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PROVOR CTS2
USER'S MANUAL

Nom Dépt / Service Entreprise	Visa	Nom Dépt / Service Entreprise	Visa	Nom Dépt / Service Entreprise	Visa	Date	Ind.
JC BOIGUES ARGOS SERPE-IESM		JC BOIGUES ARGOS SERPE-IESM		P BRAULT ARGOS SERPE-IESM		07/10/04	B
JC BOIGUES ARGOS SERPE-IESM		JC BOIGUES ARGOS SERPE-IESM		P BRAULT ARGOS SERPE-IESM		04/08/03	A
Evolution							
Nom Dépt / Service Entreprise	Visa	Nom Dépt / Service Entreprise	Visa	Nom Dépt / Service Entreprise	Visa	Date	Ind.
Rédigé par		**Vérifié par**		**Approuvé par**		**Version**	

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1. Introduction

PROVOR is a subsurface profiling float developed jointly by IFREMER (l' Institut Français pour la Recherche et l' Exploitation de la Mer - the French Institute for the Research and the Exploitation of the Sea) and MARTEC Group.
The PROVOR 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). It is expected to have an array of 3,000 free-drifting profiling floats by the year 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 initialisation 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's mission consists of a repeating cycle of descent, submerged drift, ascent and data transmission. During these cycles, PROVOR 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 continually samples the pressure at this drift depth and maintains that depth within approximately 30 m.
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 2,000 m) is not necessarily the same as the drift depth.
During its mission, PROVOR collects measurements of three parameters – salinity, temperature and depth (CTD) -- 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 transmits its saved data to 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 float, how to use it and safety precautions to be observed during handling.
Please read this manual carefully to ensure that PROVOR functions as intended.

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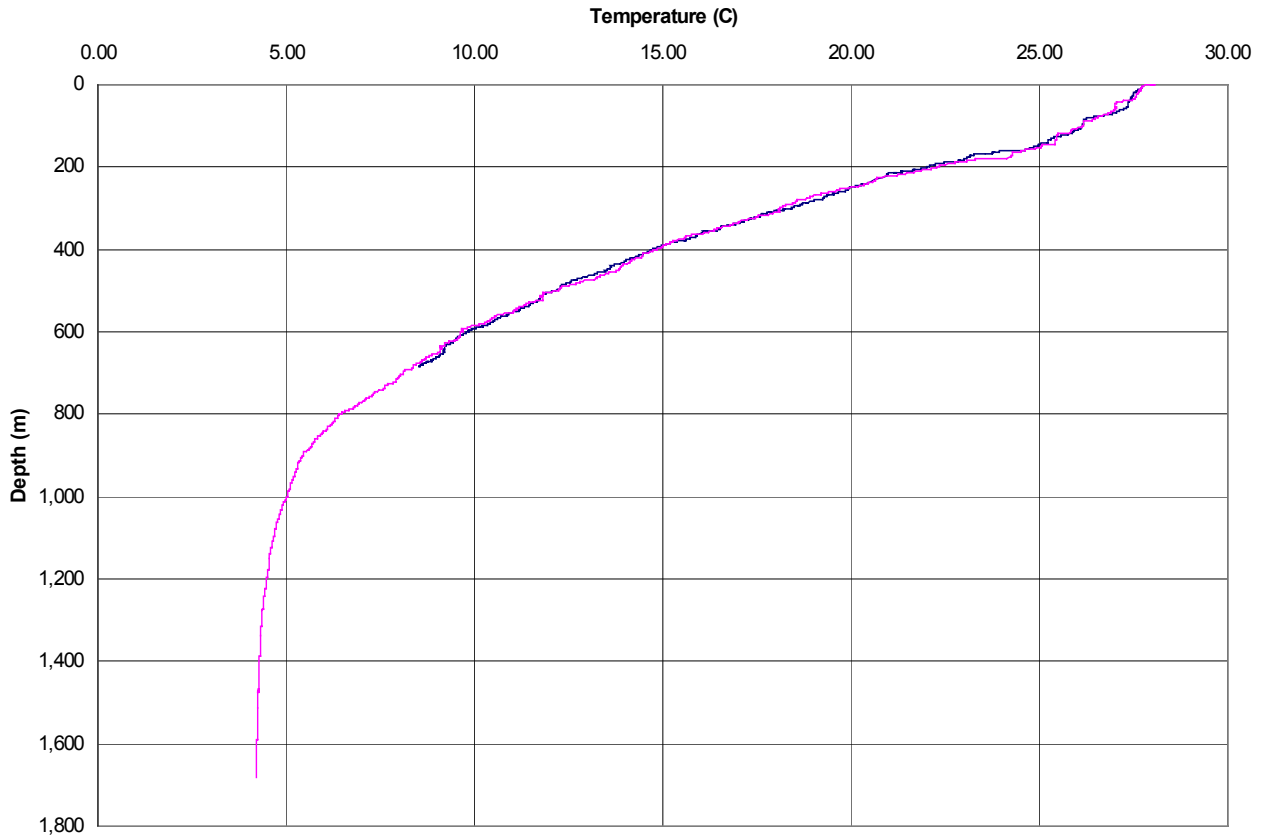Téléphone: +33 2 97 02 49 49 / Télécopie: +33 2 97 65 00 20

Figure 1:

A sample PROVOR temperature profile. The descending and ascending profiles are almost identical, indicating that the float operation was in the same water mass for the entire test.

