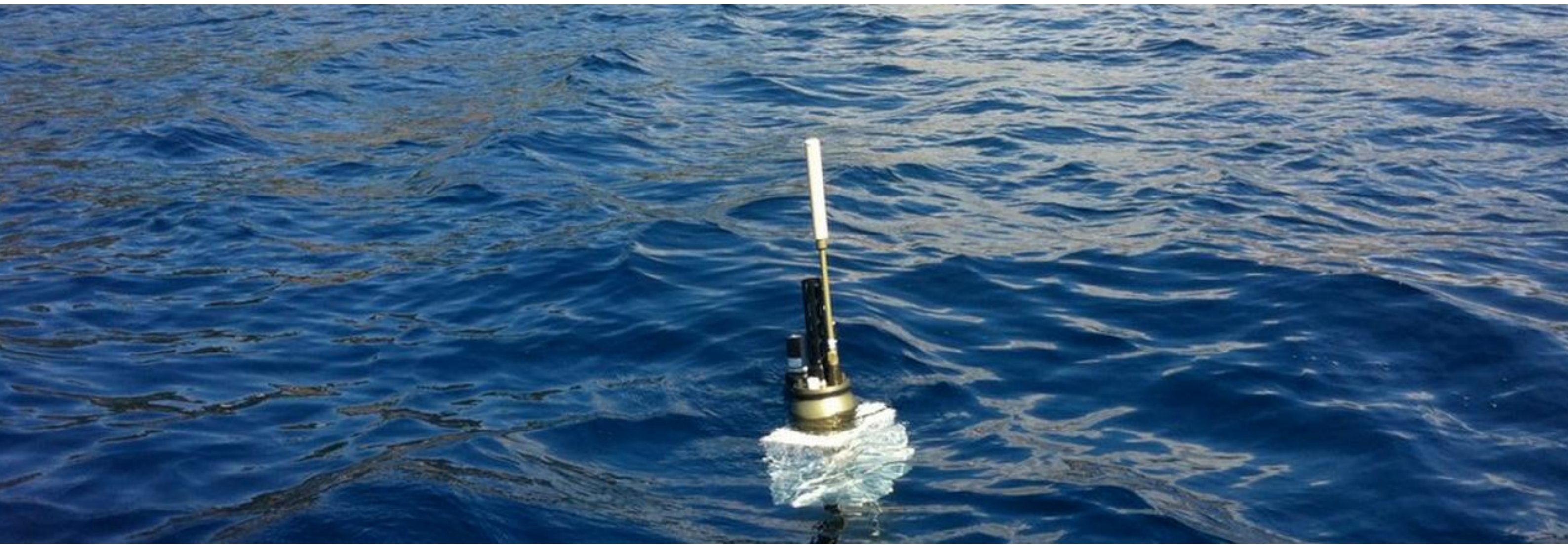
APMT Profiler – General Overview

AUTOMATED **M**ULTI-**T**ASK **P**ROFILER



33-16-051_APMT_General_Overview
Revision 1.5 (2022-01-05)

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1. Revision history

Revision	Release date	Notes	Author
1.0	2018-02-16	Original	C. SCHAEFFER
1.1	2020-01-20	Adding USEA and sensors	C. SCHAEFFER
1.2	2020-05-12	Adding “Multi-Parking” capabilities	C. SCHAEFFER
1.3	2021-01-29	Adding RAMSES, OPUS and MPE sensors	C. SCHAEFFER
1.4	2021-11-08	Adding HYDROC sensor	C. SCHAEFFER
1.5	2022-01-05	Adding RAMSES-2 and IMU sensors Adding “periodic” command in scrip-programmed actions	C. SCHAEFFER

2. Introduction

APMT float is a subsurface profiling float developed by nke. APMT float uses the same mechanical housing and density control system as the CTS3 float developed jointly by IFREMER and MARTEC group.

After launching the float, its mission consists in a repeating cycle of descent, submerged drift, ascent and data transmission. During these cycles, the float 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.

During its mission, the float collects measurements of several parameters (depending on sensor mounted) - salinity, temperature, depth, and optional measurement.

After the ascent, the float uses a GPS positioning and transmits the data saved by satellite.

This generation of nke floats differs from the others by a more flexible configuration based on a script-described mission and new functionalities.

A dedicated Graphical User Interface allow user to adjust the mission and sensor parameters prior to a deployment. This software includes parameters check to insure the float is operational.

