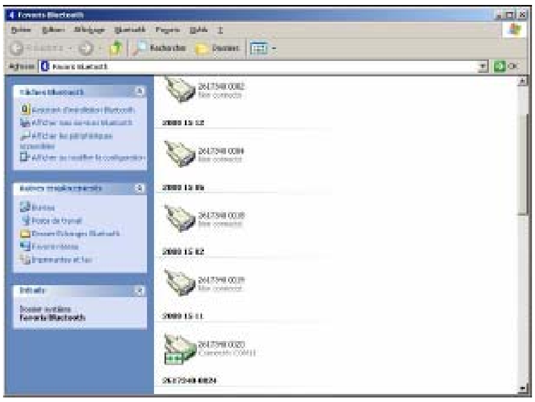


- ✓ Click on Refresh
- ✓ Check that the Bluetooth number is present on the traceability label (see Figure 1 – General view of PROVOR-DO float
- ✓ **: page 17**)
- ✓ There are two ways of establishing the connection:
- ✓ Either select the number shown and press Connect
- ✓ Or come back to the previous step and instead of selecting “other devices”, select the number shown
- ✓ When the connection is made, a dialog box appears as shown in the figure above:

Double click on it and a window appears as shown below:

- ✓ Enter the security code “0000”
- ✓ You can now check the connection by double clicking on the Bluetooth logo in bottom right corner of the Desktop

- ✓ The “Bluetooth favourites” window appears:



Use your PC's terminal emulation software to configure the selected serial port for:

- 9,600 baud
- 8 data bits
- 1 stop bit
- Parity: none
- Full duplex
- No flow control

2.5.3 Example of Bluetooth dongle tested by NKE

USB Bluetooth™ adaptor - 100 meters,
Part # F8T012fr
Made by Belkin

2.5.4 How to Send Commands

You must communicate with PROVOR-DO to verify or change its configuration parameters, to read data from the float, or to test the float's functions. You perform these verifications/changes by sending commands, and by observing the float's response to those commands. Compose commands by typing characters on the keyboard of your PC, and send them to PROVOR-DO by pressing the Enter key.
In the following descriptions of commands we will use the general syntax:

- Keystrokes entered by the user are written in **bold**.
- Replies received from the float are in normal font.
- Commands entered by the user end with the Enter key.

The software version can be viewed using the **?VL** command
PROVOR-DO will respond:
<VL 58171A0x> (where x indicates minor software revision)

The float’s serial number can be viewed using the **?NS** command
PROVOR-DO will respond:
<NS 10001>
(year 10, identification 1)

2.5.5 How to Read and change Parameter Values

Read the values of “mission parameters” by sending the PM command. Do this by typing the characters **?PM** in response to PROVOR-DO's] prompt character then confirm the command by pressing the Enter key. It should look like this:

?PM

PROVOR-DO will respond:

<PM0 255>
<PM1 10>
<PM2 2>
<PM3 6>
<PM4 0>
<PM5 0>
<PM6 12>
<PM7 10>
<PM8 1000>
<PM9 2000>
<PM10 10>
<PM11 200>
<PM12 1>
<PM13 10>
<PM14 25>
<PM15 60>
<PM16 0>
<PM17 1>
]

As you can see, the responses are of the form:

- PM parameter number, value.

You can also read the values of the parameters individually using the command
? PM X

where **X** identifies the parameter. Each parameter is identified by a parameter number corresponding to a parameter name. They are summarised for reference in **page 24, 25 & 26**

By the same way, you can read ARGOS parameters with the following command **?PA.**
PROVOR-DO will respond :

<PA0 40>
<PA1 100>
<PA2 25>
<PA3 1>
<PA4 1>
<PA5 000000>
<PA6 180>
<PA7 480>
]

Command no.	Name	Default Value	Units
Mission Parameters			
PM0	Number of Cycles	**255**	**Whole number**
PM1	Cycle Period	**10**	**Days**
PM2	Reference Day	**2**	**Number of days**
PM3	Estimated time at the surface	**6**	**Hours**
PM4	Delay Before Mission	**0**	**Minutes**
PM5	Descent Sampling Period	**0**	**Seconds**
PM6	Drift Sampling Period	**12**	**Hours**
PM7	Ascent Sampling Period	**10**	**Seconds**
PM8	Drift Depth	**1000**	**dbar**
PM9	Profile Depth	**2000**	**dbar**
PM10	Threshold surface/Middle Pressure	**10**	**dbar**
PM11	Threshold Middle/Bottom Pressure	**200**	**dbar**
PM12	Thickness of the surface slices	**1**	**dbar**
PM13	Thickness of the middle slices	**10**	**dbar**
PM14	Thickness of the bottom slices	**25**	**dbar**
PM15	End of life Iridium Period (Not Used)	**60**	
PM16	Wait Inter-Cycles (Not used)	**0**	
PM17	Optode type (0: 3830, 1 : 4330)	**1**	
Argos Parameters			
PA0	Argos Transmission Period	**40**	**Seconds**
PA1	Argos Transmission Period at Life Expiry	**100**	**Seconds**
PA2	Retransmission	**25**	**Whole number**
PA3	Argos Transmission Duration	**1**	**Hours**
PA4	Number of Argos addresses	**1**	**Whole number**
PA5	Argos ID[0 .. 6]	**0000000**	**Hexa**
	Argos ID 2[0 .. 6]	**0000000**	**Hexa**
	Argos ID 3[0 .. 6]	**0000000**	**Hexa**
	Argos ID 4[0 .. 6]	**0000000**	**Hexa**
PA6	Argos transmission test time upon launch, before surfacing adjustment.	**180**	**Minutes**
PA7	Offset on transmission frequency in hundreds of Hertz, here: 401.648 **000** MHz	**480**	**Hundreds of Hertz**

For example, to verify the value of the ascent sampling period, send the command:

? PM 7
PROVOR-DO will respond:
<PM7 10>
]
where 10 is the sampling period in ascent (see **page 24**).
The commands for **changing** the values of the mission parameters are of the form:
!PM X Y
where X identifies the parameter and Y provides its new value.
For example, to change the number of cycles to 150, send the command:
!PM 0 150
PROVOR-DO will respond:
<PM0 150>

NOTE: PROVOR-DO will always respond by confirming the present value of the parameter. This is true even if your attempt to change the parameter's value has been unsuccessful, so you should observe carefully how PROVOR-DO responds to your commands.

2.5.6 How to Check and change the Time

Connect the PC to the float using the BT connection (see **section 2.5.2 page 9**). Ask PROVOR-DO to display the time stored in its internal clock by sending the command:
? TI
(Do this by typing the characters **? TI** followed by the Enter key). PROVOR-DO will respond:
<01/03/09, 14 41 00>
]
The date and time are in the format DD/MM/YY hh:mm:ss

You can set the time on the float's internal clock by sending the command:
!TI DD MM YY hh mm ss

For example, if you send the command:
!TI 01 03 09 14 30 00
PROVOR-DO will respond:
<01/03/09, 14h 30m 00s>

2.5.7 Configuration Check

The float has been programmed at the factory. The objective of this portion of the acceptance test is to verify the float's configuration parameters.
Connect the PC to the float (see **section 2.5.2 page 9**). Send the PM command, as explained in **section 2.5.5. page 12**, to verify that PROVOR-DO's parameters have been set correctly.

2.5.8 Functional Tests

Connect the PC to the float (see **section 2.5.2 page 9**).

NOTE: The hydraulic components will function correctly only if the float is in a vertical position with the antenna up.

Orient the float vertically, and support it to prevent it from falling over during the performance of the functional tests.