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2. General Description of the PROVOR Float

2.1 Hull

The PROVOR float is encased in an aluminium cylinder measuring 17 cm in diameter and 120 cm in height. A surface finish prolongs life by impeding corrosion. The float is carefully designed to have a compressibility that is lower than that of seawater, essential for stable operation at ocean depths where pressures reach 200 atmospheres.
The influence of surface swell upon the instrument's heave is attenuated by a damping disk at the upper cover level.
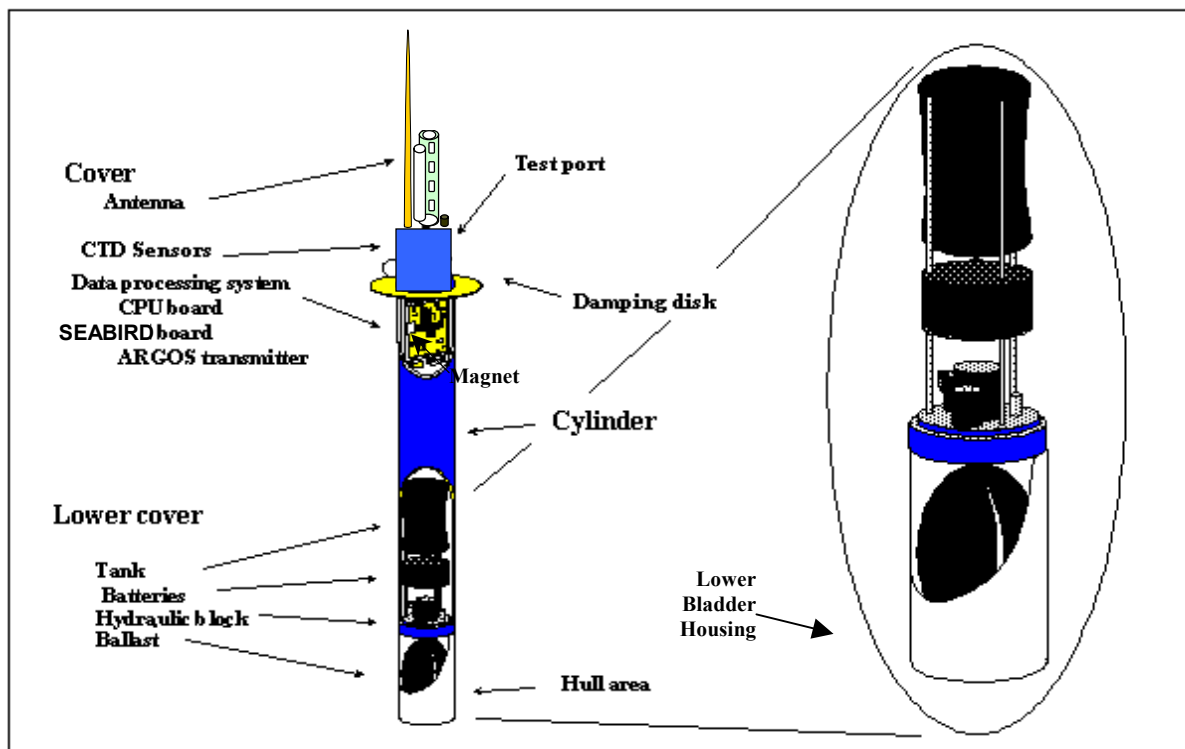
Figure 2: General view of the PROVOR float.

The exterior of the hull is labelled in compliance with the requirements of the international Argo program.

2.2 Density Control System

Descent and ascent depend upon buoyancy. PROVOR 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's density control system in Appendix B.

2.3 Sensors

PROVOR is equipped with precision instruments for measuring pressure, temperature and salinity with the SEABIRD SBE41CP CTD sensors.. Specifications of the sensor is provided in Appendix A.

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2.4 Argos Transmitter

While on the surface, the Argos transmitter sends stored data to the satellites of the Argos system. 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 float and must be above the sea surface in order for transmissions to reach the satellites.

2.5 CPU Board

This board contains a micro-controller (or CPU) that controls PROVOR. 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.

2.6 Battery

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

2.7 Accessories

PROVOR float users can be provided with an interface cable and communication software for programming the float and for checking float functions.

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3. The Life of a PROVOR Float

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

- Storage/Transport

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

- Deployment

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

- Mission

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

- 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 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 will probably remain submerged and cannot be located or recovered.

3.1 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 conducts ascent and descent profiles, separated by periods of Argos transmitting and drifting at a predetermined depth. PROVOR 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. The Mission consists of up to 150 such identical cycles. One cycle is shown in Figure 3.

- Delay Before Mission

To prevent PROVOR 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.