PROVOR-DO has several commands that allow you to test its various functions.

2.5.8.1 Display of technological parameters

2 commands are used (**?VB** and **!RV**):

Send the command:
?VB

PROVOR CTS3.1 will respond:
<V:700 B:10400> -> means 700 mBar internal and 10.4V Battery pack voltage

- Internal vacuum (V).
  This vacuum is drawn on the float as one of the final steps of assembly. It should be between 600 and 800 mbar absolute. 700 mbar is recommended.

- Battery voltage (B)
  Normal values for a new battery are 10.8 volts (see test sheets for limits).
  Send the command :

!RV

PROVOR will respond with:

<RV ON> if lower blade is full.

If lower blade is not full pump will activate until oil has been transferred and lower blade is full

2.5.8.2 Display Sensor Data

This command is used to display:

- External pressure (P).
- Temperature (T).
- Salinity (S).

Send the command:
?S

PROVOR-DO will respond:
<S P10cBars T22956mdc S0mPSU>
As this sensor is in open air, only the temperature data should be regarded as accurate.

2.5.8.3 Test of Oxygen sensor

This command is use to perform an acquisition on the oxygen sensor.
Send the command :
?D

Provor will respond with :

<O2 : 274.79 uM/l>[0A] (Software revision up to 5817A04) OR

<TCPhase=29.384> (Software revision 5817A05)

2.5.8.4 Test Hydraulic Pump

To activate the pump for one second, send the command:

!P 100

Listen for the pump running for one second (unit: centiseconds).

2.5.8.5 Test Hydraulic Valve

To activate the valve for one second, send the command:

!E 100

Listen for the actuation of the valve (unit: centiseconds).

2.5.8.6 Test Argos Subsystem

To test the Argos transmitter, send the command:

!SE

The float will respond for the number of hours programmed (PA2). Put the magnet back in place to stop the transmission.

This command will cause PROVOR-DO to transmit several messages. They are technical messages, the format of which is described in **section 6 page 26**.

Use your Argos test set to receive the message. The message content is not meaningful, this is a test of the transmission only, but the test messages do have valid Argos IDs and CRCs.

You have now completed the functional tests. Ensure the magnet is in place on the ON/OFF position (see **Figure 2: page 17**).

3 GENERAL DESCRIPTION OF PROVOR-DO FLOAT

3.1 PROVOR-DO

The main developments of PROVOR-DO compared to the CTS-3 float are mainly:

- ✓ Embedded software,
- ✓ Electronics,
- ✓ Mechanical interface with oxygen sensor

3.1.1 Electronics

A new CPU board has been developed to take in account the obsolescence of components of the CTS-3 PROVOR profiler. A I538 interface board is inserted between I535 PCB and oxygen sensor

3.1.2 Embedded software

The CPU board is equipped with a new embedded software taking in account supplementary inputs and possibilities required by the PROVOR float.

3.1.3 Mechanical interface with oxygen sensor

The oxygen sensor is mounted on top end-cap.

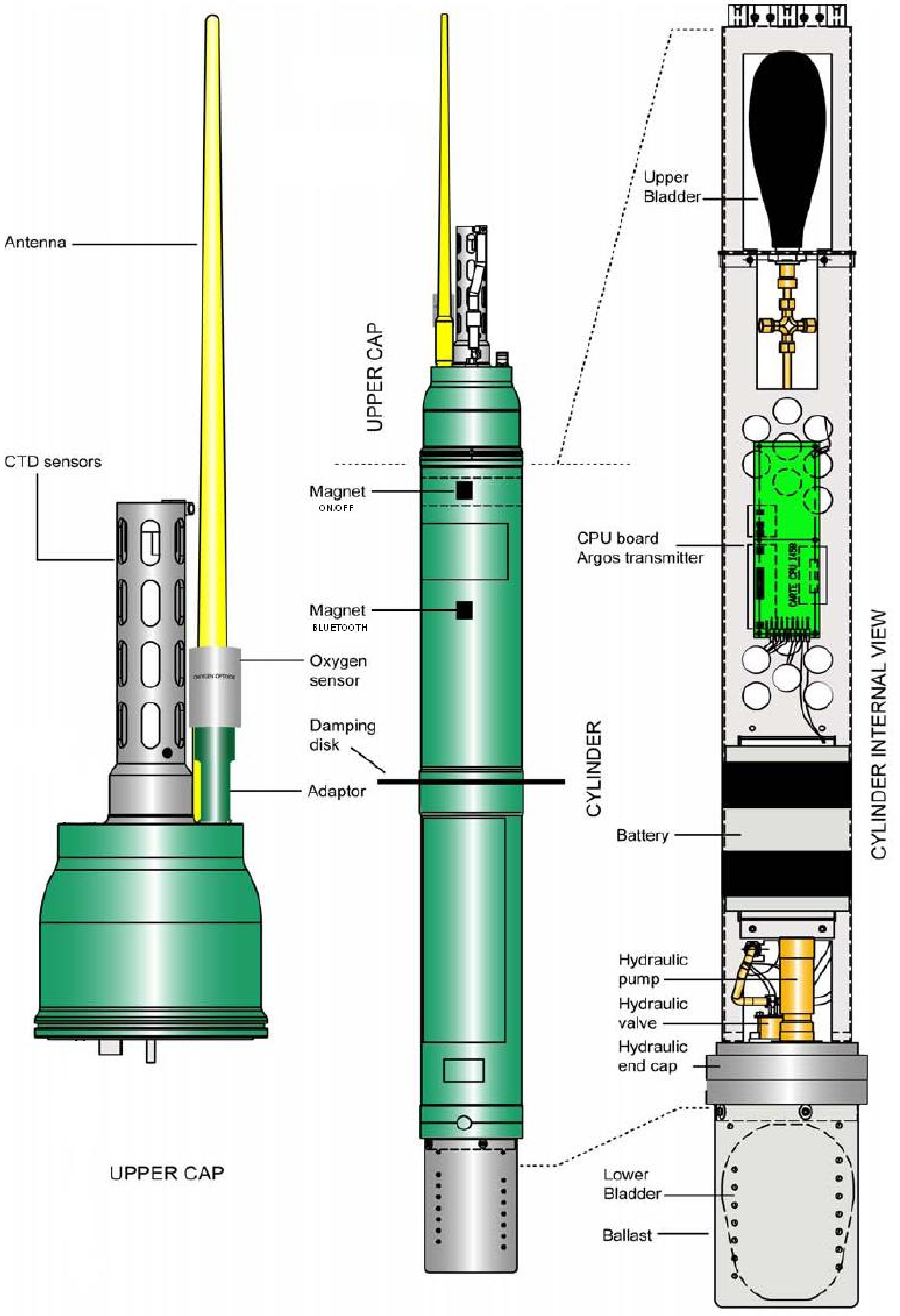


Figure 1 – General view of PROVOR-DO float

3.2 Density Control System

Descent and ascent depend upon buoyancy. PROVOR-DO is balanced when its density is equal to that of the level of surrounding water. The float has a fixed mass. A precision hydraulic system is used to adjust its volume. This system inflates or deflates an external bladder by exchanging oil with an internal reservoir. This exchange is performed by a hydraulic system comprising a high-pressure pump and a solenoid valve.

The interested reader is referred to a more detailed description of the operation of PROVOR-DO's density control system in **section 8. Page 35**.