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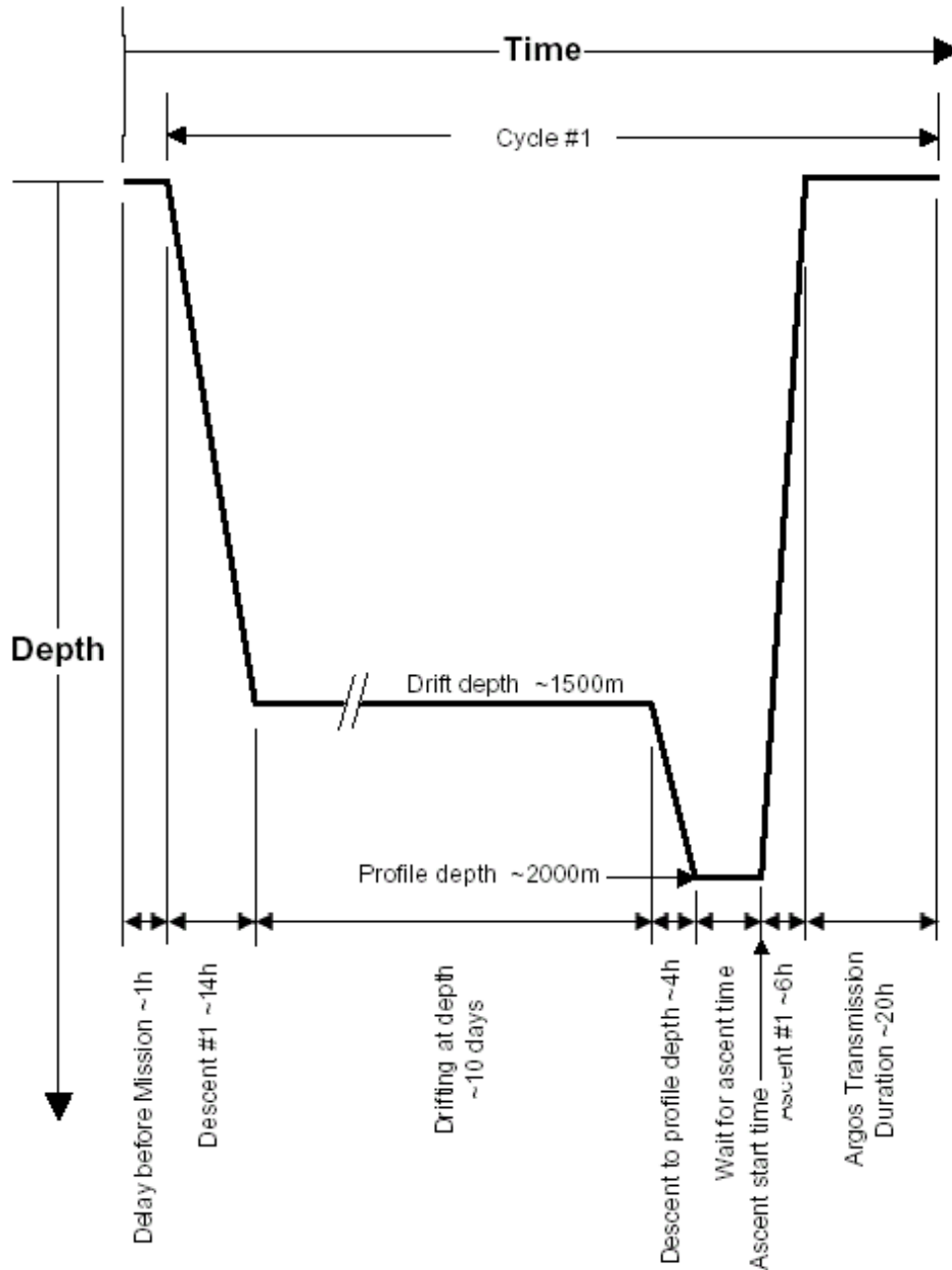
Figure 3: A schematic representation of PROVOR's depth-cycling during the Mission.

- **Descent**

The float descends at an average speed of 3 cm/sec. During descent, which typically lasts a few hours, PROVOR can detect possible grounding on a high portion of the seabed and can move away from such places (see Section 3.3 for more on grounding). PROVOR can collect CTD measurements during descent or ascent.

In order to respect the requirement of the ARGO program, the first cycle of the mission collect CTD measurements g descent at the sampling period of 10 seconds.

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- ### Drifting at Depth

During the drift period, PROVOR drifts underwater at a user-selected drift depth, typically 1,000 m to 1,500 m 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 3 bar over a 60-minute period.. PROVOR can collect CTD measurements at user-selected intervals during this drift period if the user selects this option.

- ### 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 must first descend to the profile depth before beginning the ascent profile. PROVOR can detect a possible grounding during this descent and take corrective action (as described on paragraph 3.3).

- ### Wait for Ascent Time

The user can program several floats to conduct profiles simultaneously. This makes it possible to use several PROVOR 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 to standby at the profile starting depth while awaiting the scheduled ascent time.

- ### Ascent

Ascent lasts a few hours, during which time PROVOR ascends to the sea surface at an average speed of 9 cm/sec. PROVOR can collect CTD measurements during ascent or during descent.

- ### Transmission

At the end of each cycle, the float finds sufficient buoyancy to ensure Argos transmission quality. PROVOR 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 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.

3.2 Descent

While the float is still at the sea surface PROVOR 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 the section 6 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 collision with shipping – PROVOR'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. This behaviour can be seen in the sample descent data shown in **Figure 5**.

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

3.3 Grounding

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

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.

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3.4 Submerged Drift

While PROVOR is drifting at drift depth, it checks the external pressure every 12 hours 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 adjusts its buoyancy to return to the drift depth.

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

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

3.5 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 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 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 5.5 m/min, or 9 cm/sec. For a 2,000 m profile, the ascent would, therefore, last 6 hours. Please refer to **Figure 4** for a chart of PROVOR's speed during a typical ascent.

When the pressure drops below 3 bar (signifying completion of ascent), PROVOR waits 10 minutes and then activates the pump. It does this to empty the reservoir and obtain maximum buoyancy.

If the user chooses, PROVOR will collect CTD measurements during descent or/and during ascent. CTD measurements begin at the profile start time and stop 10 minutes after the float rises above the 3 bar isobar in its approach to the sea surface. The interval between CTD measurements is user-programmable. For example, during a profile beginning at 2,000 m with a 10 sec sampling period, 2,200 CTD measurements will be collected.

3.6 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 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 the section 6 for detailed descriptions of the transmitted message formats.

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4. PROVOR Parameters

PROVOR's configuration is determined by the values of its mission parameters defined below. Instructions on how to read and change the values of these parameters are provided in Sections 5.5 and 5.8, respectively. A table summarizing all parameter names, ranges and default values is provided for convenient reference at the end of the present section.