3.3 Sensors

PROVOR-DO is equipped with precision instruments for measuring :

- pressure, temperature and salinity with the SEABIRD SBE41CP CTD sensor. Specifications of the sensor are provided in **section 6. Page 26**.
- Dissolved Oxygen with the Oxygen Optode AANDERAA 3830 or 4330 sensor

3.4 Argos Transmitter

While the float is at the surface, the Argos transmitter sends stored data to the satellites of the Argos system (see **sections 6. page 26 and 6.2. page 27**). The transmitter has a unique ID assigned by Argos. This ID identifies the individual float. The Argos antenna is mounted on the top end of the PROVOR-DO float and must be above the sea surface in order for transmissions to reach the satellites.

3.5 CPU Board

This board contains a micro-controller (or CPU) that controls PROVOR-DO. Its functions include maintenance of the calendar and internal clock, supervision of the depth cycling process, data processing and activation and control of the hydraulics.

This board allows communication with the outside world for the purpose of testing and programming.

3.6 Battery

A battery of lithium thionyl chloride cells supplies the energy required to operate PROVOR-DO.

3.7 MMI link

The User link is made via Bluetooth (radiofrequency link)

4 THE LIFE OF AN PROVOR-DO FLOAT

The life of an PROVOR-DO float is divided into four phases: Storage/Transport, Deployment, Mission, and Life Expiry.

(1) Storage/Transport

During this phase, the float, packed in its transport case, awaits deployment. The electronic components are dormant, and float's buoyancy control functions are completely shut down. This is the appropriate status for both transport and storage.

(2) Deployment

The float is removed from its protective packaging, configured, tested and launched at sea.

(3) Mission

The mission begins with the launching of the float. During the Mission, PROVOR-DO conducts a pre-programmed number of cycles of descent, submerged drift, ascent and data transmission. During these cycles it collects CTDO data and transmits it to the Argos satellite system.

(4) Life Expiry

Life Expiry begins automatically upon completion of the pre-programmed number of cycles. During Life Expiry, the float, drifting on the sea surface, periodically transmits messages until the battery is depleted. Reception of these messages makes it possible to locate the float, to follow its movements and, if desired, to recover it. PROVOR-DO floats are designed to be expendable, so recovery is not part of its normal life cycle.

If the battery is depleted before completion of the pre-programmed number of cycles, PROVOR-DO will probably remain submerged and cannot be located or recovered.

4.1 The Mission - Overview

We call "Mission" the period between the moment when the float is launched at the experiment zone and the moment when the data transmission relating to the final depth cycle is completed.

During the Mission, PROVOR-DO conducts ascent and descent profiles, separated by periods of Argos transmitting and drifting at a predetermined depth. PROVOR-DO can collect data during the descent, submerged drift, or ascent portions of the cycle, and transmits the collected data during the surface drift period at the end of each cycle. One cycle is shown in the figure below.

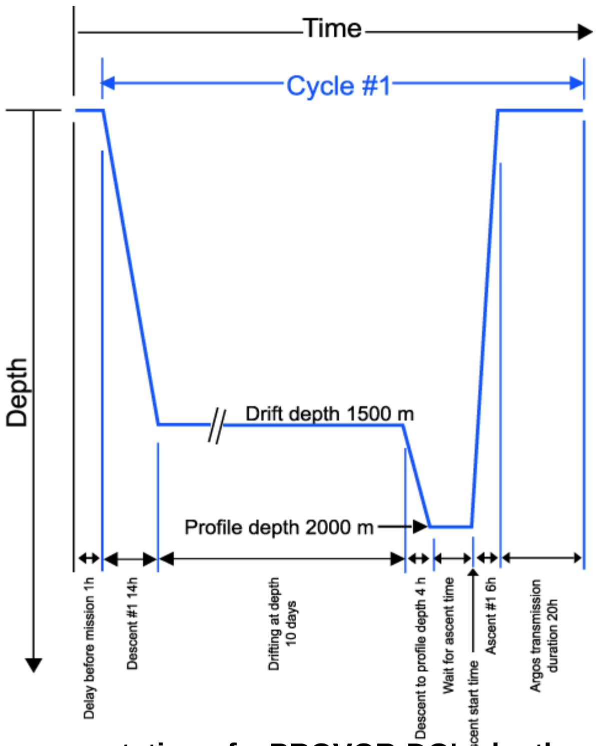


Figure 2 - Schematic representation of a PROVOR-DO's depth-cycle during the Mission.

(1) Delay Before Mission
To prevent PROVOR-DO from trying to sink before it is in the water, the float waits for this time before starting its descent. This happens only before the first cycle; it is not repeated at each cycle.

(2) ARGOS Preliminary Transmissions
To test ARGOS transmitter, before descent phase, float will perform ARGOS transmission during a period defined by user with PA 6 parameter (expressed in minutes). Argos messages are send each PA 1 seconds (end of life period). Float send technical ARGOS messages (see **section 6. page 26** for more details).

(3) Buoyancy reduction
Float is deployed with full external bladder to get a maximal buoyancy. To reach a neutral buoyancy position before descending, float needs to transfer oil inside float. For the 2 first cycles this phase can take up to one hour and a half (by opening electro-valve several times with one minute for pressure monitoring between activations). At following cycles, float memorized necessary global electro-valve opening time (precedent cycle) and reduce this global duration by reduce time between valve activations to one second instead of 1 minute.

(4) Descent
The float descends at an average speed of 5cm/sec. During descent, which typically lasts a few hours, PROVOR-DO can detect possible grounding on a high portion of the seabed and can move away from such places (see **section 4.2. page 20** for more details on grounding). PROVOR-DO can collect CTDO measurements during descent or ascent.
In order to respect the requirement of the ARGO program, the first cycle of the mission collect CTDO measurements during the descent at the sampling period of 10 seconds.

(5) Drifting at Depth
During the drift period, PROVOR-DO drifts underwater at a user-selected drift depth, typically 1,000m to 2,000m below the sea surface. The drift period is user-selectable and can last from a few days to several weeks, but is typically 10 days. The float automatically adjusts its buoyancy if it drifts from the selected depth by more than 5 bars over a 60-minute period. PROVOR-DO can collect CTDO measurements at user-selected intervals during this drift period if the user selects this option.

(6) Descent to Profile Depth
The user may select a starting depth for the ascent profile that is deeper than the drift depth. If this is the case, PROVOR-DO must first descend to the profile depth before beginning the ascent profile.
PROVOR-DO can detect a possible grounding during this descent and take corrective action (as described in **section 4.3. page 21**).

(7) Wait for Ascent Time
The user can program several floats to conduct profiles simultaneously. This makes it possible to use several PROVOR-DO floats in a network of synoptic measurements, even though the instruments are not all deployed at the same time. If this is the case, it may be necessary for PROVOR-DO to standby at the profile starting depth while awaiting the scheduled ascent time.

(8) Ascent
Ascent lasts a few hours, during which time PROVOR-DO ascends to the sea surface at an average speed of 10cm/sec. PROVOR-DO can collect CTDO measurements during descent or ascent.

(9) Transmission
At the end of each cycle, the float finds sufficient buoyancy to ensure Argos transmission quality. PROVOR-DO remains at the sea surface transmitting the data collected during the preceding descent-drift- ascent portion of the cycle.
The duration of the Argos transmission period and the interval between transmissions can both be set by the user. The choices depend upon the quantity of data that PROVOR-DO must transmit and the latitude of the float. In order to conserve battery life and minimize the chance of collision with shipping, the duration of this transmission period should be no longer than necessary. A transmission duration of 12 hours is usually more than adequate to ensure reception of all data collected during the cycle. The Argos satellite system receives the data and calculates the float's location during this transmission period.

4.2 Descent

While the float is still at the sea surface PROVOR-DO measures and records its pressure sensor offset. This offset is used to correct all pressure measurements. The offset is transmitted in a technical message (see **section 6. page 26)** for a description of the technical message format). Descent takes the float from the sea surface to the drift depth. Initially, in order to avoid possible collisions with ships, PROVOR-DO's objective is to lose buoyancy in the shortest possible time. It does this by opening the solenoid valve for a time period that is initially long, but decreases as the float approaches its target depth.

If the user chooses, PROVOR-DO will collect CTDO measurements during descent or during ascent. The interval between CTDO measurements is user-programmable.

4.3 Grounding

PROVOR-DO monitors itself for possible grounding on the seabed. During descent to drift depth, if the pressure remains unchanged for too long, PROVOR-DO enters a correction mode. The user selects one of two available modes during Mission programming before launch (technical parameter PT10) :

- Grounding Mode = 0: The pre-programmed drift depth is disregarded. The pressure at the time of grounding minus an offset (5 bar) is taken as the new value for the drift pressure. The float adjusts its buoyancy to reach this new drift depth. The drift depth reverts to its programmed value for subsequent cycles.
  If the grounded pressure is lower than a programmed threshold (20 bar), the float remains on the seabed until the next programmed ascent time.
- Grounding Mode = 1: the float remains where it is until the next scheduled ascent time. The pressure measured at grounding becomes the profile start pressure for the cycle in progress. The profile start pressure reverts to its programmed value for subsequent cycles.

4.4 Submerged Drift

While PROVOR-DO is drifting at drift depth, it checks the external pressure every 30 minutes to determine whether there is need either for depth adjustment or for an emergency ascent.

If the measured pressure differs from the drift depth pressure by more than a specified tolerance, and this difference is maintained, PROVOR-DO adjusts its buoyancy to return to the drift depth.

If the pressure increases by an amount that exceeds a factory-set danger threshold, PROVOR-DO immediately ascends to the sea surface.

If the user chooses, PROVOR-DO will collect CTDO measurements at user-selected intervals during submerged drift.

4.5 Ascent

If the chosen ascent profile starting pressure is higher than the drift pressure, the float must first descend to reach the profile starting pressure.

If grounding is detected while PROVOR-DO is descending to the profile starting pressure, the present pressure is substituted for the profile starting pressure. This substitution is only for the cycle in progress; the profile starting pressure reverts to its pre-programmed value for subsequent cycles.

Once the profile starting pressure has been reached, the float waits for the programmed time to begin the ascent. If this time is reached before the float has arrived at the profile starting pressure, the ascent starts immediately.

PROVOR-DO ascends by repeated use of the pump. When the pressure change between two successive measurements is less than 1 bar, the pump is activated for a pre-set time period. In this way, the pump performs minimum work at high pressure, which ensures minimum electrical energy consumption. The average speed of ascent is approximately 10cm/sec. For a 2,000m profile, the ascent would therefore last 6 hours.

When the pressure drops below 1 bar (signifying completion of ascent), PROVOR-DO waits 10 minutes and then activates the pump in order to empty the reservoir and achieve maximum buoyancy. If the user chooses, PROVOR-DO will collect CTDO measurements during descent and/or ascent. CTDO measurements begin at the profile start time and stop 10 minutes after the float rises above the 1 bar isobar in its approach to the sea surface. The interval between CTDO measurements is user-programmable. For example, during a profile beginning at 2,000 m with a 10 sec sampling period, 2,200 CTDO measurements will be collected.

4.6 Transmission

The data transmission process takes into account the limitations of the Argos data collection system, including:

- the flight frequency of the satellites above the experiment zone;
- the uncertainty of the float's antenna emerging in rough seas;
- radio propagation uncertainties due to weather conditions, and;
- the satellites' operational status.

PROVOR-DO creates transmission messages from the stored data. The transmission of all messages is repeated until the total duration of transmissions exceeds the user-programmed minimum duration. The interval between transmissions is also user-programmable.

Please refer to **section 6. page 26** for a detailed description of the transmitted message formats.

5 PROVOR-DO PARAMETERS

PROVOR-DO's configuration is determined by the values of its mission and Argos parameters defined below. Instructions on how to read and change the values of these parameters are provided in sections 2.5.5. page 12. The following table summarizes all parameter names, ranges and default values (Software YLA5817A0x).

Command no.	Name	Default Value	Units
Mission Parameters			
PM0	Number of Cycles	**255**	**Whole number**
PM1	Cycle Period	**10**	**Days**
PM2	Reference Day	**2**	**Number of days**
PM3	Estimated time at the surface	**6**	**Hours**
PM4	Delay Before Mission	**0**	**Minutes**
PM5	Descent Sampling Period	**0**	**Seconds**
PM6	Drift Sampling Period	**12**	**Hours**
PM7	Ascent Sampling Period	**10**	**Seconds**
PM8	Drift Depth	**1000**	**dbar**
PM9	Profile Depth	**2000**	**dbar**
PM10	Threshold surface/Middle Pressure	**10**	**dbar**
PM11	Threshold Middle/Bottom Pressure	**200**	**dbar**
PM12	Thickness of the surface slices	**1**	**dbar**
PM13	Thickness of the middle slices	**10**	**dbar**
PM14	Thickness of the bottom slices	**25**	**dbar**
PM15	End of life Iridium Period (Not Used)	**60**	
PM16	Wait Inter-Cycles (Not used)	**0**	
PM17	Optode type (0: 3830, 1 : 4330)	**1**	
Argos Parameters			
PA0	Argos Transmission Period	**40**	**Seconds**
PA1	Argos Transmission Period at Life Expiry	**100**	**Seconds**
PA2	Retransmission	**25**	**Whole number**
PA3	Argos Transmission Duration	**1**	**Hours**
PA4	Number of Argos addresses	**1**	**Whole number**
PA5	Argos ID[0 .. 6]	**0000000**	**Hexa**
	Argos ID 2[0 .. 6]	**0000000**	**Hexa**
	Argos ID 3[0 .. 6]	**0000000**	**Hexa**
	Argos ID 4[0 .. 6]	**0000000**	**Hexa**
PA6	Argos transmission test time upon launch, before surfacing adjustment.	**180**	**Minutes**
PA7	Offset on transmission frequency in hundreds of Hertz, here: 401.6**53 0**00 MHz	**530**	**Hundreds of Hertz**

Table 1 - Summary of PROVOR-DO user-programmable parameters

5.1 Mission Parameters

PM(0) Number of Cycles

This is the number of cycles of descent, submerged drift, ascent and transmission that PROVOR-DO will perform. The mission ends and PROVOR-DO enters Life Expiry mode when this number of cycles has been completed.

The capacity of PROVOR-DO's batteries is sufficient for at least 180 cycles. If you wish to recover float at the end of the mission, you must set the number of cycles at less than 180 to ensure there is sufficient battery capacity remaining to allow float to return to the sea surface and enter Life Expiry.

Under favourable conditions, the battery capacity may exceed 180 cycles. If you do not plan to recover the PROVOR-DO float, you may choose to set the number of cycles to 180 to ensure that PROVOR-DO completes the maximum number of cycles possible.

PM(1) Cycle Period (days)

The duration of one cycle of descent, submerged drift, ascent and transmission. PROVOR-DO waits submerged at the drift depth for as long as necessary to make the cycle the selected duration.

PM(2) Reference Day (number of days)

Allows you to configure a group of floats so that they all conduct their profiles at the same time. The parameter defines a particular day on which the first profile is to be made. When the float's internal clock's day number equals the reference day, it will conduct its first profile. The float's internal clock day number is set to zero when the mission starts. When setting the reference day, it is recommended to allow enough time between the deployment and reach of profiling depth. Using a reference day of at least 2 will ensure the first profile is complete.