1. Number of Cycles--This is the number of cycles of descent, submerged drift, ascent and transmission that PROVOR will perform. The mission ends and PROVOR enters Life Expiry mode when this number of cycles has been completed. PROVOR's batteries have capacity sufficient for approximately 150 cycles. If you wish to recover PROVOR at the end of the mission, you must set the number of cycles for less than 150 to ensure there is sufficient battery capacity remaining to allow PROVOR to return to the sea surface and enter Life Expiry.
Under favourable conditions, the battery capacity may exceed 150 cycles. If you do not plan to recover the float, you may choose to set the number of cycles to 255 to ensure that PROVOR completes the maximum number of cycles possible.
2. Cycle Period (days)--The duration of one cycle of descent, submerged drift, ascent and transmission. PROVOR waits submerged at the drift depth for as long as necessary to make the cycle the selected duration.
3. Reference Day (day number)-- 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.
Two possibilities exist:
-        The float reaches the profile starting depth before the reference. The float waits for the reference day to start the profile.
-        The float reaches the profile starting depth after the reference day. The float calculates a new reference day by adding an integer number of cycle periods to the reference day until the new reference day is later than the present day.
4. Ascent Time (hour)--time of day to start ascent profiles, according to 24-hour clock.
5. Delay Before Mission (minutes)--To prevent PROVOR 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 will wait for this delay before beginning the descent. The delay is measured after the valve clicking and before the start of the descent.
6. Descent Sampling Period (seconds)--the time interval between successive CTD measurements during descent.
If this parameter is set to 0 seconds, any 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.
7. Drift Sampling Period (hours)--the time interval between successive CTD measurements during PROVOR's stay at the drift depth.
8. Ascent Sampling Period (seconds)--the time interval between successive CTD measurements during ascent.
9. Drift Depth (dbar)--the depth at which PROVOR drifts after completion of a descent while awaiting the time scheduled for the beginning of the next ascent.
10. Profile Depth (dbar)--depth to begin profiling, if an ascending profile, and the ending depth, if a descend profile. If PROVOR is drifting at some shallower depth, it will first descend to the profile depth before starting the ascent profile.
11. Grounding Mode--PROVOR monitors itself for possible grounding on the seabed. During descents, if the pressure remains unchanged for too long, PROVOR enters a correction mode (see description in Section 3.3).
12. 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.
13. Argos Transmission Duration (hours)--the time that PROVOR 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.
14. Argos ID--the unique 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.
15. Retransmission : Argos messages retransmission. Retransmission rate is calculated according to the number of messages to transmit.

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Table 1: Summary of PROVOR's User-Programmable Parameters

Number	Long Name	Short Name	Range		Default Value	Units
			Min	Max		
01	NUMBER_OF_CYCLES	NOC	1	255	1	
02	CYCLE_PERIOD	CYP	1	60	10	days
03	REFERENCE_DAY	RED	0	366	2	day number
04	ASCENT_TIME	AST	0	23	23	hours
05	DELAY_BEFORE_MISSION	DBM	0	60	0	minutes
06	DESCENT_SAMPLE_PERIOD	DES	0	120	10	seconds
07	DRIFT_SAMPLE_PERIOD	DRI	0	45	12	hours
08	ASCENT_SAMPLE_PERIOD	ASC	0	120	10	seconds
09	DRIFT_DEPTH	DRD	0	2000	400	decibars
10	PROFILE_DEPTH	PRD	0	2000	2000	decibars
11	GROUNDING_MODE	GRM	0	1	0	
12	ARGOS_PERIOD	ARP	10	200	40	seconds
13	ARGOS_TRANS_DUR	ATD	0	48	6	hours
14	ARGOS_ID	ARI	0000000	FFFFFFF	0000000	hexa-decimal
15	RETRANSMISSION	RTM	0	100	25	

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5. Operating Instructions

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

5.1 Handling Precautions

PROVOR 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:** The plastic housing of PROVOR's test port can easily be broken. Be careful to protect it from impact.
>
> **NOTE:** Regulations state that PROVOR must not be switched on during transport.

5.2 Necessary Equipment

The tools necessary to check that PROVOR is functioning correctly and to prepare it for the Mission are:

➢ a PC. The most convenient way of communicating with PROVOR 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).

➢ VT52 or VT100 terminal emulation software. The TALK.EXE terminal emulation software is included with the equipment received from SERPE-IESM with your PROVOR float. The DTR line of the serial port is used as the external communications enable.

➢ an RS232 interface cable. You will need an RS232 interface cable to connect between PROVOR and the PC. This is provided with PROVOR when it arrives from the factory.

➢ 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.

➢ an Argos test set. This device receives Argos messages directly from the transmitter for test purposes.

5.3 Connecting the PC

Connect the PC's serial port (usually called COM1 or COM2) to PROVOR using the interface cable provided. The connection to PROVOR is via its test port - an XSJ-5-BCR submersible connector located on the float's upper cover (see Figure 2). Remove the protective cover from the test port and insert the interface cable's connector, taking care not to break the plastic housing of the test port.

> **NOTE: Before inserting, check that the interface cable's connector is oriented correctly. Failure to orient the connector correctly before insertion could damage the contacts.**

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

9,600 baud

8 data bits

1 stop bit

no parity

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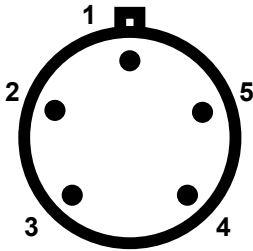
full duplex

no flow control

The pin-out for the PROVOR's test port is shown below:

Pin 1: ON/OFF (DTR)
Pin 2: Transmit (TX)
Pin 3: Receive (RX)
Pin 4: NC
Pin 5: Common (Ground)

5.4 How to Send Commands

You must communicate with PROVOR 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 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.

To begin communication with PROVOR, set DTR to high (+V). PROVOR should respond with initialization information followed by a prompt character, $. This means that PROVOR is functioning and awaiting your command(s).

5.5 How to Read Parameter Values

Read the values of parameters by sending the MCONFIG command. Do this by typing the characters MCONFIG in response to PROVOR's $ prompt character. End the command by pressing the Enter key. It should look like this:

$ **MCONFIG**

PROVOR will respond:

VAL01: NOC: NUMBER_OF_CYCLES = 1

VAL02: CYP: CYCLE_PERIOD, days = 10

VAL03: RED: REFERENCE_DAY = 2

VAL04: AST: ASCENT_TIME, hours = 23

VAL05: DBM: DELAY_BEFORE_MISSION, minutes = 0

VAL06: DES: DESCENT_SAMPLE_PERIOD, seconds = 10

VAL07: DRI: DRIFT_SAMPLE_PERIOD, hours = 12

VAL08: ASC: ASCENT_SAMPLE_PERIOD, seconds = 10

VAL09: DRD: DRIFT_DEPTH, decibars = 400

VAL10: PRD: PROFILE_DEPTH, decibars = 2000

VAL11: GRM: GROUNDING_MODE = 0

VAL12: ARP: ARGOS_PERIOD, seconds = 40

VAL13: ATD: ARGOS_TRANS_DUR, hours = 6

VAL14: ARI: ARGOS_ID = 0000000

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VAL15: RTM: RETRANSMISSION = 25

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

parameter number, parameter short name, parameter long name, units, value.