PM(3) Estimated Time on Surface (hours)

Estimated time float must reach surface.

PM(4) Delay Before Mission (minutes)

To prevent PROVOR-DO from trying to sink while still on deck, the float waits for this time before commanding the buoyancy engine to start the descent. After disconnection of the PC, followed by removal of the magnet, PROVOR-DO will wait for this delay before beginning the descent. The delay is measured after the first start of the pump which confirms the removal of the magnet (see **section 2.4.1. page 7**) and before the start of the descent.

PM(5) Descent Sampling Period (seconds)

The time interval between successive CTDO measurements during descent. If this parameter is set to 0 seconds, no profile will be carried out during the descent phase. Nevertheless, due to the ARGO requirements, the first descent profile of the mission is automatically done even if the parameter was equal to 0.

PM(6) Drift Sampling Period (hours)

The time interval between successive CTDO measurements during PROVOR-DO's stay at the drift depth.

PM(7) Ascent Sampling Period (seconds)

The time interval between successive CTDO measurements during ascent.

PM(8) Drift Depth (dbar)

The depth at which PROVOR-DO drifts after completion of a descent while awaiting the time scheduled for the beginning of the next ascent.

PM(9) Profile Depth (dbar)

Depth at which profiling begins if in an ascending profile. If PROVOR-DO is drifting at some shallower depth, it will first descend to the profile depth before starting the ascent profile.

PM(10) Threshold Surface/Middle Pressure (dbar)

The isobar that divides surface depths from middle depths for the purpose of data reduction.

PM(11) Threshold Middle/Bottom Pressure (dbar)
The isobar that divides Middle depths from Bottom depths for the purpose of data reduction.

PM(12) Thickness of the Surface slices (dbar)
Thickness of the slices for surface depths (algorithm of data reduction).

PM(13) Thickness of the Middle slices (dbar)
Thickness of the slices for Middle depths (algorithm of data reduction).

PM(14) Thickness of the bottom slices (dbar)
Thickness of the slices for deep depths (algorithm of data reduction).

PM(15) End Of Life Iridium Period (Not used)

PM(16) Wait Inter-Cycles (Not Used)

PM(17) Optode Type
Set Optode type mounted on float, 0 : 3830, 1 : 4330.

5.2 Argos Parameters

PA(0) Argos Transmission Period (seconds)
The time interval between successive Argos transmissions. If you use a short transmission period, Argos messages will be sent more frequently, improving the chances of reception. However, a shorter period also increases the fees charged to you by Argos. You must request the period that you want from Argos, and then you must use the value that they assign.

PA(1) Argos Transmission Period at Life Expiry (seconds)
The time interval between successive Argos transmissions. If you use a short transmission period, Argos messages will be sent more frequently, improving the chances of reception. However, a shorter period also increases the fees charged to you by Argos. You must request the period that you want from Argos, and then you must use the value that they assign.

PA(2) Retransmission
Argos messages retransmission. Retransmission rate is calculated according to the number of messages to transmit.

PA(3) Argos Transmission Duration (hours)
The time that PROVOR-DO will remain on the surface transmitting its data at the end of each cycle. At lower latitudes you may wish to increase the value of this parameter to increase the probability of reception of all of your data.

PA(4) Number of Argos addresses
The number of addresses for the Argos transmitter. Up to 4 identification numbers are available. Argos transmission period between each Argos messages is divided by the Number of ARGOS ID.

PA(5) Argos ID
The identification number for the Argos transmitter. It is a 7-character hexadecimal number. This parameter must be set to the value provided by Argos. It is always possible to use an old Argos ID onto 5-character hexadecimal number. Then, the two last digits must be set to 00.

PA(6) Argos transmission test time upon launch, before surfacing adjustment.

PA(7) Transmission frequency
This is the offset, in hundreds of Hertz, of the ARGOS transmission frequency.
Ex.: 480 gives a transmission frequency of 401.6**480**000 MHz
This value is added to the frequency 401.6000 MHz

6 ARGOS FORMATS

6.1 ARGOS Reminder

6.1.1 Reminder on ARGOS principle

ARGOS system is used to locate any mobile (ocean or meteorological buoy, animal, fishing vessel, etc.) carrying an ARGOS transmitter to within 300 meters and better and to collect data from sensors connected to the transmitter.

CLS is the worldwide operator of ARGOS satellites systems. From this system, CLS supplies platform location and scientific data collection.

The working principle of the ARGOS system is the following:

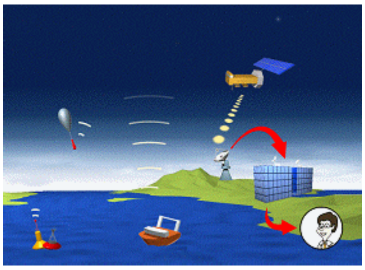


Figure 2 - ARGOS principle

(1) ARGOS transmitters automatically send messages that are received by satellites in low-earth orbit.
(2) Satellites relay messages to ground stations.
(3) Ground stations forward messages to processing centers. These centers calculate the transmitter locations and process any sensor data.
(4) The user access its results from its closest processing center.

6.1.2 Reminder on ARGOS Facilities

Figure 3 - ARGOS worldwide facilities

Five interlinked processing centers and 18 receiving stations worldwide provide continuous location and data collection service, and access to results.

6.2 Overview

The data transmission process begins as soon as an ascent profile is completed. It starts with reduction of the data. PROVOR-DO then formats and transmits the message. The reduction of data processing consists in storing the significant points of the CTDO quartets arithmetic mean with the layer format.

For a given descent-drift-ascent-transmit cycle, the transmission of all of the data will usually require several messages of the same type.

To improve the probability of reception, data are transmitted several times. The number of repetitions depends upon the quantity of data to be transmitted, the transmission period and the programmed minimum transmission duration. Messages are sent in a random sequence in order to minimize the chance of accidental synchronization of one message with some form of transmission interference.

To provide the reception of a continuous profile, messages contain one CTDO quartet in two. This allows reconstruction of the profile when a message is lost. Example:

Message N: { quartet 1 ; quartet 3 ; quartet 5 ; quartet 7 ; quartet 9 ;.. quartet

21} Message N+1 { quartet 2 ; quartet 4 ; quartet 6 ; quartet 8 ;... quartet 22 }.

The content of the Argos messages consists of a preamble of 28 bits, followed by:

- the 20-bit Argos PTT identification number;
- the 8-bit Argos PTT identification complement;
- the data frame, consisting of 31 words of 8 bits (248 bits).

Four types of messages are generated according to the content of the data frame:

- Type 0100: Descent profile CTDO message
- Type 0101: Submerged drift CTDO message
- Type 0110: Ascent profile CTDO message
- Type 0000: Technical message

The three types of CTDO messages all contain recorded physical measurements. The technical message contains data regarding the configuration and functioning of the float and its buoyancy control mechanism.

The message type is formed from bits 1 to 4 of the data frame. The formatting of the data frame for each message type is described in the pages that follow.

6.3 Descent profile CTDO Message

Data	Format	Bit Number
28 bits ARGOS ID complement	8 bits	1 to 8
Message type (type = 0100)	4 bits	9 to 12
CRC	16 bits	13 to 28
Date of the first CTDO measurement	9 bits	29 to 37
First pressure measurement	11 bits	38 to 48
First temperature measurement	15 bits	49 to 63
First salinity measurement	15 bits	64 to 78
First Oxygen Measurement	13 bits	79 to 91
CTDO measurements	165 bits	92 to 256

6.3.1 Cyclic Redundancy Check

The CRC type used is the CRC-CCITT of which the polynomial is $X^{16} + X^{12} + X^5 + 1$. The exclusive OR of the result is tested. The calculation of the CRC is carried out on the 256 bits of the message (the 248 bits of the message + 8 bits set to 0), the 16 bits (bits 5 to 20) reserved for the CRC being set to 0.

6.3.2 CTDO Quartets

The stored quartets are sent in the same order in which they were collected - that is, in order of decreasing depth for ascent profiles. Measurements within a quartet are sent in the sequence - pressure, temperature, salinity, Oxygen.

Only the first quartet is dated. It is dated with the time of the profile start. The time counts from the time of the descent at the beginning of the first cycle, which is time = 0. The least significant bit represents 1 minute.

Subsequent quartets correspond to alternating data points in the profile (for example, number of measurements 1, 3, 5, 7, ...). Interleaving data points are sent in another message. This technique minimizes the impact of the loss of any one data message.

The CTDO measurements starting from bit 92 (measurement numbers 3, 5, 7, etc.) are coded either as absolute measurements or as relative measurement. The first bit of each measurement is a format bit that indicates whether the reading is absolute (format bit = 0) or relative (format bit = 1).

6.3.3 Pressure Coding

Depending upon the value of the first bit, it is followed by either 6 or 11 data bits. If the difference between the current pressure measurement, Pn, and the previous pressure measurement, Pn-1, is less than 63 dbar, the difference, |Pn - Pn-1|, is expressed in 6 bits. Otherwise, the pressure measurement is coded in 11 bits as an absolute measurement. Pressure is reported in the range 0 dbar to +2047 dbar with a resolution of 1 dbar.

6.3.4 Temperature Coding

Depending upon the value of the first bit, it is followed by either 10 or 15 data bits. If the difference between the current temperature measurement and the previous temperature measurement (Tn - Tn-1) is included in the closed interval [-0.923 °C, +0.100 °C], the difference -(Tn - Tn-1 - 0.1 °C) is coded into 10 bits.

The decoding will carry out the following operation: (- Ttransmitted + 0.1 °C)

Otherwise the measurement is absolutely coded in 15 bits with an offset of - 2 °C. The temperature is reported in the range -2°C to + 30.767°C, with a resolution of 0.001°C.

6.3.5 Salinity Coding

Depending upon the value of the first bit, it is followed by either 8 or 15 data bits. If the difference between the current salinity measurement and the previous salinity measurement (Cn - Cn-1) is included in the closed interval [-0.230 PSU ; +0.025 PSU], the difference -(Cn - Cn-1 -0.025PSU) is expressed in 8 bits.

The decoding will carry out the following operation: (- Ctransmitted + 0.025PSU)

Otherwise, the measurement is absolutely coded in 15 bits with an offset of 10 PSU. Salinity is reported in the range of 10 PSU to 42.767 PSU with a resolution of 0.001 PSU.

6.3.6 Dissolved Oxygen coding

State of 1st bit indicates the following type of coding (0: absolute, 1 : relative) : 9 or 13 data bits. If the difference between the current TCPhase and the previous one is included in the closed interval [-2.048 ; +2.047]°, the difference (On – On_1) is expressed in 9 bits with a 0.008° resolution.

Otherwise, the measurement is absolutely coded in 13 bits representing the 10.000 to 75.000 ° range with a gap of 10° and a 0.008° resolution (I.e. a range of [0;65000] is transmitted in ARGOS). In relative the coded value for the 9 bits message is the following : (On – O(n-1) + 256) with a 0.008° resolution.

Note that a default of sensor for the cycle in progress is identified by a value transmitted at 0x1FFF, i.e. 8192 in decimal [default also characterized by a modification of the state of the oxygen sensor in the technical message].

6.4 Submerged Drift CTDO Message

Data	Format	Bit Number
28 bits ARGOS ID complement	8 bits	1 to 8
Message type (type = 0101)	4 bits	9 to 12
CRC	16 bits	13 to 28
Date of the first CTDO measurement	6 bits	29 to 34
Time of first CTDO measurement	5 bits	35 to 39
First pressure measurement	11 bits	40 to 50
First temperature measurement	15 bits	51 to 65
First salinity measurement	15 bits	66 to 80
First oxygen measurement	13 bits	81 to 93
CTDO measurements	163 bits	94 to 256

6.4.1 Cyclic Redundancy Check

CRC coding is as described above for the Ascent/Descent Profile CTDO Message.

6.4.2 CTDO Quartets

Only the first quartet is dated. The day number counts from the date at the beginning of the descent (for transmitted cycle that is also coded in technical message, in 4th field). The hour number is the hour of the first measurement, relative to the descent start time. The least significant bit are 1 day (Date) & 1 hour (Time).

The stored quartets are sent in the same order in which they were collected. Measurements within a quartet are sent in the sequence - pressure, temperature, salinity.

Subsequent quartets correspond to alternating data points in the profile (for example, number of measurements 1,3, 5, 7, ...). Interleaving data points are sent in another message. This technique minimizes the impact of the loss of any one data message.

The CTDO measurements starting from bit 94 (measurement numbers 3, 5, 7, etc.) are coded either as absolute measurements or as relative measurement. The first bit of each measurement is a format bit that indicates whether the reading is absolute (format bit = 0) or relative (format bit = 1).

6.4.3 Pressure Coding

If the difference between the current pressure sample, Pn , and the previous pressure sample, Pn-1 , is included in the closed interval [-31 dbar, +32 dbar], the coding of the difference, |Pn - Pn-1|, is carried out into 6 bits two's-complement. Otherwise the pressure sample is coded in 11 bits as an absolute measurement. Pressure data is limited to the maximum value of 2,047 dbar.

6.4.4 Temperature Coding

Depending upon the value of the first bit, it is followed by either 10 or 15 data bits. If the difference between the current temperature measurement and the previous temperature measurement (Tn - Tn-1) is included in the closed interval [-0.512 °C, +0.511 °C], the difference (Tn - Tn-1) is coded into 10 bits two's- complement. Otherwise the measurement is absolutely coded in 15 bits with an offset of - 2 °C. The temperature is reported in the range -2°C to + 30.767°C, with a resolution of 0.001°C.

6.4.5 Salinity Coding

Depending upon the value of the first bit, it is followed by either 8 or 15 data bits. If the difference between the current salinity measurement and the previous salinity measurement (Cn - Cn-1) is included in the closed interval [-0.128 PSU ; +0.127 PSU], the difference (Cn-Cn-1) is expressed in 8 bits two's- complement. Otherwise, the measurement is absolutely coded in 15 bits with an offset of 10 PSU. Salinity is reported in the range of 10 PSU to 42.767 PSU with a resolution of 0.001 PSU.

6.4.6 Oxygen Coding

Identical to descent Profile.

6.5 Ascent profile CTDO Message

Data	Format	Bit Number
28 bits ARGOS ID complement	8 bits	1 to 8
Message type (type = 0110)	4 bits	9 to 12
CRC	16 bits	13 to 28
Date of the first CTDO measurement	9 bits	29 to 37
First pressure measurement	11 bits	38 to 48
First temperature measurement	15 bits	49 to 63
First salinity measurement	15 bits	64 to 78
First oxygen measurement	13 bits	79 to 91
CTDO measurements	165 bits	92 to 256

6.5.1 Cyclic Redundancy Check

The CRC type used is the CRC-CCITT of which the polynomial is $X^{16} + X^{12} + X^5 + 1$. The exclusive OR of the result is tested. The calculation of the CRC is carried out on the 256 bits of the message (the 248 bits of the message + 8 bits set to 0), the 16 bits (bits 5 to 20) reserved for the CRC being set to 0.