You can also read the values of the parameters individually using commands of the form

$ **MCONFIG X**

where X identifies the parameter. Each parameter is identified by a parameter number, a parameter long name and a parameter short name. These are summarised for your reference in Table 1. You may use either the parameter number or its short name in place of X in any command.

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

$ **MCONFIG 07**

PROVOR will respond:

VAL07: DRI: DRIFT_SAMPLE_PERIOD, hours = 0

Or...

$ **MCONFIG DRI**

PROVOR will respond:

VAL07: DRI: DRIFT_SAMPLE_PERIOD, HOURS = 0

5.6 How to Check the Time

Connect the PC to the float using the RS232 interface cable (refer to Section 5.3).
Ask PROVOR to display the time stored in its internal clock by sending the command:

$ **MTIME**

(Do this by typing the characters MTIME followed by the Enter key.)
PROVOR will respond with the time in the format YYYY/MM/DD hh:mm:ss, for example:

2001/05/24 11:50:38

5.7 Acceptance Tests

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

5.7.1 Inventory

The following things should have arrived with your PROVOR float:
- This user's manual
- RS232 interface cable (if requested)
- A diskette containing a copy of the communication program, TALK.EXE (if requested)
- Damping disk (with 4 plastic rivets for fastening it)
- Test sheet

NOTE: Disassembly of the float voids the warranty.

Check that all of the above items are present. If any are missing, contact SERPE-IESM.

5.7.2 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, and the test port for dents or any other signs of damage (refer to Figure 2 for the locations of these components).

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> **NOTE: Ensure the magnet is in place against the hull. Removal of this magnet will begin the mission.**

5.7.3 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 using the RS232 interface cable (refer to Section 5.3).

Send the MCONFIG command, as explained in Section 5.5, to verify that PROVOR's parameters have been set correctly.

5.7.4 Functional Tests

Connect the PC to the float using the RS232 interface cable (refer to Section 5.3).

> **NOTE:** The magnet should not be removed for the functional test.

> **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 has several commands that allow you to test its various functions.

Display Battery Voltages

Send the command:

$ **MBATTERY**

PROVOR will respond with:

Electronic Supply Voltage: 14000 mV

Power Supply Voltage: 14100 mV

Normal values for a new battery are 14 volts, respectively (see test sheets for limits).

-    **Display Internal Vacuum**

This vacuum is drawn on the float as one of the final steps of assembly. It should be between 600 and 800 mbar absolute. 700mbar is recommended. Send the command:

$ **MVACUUM**

PROVOR will respond with:

Internal Vacuum: 785 mbar Absolute

-    **Display Sensor Data**

Send the command:

$ MTRIPLET

PROVOR will respond with:

External Pressure: 10 mbar

External Temperature: 22956 møC

External Salinity: 0 mPSU

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As this sensor is in open-air, only the temperature data should be regarded as accurate.

- ### Display Hydraulic Level

Send the command:
> $ **MLEVEL**

PROVOR will respond with:

Tank Hydraulic Level: 0 cm^3

The tank level will be 0 or 1920 cm^3. For this command to report a valid value, the float must be standing upright. If the level is 1920, use the MEMPTY command to return the level to 0.

- ### Test Hydraulic Pump

To activate the pump for one second, send the command:
> $ **MTESTPUMP**

Listen for the pump running.

- ### Test Hydraulic Valve

To activate the valve for one second, send the command:
> $ **MTESTVALVE**

Listen for the actuation of the valve.

- ### Test Argos Subsystem

To test the Argos transmitter, send the command:
> $ **MTESTARGOS X**

Note: X is the number of hours to transmit.

The MTESTARGOS command takes about 5 minutes to execute. PROVOR will respond with a spinner (sequence of characters |, /, -, \, |, /, -, \) to indicate progress.
This command will cause PROVOR to transmit several messages. They are technical messages, the format of which is described in section 6. 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.

5.8 How to Change Parameter Values

Your PROVOR float has been pre-configured at the factory and should arrive ready for launch. Normally, you will simply test the float (as described in Section 5.7), and then launch it. Should you wish to change any of the float's parameters, you must follow the instructions provided below.
Connect the PC to the float using the RS232 interface cable (refer to Section 5.3).
You can read parameter values at any time (by sending the MCONFIG command as explained in Section 5.5), but the parameter values are locked to protect them from being changed accidentally. If you want to change the value of any parameter, you must first tell PROVOR to enter INIT mode and then send the MUNLOCK command.
Tell PROVOR to enter the INIT mode by sending the command:
> $ **MPREMISSION 1**

PROVOR will respond:

System Status is INIT

Then unlock the parameter values by sending the unlock command:
> $ **MUNLOCK**

The commands for changing the values of the mission parameters are of the form:
> $ **MCONFIG X Y**

where X identifies the parameter and Y provides its new value.

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Remember that you may use either the parameter number or the parameter short name in place of X (see Table 1 for a summary of all parameter numbers and short names).

For example, to change the number of cycles to 150, first unlock PROVOR's parameters using the MPREMISSION and MUNLOCK commands, as described above, then send the command:

$ **MCONFIG 01 150**

PROVOR will respond:

VAL01: NOC: NUMBER_OF_CYCLES = 150

> **NOTE:** PROVOR 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 responds to your commands.