6.5.2 CTDO Quartets

The stored quartets are sent in the same order in which they were collected - that is, in order of decreasing depth for ascent profiles. Measurements within a quartet are sent in the sequence - pressure, temperature, salinity.

Only the first quartet is dated. It is dated with the time of the profile start. The time counts from the time of the descent at the beginning of the first cycle, which is time = 0. The least significant bit represents 1 minute.

Subsequent quartets correspond to alternating data points in the profile (for example, number of measurements 1, 3, 5, 7, ...). Interleaving data points are sent in another message. This technique minimizes the impact of the loss of any one data message.

The CTDO measurements starting from bit 92 (measurement numbers 3, 5, 7, etc.) are coded either as absolute measurements or as relative measurement. The first bit of each measurement is a format bit that indicates whether the reading is absolute (format bit = 0) or relative (format bit = 1).

6.5.3 Pressure Coding

Depending upon the value of the first bit, it is followed by either 6 or 11 data bits. If the difference between the current pressure measurement, Pn, and the previous pressure measurement, Pn-1, is less than 63 dbar, the difference, |Pn - Pn-1|, is expressed in 6 bits. Otherwise, the pressure measurement is coded in 11 bits as an absolute measurement. Pressure is reported in the range 0 dbar to +2047 dbar with a resolution of 1 dbar.

6.5.4 Temperature Coding

Depending upon the value of the first bit, it is followed by either 10 or 15 data bits. If the difference between the current temperature measurement and the previous temperature measurement (Tn - Tn-1) is included in the closed interval [-0.100 °C, +0.923 °C], the difference (Tn - Tn-1 + 0.1 °C) is coded into 10 bits.

The decoding will carry out the following operation: (Ttransmitted - 0.1 °C)

Otherwise the measurement is absolutely coded in 15 bits with an offset of - 2 °C. The temperature is reported in the range -2°C to + 30.767°C, with a resolution of 0.001°C.

6.5.5 Salinity Coding

Depending upon the value of the first bit, it is followed by either 8 or 15 data bits. If the difference between the current salinity measurement and the previous salinity measurement (Cn - Cn-1) is included in the closed interval [-0.025 PSU ; 0.230 PSU], the difference (Cn - Cn-1 + 0.025PSU) is expressed in 8 bits.

The decoding will carry out the following operation: (Ctransmitted - 0.025PSU).

Otherwise, the measurement is absolutely coded in 15 bits with an offset of 10 PSU. Salinity is reported in the range of 10 PSU to 42.767 PSU with a resolution of 0.001 PSU.

6.5.6 Oxygen Coding

Identical to descent Profile.

6.6 Technical Message

For each complete set of CTDO messages sent, the technical message is sent one and one-half times. Thus, for two complete sets of CTDO messages sent, there will be three technical messages.

Data	Format	Bit Number
28 bits ARGOS ID complement	8 bits	1 to 8
message type (type = 0000)	4 bits	9 to 12
CRC	16 bits	13 to 28
descent start time	8 bits	29 to 36
number of valve actions at the surface	7 bits	37 to 43
float stabilisation time	8 bits	44 to 51
float stabilisation pressure	8 bits	52 to 59
number of valve actions in descent	4 bits	60 to 63
number of pump actions in descent	4 bits	64 to 67
end of descent time	8 bits	68 to 75
number of repositions	4 bits	76 to 79
time at end of ascent	8 bits	80 to 87
number of pump actions in ascent	5 bits	88 to 92
number of descent CTDO messages	5 bits	93 to 97
number of drift CTDO messages	5 bits	98 to 102
number of ascent CTDO messages	5 bits	103 to 107
number of descent slices in shallow zone	7 bits	108 to 114
number of descent slices in deep zone	8 bits	115 to 122
number of ascent slices in shallow zone	7 bits	124 to 129
number of ascent slices in deep zone	8 bits	130 to 137
number of CTDO measurements in drift	8 bits	138 to 145
Float's time (hh+mm+ss)	17 bits	146 to 162
pressure sensor offset	6 bits	163 to 168
internal pressure	3 bits	169 to 171
max pressure in descent to parking depth	8 bits	172 to 179
profile ascent start time	8 bits	180 to 187
number of entrance in drift target range (descent)	3 bits	188 to 190
minimum pressure in drift (bars)	8 bits	191 to 198
maximum pressure in drift (bars)	8 bits	199 to 206
grounding detected (grounding = 1, No grounding = 0)	1 bit	207
number of hydraulic valve action in descent profile	4 bits	208 to 211
number of pump actions in descent profile	4 bits	212 to 215
max pressure in descent or drift to Pprofile (bars)	8 bits	216 to 223
number of re-positioning in profile stand-by	3 bits	224 to 226
batteries voltage drop at Pmax, pump ON (with regard to Unom = 10.0 V) (in dV)	5 bits	227 to 231
profile descent start time	8 bits	232 to 239
profile descent stop time	8 bits	240 to 247
RTC state indicator (normal = 0, failure = 1)	1bit	248
number of entrance in profile target range (descent)	3 bits	249 to 251
Oxygen sensor state indicator (normal = 0, failure = 1)	1 bits	252
not used	4 bits	253 to 256

Tableau 2 - Technical Message

6.6.1 Descent Data

- Descent start time is expressed in tenths of an hour since midnight.
- Number of solenoid valve actions at the surface until the crossing of the 8 dbar threshold is an integer from 1 to 127 (modulo 128).
- Float stabilisation time after the crossing of the 8 dbar threshold is expressed in tenths of an hour.
- Float stabilisation pressure after crossing the 8 dbar threshold is coded in 8 bits with least significant bit = 1 bar.
- Number of solenoid valve actions carried out to reach the target pressure after crossing the 8 dbar threshold.

6.6.2 Drift Data

- Minimum and maximum pressure in drift collected during the hydraulics measurements.
- Grounding detected during the dive (Boolean).

6.6.3 Ascent Data

- Time at end of ascent is the time at the end of the pump action after surfacing. It is expressed in tenths of an hour.
- Number of pump actions in ascent (at the target pressure until the crossing of the threshold of 1 bar), expressed in 5 bits.

6.6.4 Housekeeping Data

- Pressure sensor offset is measured at the surface. Least significant bit = 1 cbar
  Range: -32 cbar to +31 cbar
- Internal pressure is measured at the end of the ascent and before the Mission start. Measurements are given in 25 mbar steps starting from 725 mbar and are coded in 3 bits:

000	#725 mbar
001	726 mbar to 750 mbar
010	751 mbar to 775 mbar
011	776 mbar to 800 mbar
100	801 mbar to 825 mbar
101	826 mbar to 850 mbar
110	851 mbar to 875 mbar
111	>875 mbar

6.7 Life Expiry Message

Life expiry messages are transmitted when the float is drifting on the surface and has completed transmission of all data from the last cycle of the Mission. Life Expiry mode continues until the recovery of the float or depletion of the battery.

These transmissions - unlike other transmissions - occur at 100-sec intervals. The content of the life expiry message is identical to the technical message (see **page 30)**.

7 SPECIFICATIONS

- Storage

Temperature range... -20°C to +50°C
Storage time before expiry ....up to 1 year

- Operational

Temperature range.. 0°C to +40°C
Pressure at drift depth .... 40 bar to 200 bar
Depth maintenance accuracy ....± 3 bar typical (adjustable)
Survival at sea ....up to 3 years
Maximum number of cycles...up to 255 cycles

- Mechanical

Length

with antenna ....#220 cm

Diameter

casing ....17 cm
damping disk .... 35 cm
Weight 35kg
Material... anodized aluminum casing

- Sensors

Salinity

range...................... .... 10 to 42 PSU
initial accuracy .... ± 0.005 PSU
resolution.. 0.001 PSU

Temperature

range... .... -3°C to +32°C
initial accuracy ....± 0.002°C
resolution..0.001°C

Pressure

range... .... 0 bar to 2500 dbar
initial accuracy .... ± 2.4 dbar*
resolution..0.1 dbar
Offset adjusted when surfacing

Oxygen

range... .... 0 bar to 500 µM/l l
initial accuracy .... ±8 µM/l (if < 160 µM/l) or 5% (if >160 µM/l)
resolution..< 1 µM/l

(*) offset has to be adjusted at each surfacing

8 PROVOR-DO OPERATING PRINCIPLE

Movement of the float through its profile is accomplished by a pump and valve system. The pump transfers oil from the inner reservoir to the outer bladder. Oil moves back to the reservoir when the valve is opened- -driven by the difference between the float's internal and external pressures.

As seen in figure below, the float's speed of ascent oscillates. This oscillation is due to the way in which the float's controller regulates its speed. The controller, using depth measurements from the float's pressure sensor, calculates the change in depth over a set period of time. With this information, the controller determines the float's speed.

When ascending, if the calculated speed is lower than desired, the pump is activated for about 10 seconds, pumping oil into the outer bladder. This produces an increase in buoyancy, which increases the speed of ascent.

As the float rises to shallower depths, its buoyancy decreases, causing the ascent speed to also decrease. When the calculated speed is too low, the pump is activated again.

This cycle repeats until the float reaches the surface.

The same regulating method is used to control the float's descent speed, by opening the valve and allowing oil to flow from the external bladder to the internal reservoir.

Why does PROVOR-DO's speed decrease as it ascends?

The buoyancy of a float is determined principally by its mass and its volume, but another factor, hull compressibility, also plays an important role. As PROVOR-DO ascends, the decrease in water density reduces the float's buoyancy. At the same time, the decrease in water pressure causes PROVOR-DO's hull to expand, which increases the float's buoyancy. The two effects tend to counteract each other.

Because PROVOR-DO's compressibility is actually less than that of sea water, the decrease in buoyancy due to decreasing water density is greater than the increase in buoyancy due to hull expansion. This causes PROVOR-DO's speed of ascent to decrease as it rises in the water column.

Conversely, as the float descends, the increasing water density increases the buoyancy more than the decreasing buoyancy from hull compression. This causes PROVOR-DO's speed of descent to slow as it goes deeper.

To reduce the probability of contact with ships, PROVOR-DO's target speed during the initial stage of descent is high at shallow depths. This minimizes the time during which the float is at risk of damage.

To slow the float's descent, its controller is programmed with a series of depths at which the descent speed is halved until it reaches the target depth.

9 LITHIUM BATTERY

All batteries, both lithium batteries and batteries with other chemical elements, contain large quantities of stored energy. This is, of course, what makes them useful, but it also makes them potentially hazardous.

If correctly handled, neither alkaline nor lithium batteries present any risk to humans or the environment. Improper handling of these batteries presents potential risks to humans, but does not present an environmental risk.

The energy stored in a battery cell is stored in chemical form. Most batteries contain corrosive chemicals. These chemicals can be released if the cells are mishandled. Mishandling includes:

- short-circuiting the cells;
- (re)charging the cells;
- puncturing the cell enclosure with a sharp object;
- exposing the cell to high temperatures.

WARNING: BOTH ALKALINE AND LITHIUM BATTERIES MAY EXPLODE, PYROLIZE OR VENT IF MIS-HANDLED. DO NOT DISASSEMBLE, PUNCTURE, CRUSH, SHORT-CIRCUIT, (RE)CHARGE OR INCINERATE THE CELLS. DO NOT EXPOSE CELLS TO HIGH TEMPERATURES.

The lithium thionyl chloride cells used in PROVOR-DO floats incorporate sealed steel containers, warning labels and venting systems to guard against accidental release of their contents.

WARNING: IF A BATTERY SPILLS ITS CONTENTS DUE TO MISHANDLING, THE RELEASED CHEMICALS AND THEIR REACTION PRODUCTS INCLUDE CAUSTIC AND ACIDIC MATERIALS, SUCH AS HYDROCHLORIC ACID (HCL) IN THE CASE OF LITHIUM THIONYL CHLORIDE BATTERIES, AND POTASSIUM HYDROXIDE (KOH) IN THE CASE OF ALKALINE BATTERIES. THESE CHEMICALS CAN CAUSE EYE AND NOSE IRRITATION AND BURNS TO EXPOSED FLESH.

The hazard presented by these chemicals is comparable to that presented by common domestic cleaning materials like bleach, muriatic acid or oven cleaner.

Inevitably, the battery contents will eventually be released into the environment, regardless of whether the cells are deliberately dismantled or simply disintegrate due to the forces of nature. Because of their highly reactive nature, battery materials disintegrate rapidly when released into the environment. They pose no long-term environmental threat. There are no heavy metals or chronic toxins in PROVOR-DO's lithium cells. Indeed, a recommended safe disposal method for thionyl chloride lithium cells is to crush them and dilute them in sufficient quantities of water.

Discharged batteries pose a greatly reduced threat, as the process of discharging them consumes the corrosive chemicals contained in them.

In summary, PROVOR-DO's lithium battery poses no significant or long-term environmental threats. Any threats that they do present, are short-term threats to the safety of persons mishandling the cells. These safety threats are similar to those of other common household-use materials. These threats are reduced when the cells are discharged - and exist only if the cells are mishandled in extreme ways. These threats are the same as those presented by the alkaline cells widely used by consumers.

10 GLOSSARY

CPU
Central Processing Unit. In the context of PROVOR-DO, this term denotes the board that ensures the running and control of the system.

COM1, COM2.
Serial communication ports.

dbar.
1/10 bar = 1 decibar Unit of pressure used for PROVOR-DO. It roughly corresponds to a depth of 1m.

IFREMER
Institut Français pour la Recherche et l'Exploitation de la MER (French Institute for the Research and the Exploitation of the Sea).

Mission
The portion of PROVOR-DO's life that consists of a number of repeating cycles of descent, submerged drift, ascent and data transmission.

PC
Personal Computer; IBM-PC compatible.

CTDO
Celerity (for salinity), Temperature, Depth and Oxygen

PROVOR-DO
Name given to the drifting profiler developed by **nke** and IFREMER.

PTT
Platform Terminal Transmitter (Argos transmission electronics).

Quartet
Set of four measurements (Salinity, Temperature, Depth and dissolved oxygen) all taken at the same time.

RS232
Widely recognized standard for the implementation of a serial data communication link.

Two's-complement
A system for representation of negative numbers in binary notation. The decimal equivalent of a two's-complement binary number is computed in the same way as for an unsigned number, except that the weight of the most significant bit is -2n-1 instead of +2n-1.

VT52, VT100
Video Terminal, type 52 or 100
Computer terminals developed by Digital Equipment Corporation (DEC). They are considered standard in the field.

Fabriqué par / Manufactured by

Nke
Z.I de KERANDRE - RUE GUTENBERG
56700 HENNEBONT - FRANCE
Telephone: +33 (0)2 97 36 10 12 Fax: +33 (0)2 97 36 55 17
Web : http://www.nke.fr - E-mail : info.instrumentation@nke.fr