You can set the time on the float's internal clock by sending the command:

$ **MTIME   YYYY/MM/DD h:m:s**

For example, if you send the command:

$ **MTIME   2002/05/24 11:50:38**

PROVOR will respond:

2002/05/24 11:50:38

After you have finished making any changes, you must lock the parameters again by issuing the MPREMISSION command:

$ **MPREMISSION R**

PROVOR will respond:

Buoyancy Controller CPU :   OK

Internal Pressure (mBar):   700 OK

Hydraulic Level (cm^3) :   0 OK

Electronic Voltage (mV) : 14200 OK

Motor Voltage(mV)   : 14000 OK

Argos Transmitter   :   OK

Sensors in head   :   OK

External Pressure: 10 mbar

External Temperature: 22987 møC

External Salinity: 1 mPSU

PREMISSION Success...

Powering Down...

5.9 Launching

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

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5.9.1 Test the Float

Before you take PROVOR on deck for deployment, we recommend that you repeat all of the acceptance tests described in Section 5.7. This will ensure that the float is functioning and configured correctly and maximize the probability of success of your experiment.

> → **WARNING:** If you have changed any of the parameter values, be sure to lock them again by sending the MPREMISSION R command, as described in Section 5.8.

Upon completion of these tests, install the damping disk and remove the magnet as described below.

5.9.2 Remove the Magnet

Remove the magnet located near the top of the float (see Figure 2). Retain the magnet for future use in case the PROVOR float is recovered.
PROVOR is now ready for launch.
To confirm that the magnet has been removed and that the float is ready for launch, PROVOR transmits Argos messages 5 minutes after magnet removal and gives 10 clicks of its internal solenoid valve 11 minutes after magnet removal. The PROVOR may be horizontal during this stage of deployment.

> **NOTE: Once the magnet has been removed, the PROVOR float performs an initial test. This takes 11 minutes. Ensure that the Argos messages are sent and that the valve clicks before placing the PROVOR in the water.**

Use your Argos test set to confirm transmission of an Argos message before launching the float. The message contents do not matter, but you should check that the received Argos ID is correct.
If your test set does not receive an Argos transmission with the correct PTT ID after 11 minutes, there is a problem. Replace the magnet, connect the PC, and conduct the acceptance test described in Section 5.7. If that fails, contact SERPE-IESM for technical support.

5.9.3 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.**

Use a launching crate to deploy the float to the sea. After launch, you may choose to wait alongside the float until it sinks, but this may take up to 3 hours depending on the float's buoyancy when launched.

The damping disk is already fastened on the tube.
It is possible to use the hole in the damping disk in order to handle and secure the float during deployment.

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

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6. ARGOS formats

6.1 Overview

The data transmission process begins as soon as an ascent profile is completed. It starts with reduction of the data using the Chords Method. PROVOR then formats and transmits the message.

The reduction of data processing consists in storing the significant points of the CTD triplets arithmetic mean with the layer format.

For a given descent-drift-ascent-transmit cycle, the transmission of all of the data will usually require the capacity of 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 CTD triplet in two. This data interleaving scheme shares the points of each profile between two Argos messages. This allows reconstruction of the profile when a message is lost.

Example:

    Message N: { triplet 1 ; triplet 3 ; triplet 5 ; triplet 7 ; triplet 9 ; **. . .** triplet 21 }

    Message N+1 { triplet 2 ; triplet 4 ; triplet 6 ; triplet 8 ; **. . .** triplet 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 CTD message

    Type 0101 : Submerged drift CTD message

    Type 0110 : Ascent profile CTD message

    Type 0000 : Technical message

The three types of CTD 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.

6.2 Descent profile CTD Message

Data	Format	Bit Numbers
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 CTD 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
CTD measurements	178 bits	79 to 256

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6.2.1 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.

6.2.2 CTD Triplets

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

Only the first triplet 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 triplets correspond to alternating data points in the profile (for example, measurement numbers 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 CTD measurements starting from bit 79 (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).

6.2.3 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, P_n, and the previous pressure measurement, P_{n-1}, is less than 63 dbar, the difference, $|P_n - P_{n-1}|$, 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.

6.2.4 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 $(T_n - T_{n-1})$ is included in the closed interval [-0.923 °C, +0.100 °C], the difference $-(T_n - T_{n-1} - 0.1 °C)$ is coded into 10 bits.
The decoding will carry out the following operation : (- $T_{transmitted}$ + 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.

6.2.5 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 $(C_n - C_{n-1})$ is included in the closed interval [-0.230 PSU ; +0.025 PSU], the difference $-(C_n - C_{n-1} - 0.025PSU)$ is expressed in 8 bits.
The decoding will carry out the following operation : (- $C_{transmitted}$ + 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 Submerged Drift CTD Message

Data	Format	Bit Numbers
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 CTD measurement	6 bits	29 to 34
Time of first CTD measurement	5 bits	35 to 39
First pressure measurement	11 bits	40 to 50

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First temperature measurement	15 bits	51 to 65
First salinity measurement	15 bits	66 to 80
CTD measurements	176 bits	81 to 256

6.3.1 Cyclic Redundancy Check

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

6.3.2 CTD Triplets

Only the first triplet is dated. The day number counts from the day of the descent at the beginning of the first cycle, which is day number 0. The hour number is the hour of the first measurement. The least significant bit represents 1 minute.

The stored triplets are sent in the same order in which they were collected. Measurements within a triplet are sent in the sequence - pressure, temperature, salinity.
Subsequent triplets correspond to alternating data points in the profile (for example, measurement numbers 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 CTD measurements starting from bit 81 (measurement numbers 3, 5, 7, etc.) are coded either as absolute measurements or as relative measurement. The first (most significant) 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

If the difference between the current pressure sample, P_n, and the previous pressure sample, P_{n-1}, is included in the closed interval [-31 dbar, +32 dbar], the coding of the difference, $|P_n - P_{n-1}|$, 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.

6.3.4 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 $(T_n - T_{n-1})$ is included in the closed interval [-0.512 °C, +0.511 °C], the difference $(T_n - T_{n-1})$ 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.

6.3.5 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 $(C_n - C_{n-1})$ is included in the closed interval [-0.128 PSU ; +0.127 PSU], the difference 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 Ascent profile CTD Message

Data	Format	Bit Numbers
ARGOS ID complement	8 bits	1 to 8
Message type (type = 0110)	4 bits	9 to 12

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CRC	16 bits	13 to 28
Date of the first CTD 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
CTD measurements	178 bits	79 to 256

6.4.1 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.

6.4.2 CTD Triplets

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

Only the first triplet 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 triplets correspond to alternating data points in the profile (for example, measurement numbers 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 CTD measurements starting from bit 79 (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

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, P_n, and the previous pressure measurement, P_{n-1}, is less than 63 dbar, the difference, $|P_n - P_{n-1}|$, 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.

6.4.4 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 $(T_n - T_{n-1})$ is included in the closed interval [+0.923 °C, -0.100 °C], the difference $(T_n - T_{n-1} + 0.1 °C)$ is coded into 10 bits.
The decoding will carry out the following operation : $(T_{transmitted} - 0.1 °C)$
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.

6.4.5 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 $(C_n - C_{n-1})$ is included in the closed interval [0.230 PSU ; -0.025 PSU], the difference $(C_n - C_{n-1} + 0.025PSU)$ is expressed in 8bits.
The decoding will carry out the following operation : $(C_{transmitted} - 0.025PSU)$
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.

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6.5 Technical Message

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

Data	Format	Bit Numbers
ARGOS ID complement	8 bits	1 to 8
message type	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
duration of pump actions at the surface	5 bits	93 to 97
number of descent CTD messages	5 bits	98 to 102
number of drift CTD messages	5 bits	103 to 107
number of ascent CTD messages	5 bits	108 to 112
shallow/deep boundary isobar for descent profile	11 bits	113 to 123
number of descent slices in shallow zone	6 bits	124 to 129
number of descent slices in deep zone	8 bits	130 to 137
shallow/deep boundary isobar for ascent profile	11 bits	138 to 148
number of ascent slices in shallow zone	6 bits	149 to 154
number of ascent slices in deep zone	8 bits	155 to 162
number of CTD measurements in drift	8 bits	163 to 170
float's time : hh (5 bits)+mm (6 bits)+ss (6 bits)	17 bits	171 to 187
pressure sensor offset	6 bits	188 to 193
internal pressure	3 bits	194 to 196
surface temperature	16 bits	197 to 212
profile ascent start time	8 bits	213 to 220
number of entrance in target range	3 bits	221 to 223
minimum pressure in drift (bars)	8 bits	224 to 231
maximum pressure in drift (bars)	8 bits	232 to 239
grounding	1 bits	240
not used	16 bits	241 to 256

6.5.1 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 GAP threshold is an integer from 1 to 127 (modulo 128).
- Float stabilisation time after the crossing of the GAP threshold is expressed in tenths of an hour.
- Float stabilisation pressure after crossing the GAP threshold is coded in 8 bits with least significant bit = 1 bar.

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- Number of solenoid valve actions carried out to reach the target pressure after crossing the GAP threshold.

6.5.2 Drift Data

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

6.5.3 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.
- Duration of pump action to acquire buoyancy at the surface (after crossing the threshold of 3 bar), expressed in 5 bits with least significant bit = 20 sec.
-     Number of pump actions in ascent (at the target pressure until the crossing of the threshold of 3 bar), expressed in 5 bits.

6.5.4 Housekeeping Data

- Pressure sensor offset is measured at the surface.
      least significant bit = 1 dbar
      range: -32 dbar to +31 dbar

- 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

- Surface temperature
      least significant bit = 0.001° C

6.6 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.

7. Summary: float's programming

The programming operations are listed below :
N.B.: the character "_" indicates the Space character between the commands.

a) With the PC, launch the software: "talk.exe"

b) Activate the "F8" and "F9" keys of the keyboard in the inactive state "-9V".
The magnet is put up the hull of the float.

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The "F9" key, connected to the DTR line of the serial port, wakes up the float and sets up the communication ("+9V" impulse). If there is no activity on the communication line for 5 minutes, the float will pass into the waking state.

c)   Connect the float to the PC with the RS232 cable.

d)   Unlock the mission :
→ command : "mpremission _1".
In this state, the magnet can be removed, the float will not begin this mission.
Nevertheless, **it is recommended to keep the magnet onto the hull** in order to avoid a consumption in the sleep mode of the electronics.

e)   Unlock the parameters:
→ command : "munlock"

f)   Update the date and the time :
→ command :"mtime".

g)   Modification of the mission parameters:
→ command "mconfig_NumberOfParameters_Value"
This command enables the mission programming and the ARGOS programming.

h)   Lock the mission:
→ command "mpremission_r"
This command generates a control of the electronics components (hydraulic, vacuum, ARGOS PTT, sensor..). If the results are OK (validated by the message: "Premission Success "), the float will pass into the waking state.

i)   The float can be stored pending the deployment.

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Appendix A--Specifications

- **Storage**

   Temperature range...-5°C to +50°C

   Storage time before expiry .... up to 1 year

- **Operational**

   Temperature range .... -3°C to +32°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 .... 34 kg

   Material...anodized aluminium casing

- **Sensors**

   Salinity

        - range...10 to 42 PSU

        - accuracy..± 0.005 PSU

        - resolution ....0.001 PSU

   Temperature

        - range...-3°C to +32°C

        - accuracy... ± 0.002°C

        - resolution .... 0.001°C

   Pressure

        - range...0 bar to 2500 dbar

        - accuracy... ± 1 dbar

        - resolution .... 0.1 dbar

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Appendix B--How PROVOR Works

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 4 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.
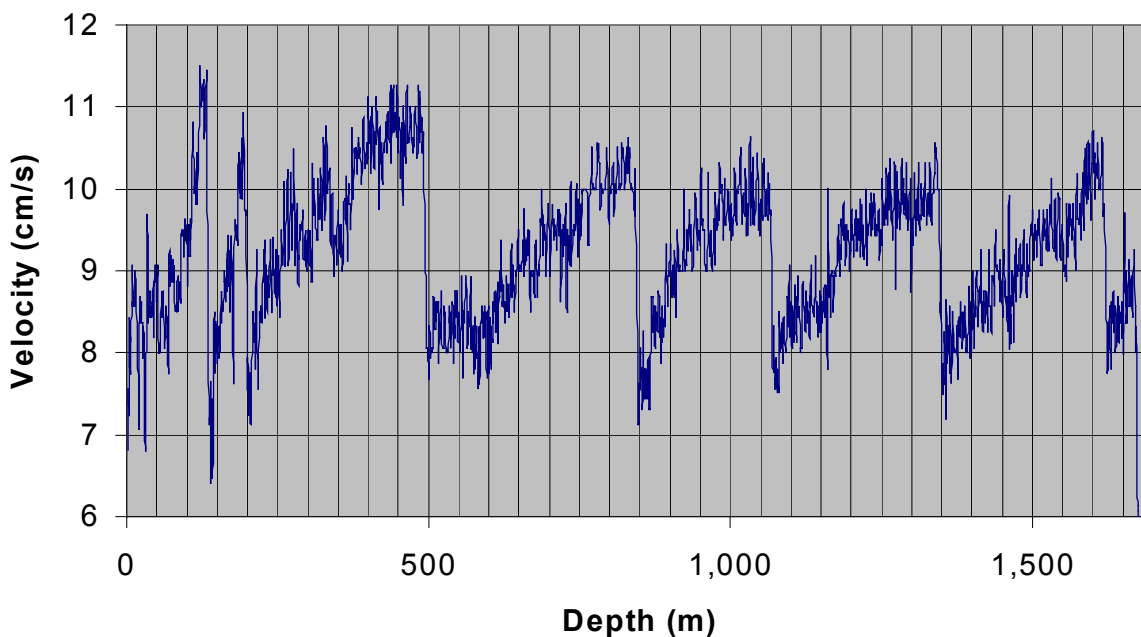
Figure 4: This figure depicts the speed of a PROVOR float as it ascends in a deep-sea test.

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'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 ascends, the decrease in water density *reduces* the float's buoyancy. At the same time, the decrease in water pressure causes PROVOR's hull to expand, which *increases* the float's buoyancy. The two effects tend to counteract each other.

Because PROVOR'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'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's speed of descent to slow as it goes deeper (see Figure 5).

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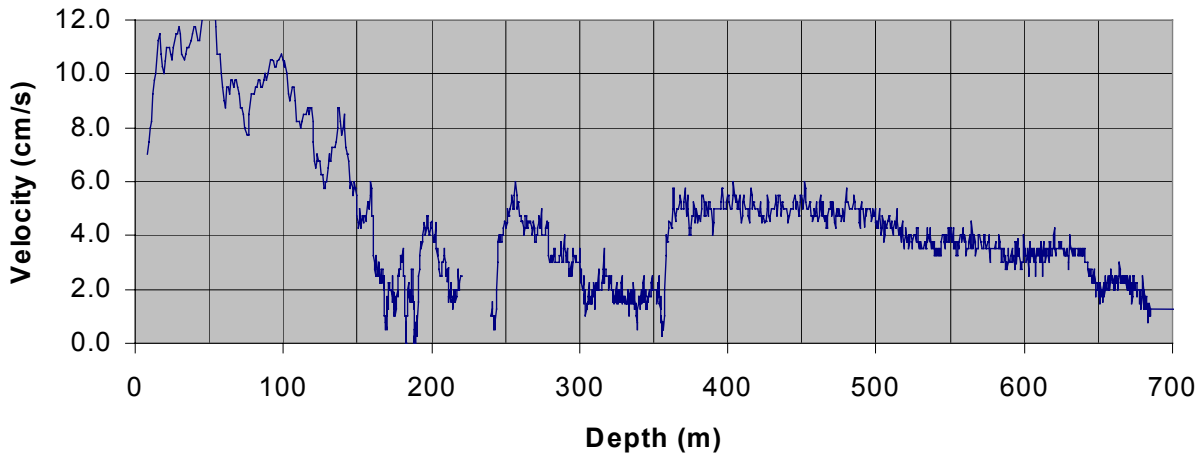
Figure 5: A graph of PROVOR's descent speed versus depth in an actual deployment.

To reduce the probability of contact with water craft, PROVOR's target speed during the initial stages of descent is high (see Figure 5) above. 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.

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Appendix C--Lithium Battery

All batteries -- both lithium batteries and batteries with other chemistries -- 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 mishandled. 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 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'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'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.

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Appendix D—Glossary

Argos   The Argos system makes it possible to collect transmitted data by fixed or mobile platforms and to locate these platforms. These services are provided worldwide by the NOAA (National Oceanic and Atmosphere Administration) satellites.

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

COM1, COM2   Serial communication ports available as a standard feature on a PC.

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

drift depth   A user-selected depth at which PROVOR hovers between ascent profiles.

grounding mode PROVOR can take corrective action if it determines that it has run aground (see description in Section 3.3).

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

LSB   least significant bit; the bit - usually the one at the extreme right hand end of a binary number - that has the smallest significance - that is, the bit that gets multiplied by the factor 2^0 (=1) to convert the binary number to decimal.

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

PC   Personal Computer; IBM-PC compatible.

CTD   Salinity, Temperature and Depth.

profile   The set of CTD measurement triplets collected during each descent or ascent is called an CTD profile. The set of measurements collected during descent is called a descent profile, and the set collected during ascent is called an ascent profile.

PROVOR   Name given to the drifting profiler developed by MARTEC and IFREMER.

PTT   Platform Terminal Transmitter--it is the Argos transmission electronics.

triplet   A set of three measurements - one each of salinity, temperature and depth - all taken at the same time.
RS232   A 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 -2^{n-1} instead of $+2^{n-1}$.

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

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Appendix E—Subject Index

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