3. Specifications

3.1 Storage

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

3.2 Operational

- Temperature range: 0 to +40°C
- Pressure at “parking” depth: 40 to 200 bar
- Depth maintenance accuracy: ±3 bar typical (adjustable)
- Survival at sea: up to 4 years (depending on float version)

3.3 Mechanical

- Length with antenna: 2.20m
- Hull diameter: 17 cm
- Dumping disk diameter: 35 cm
- Weight: 35 kg typical (depending on float version)
- Material: anodized aluminium casing

4 General description

4.1 Overview

APMT float mainly differs from standard/historical nke float by:

- **Electronics**
  The float integrates APMT navigation board associated to USEA acquisition board.
- **Embedded software**
  The APMT and USEA boards use specific software more scalable and versatile in mission management.
- **Functionalities**
  The float offers new features in configuring, deploying, realizing and updating the mission.
- **Graphical User Interface**
  nke provides PC software to help user in preparing a deployment.

4.2 APMT navigation board

This electronic board contains a micro-controller (CPU) that controls the float. Its functions include supervision of the navigation, activation and control of the hydraulic system, storage, calendar and transmission task.

Float management is based on a specific file system developed by nke. This file system allows technical information and data to be stored when the float is turned off, together with the mission configuration.

4.3 USEA acquisition board

This electronic board contains a micro-controller (CPU) that controls the acquisition of sensors data. Its functions include sensor management and data processing.

4.4 Density control system

Descent and ascent depend on buoyancy. The profiling float is balanced when its density is equal to that of the level of surrounding water. The profiling float has a fixed mass. A precise 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 an electro-valve.

4.5 Sensors

- **(SBE41) Argo CTD**
  This sensor is used for navigation and pressure reference for other sensors.
  Sampling at high frequency (period of 1 s) is available.
- **(DO) Dissolved Oxygen**
  Measurements from this sensor can be achieved during descent, drift, ascent and "in air measurement" stages. Sampling at high frequencies (period of 1 sec) is possible thanks to a +5V power supply which reduce self-heating effects.
- **(OCR) Radiometry**
  Measurements from this sensor can be achieved during descent, drift and ascent stages.
  Sampling at high frequency (period of 1 s) is available.
- **(ECO & ECOv2) Fluorescence**
  Measurements from this sensor can be achieved during descent, drift and ascent stages.
  Sampling at high frequency (period of 1 s) is available.
- **(CROVER) Transmittance**
  Measurements from this sensor can be achieved during descent, drift and ascent stages.
  Sampling at high frequency (period of 1 s) is available.
- **(SBEPH) pH**
  Measurements from this sensor can be achieved during descent, drift and ascent stages.
  Sampling at high frequency (period of 1 s) is available.
- **(SUNA) Nitrate**
  Measurements from this sensor can be achieved during descent, drift and ascent stages.
  Sampling at high frequency is not recommended due to lamp lifetime and power consumption.
- **(UVP6) Particles**
  Measurements from this sensor can be achieved during descent, drift and ascent stages.
  Sampling at high frequency (period of 2 s) is available.
- **(RAMSES) Radiometry**
  Measurements from this sensor can be achieved during descent, drift and ascent stages.
  It is possible to embed two sensors simultaneously (e.g.: Ed + Lu).
- **(OPUS) Nitrate**
  Measurements from this sensor can be achieved during descent, drift and ascent stages.
- **(MPE) Radiometry**
  Measurements from this sensor can be achieved during descent, drift and ascent stages.
  Sampling at high frequency (period of 1 s) is available.
- **(HYDROC) Carbon dioxide**
  Measurements from this sensor can be achieved during ascent stage only.
  Sampling at high frequency (period of 1 s) is available.
- **(IMU) Inertial movements**
  Measurements from this sensor can be achieved during descent, drift and ascent stages.
  User can choose between raw and tilt plus heading format.
- **(A) Acoustic noise**

The profiling float realises upward acoustic windows acquisition and then extract 1/3 octave band noise, sound pressure level (RMS/peak) and sound exposure level. Each acoustic window is 20 seconds long.

4.6 Transmitter

While the float is drifting at the sea surface, the transmitter sends the stored data to the back office server via satellite. The antenna is mounted on the top end of the float and must remain above the surface so that transmissions reach the satellites.

APMT float is able to transmit data over different satellite constellation:

- **(R) Iridium RUDICS**
  nke proprietary speed enhancement allows the float to reach an effective communication bandwidth up to 14 KB/min (reducing significantly the communication cost).
- **(B) Beidou**
  Chinese use restricted.

4.7 Batteries

The float embeds lithium thionyl chloride cells to supply the required energy to operate.

5 Float operation

5.1 Life of a float

The life of a float is divided into 4 phases:

- **(1) Storage/transport**
  During this phase, the float, packed in its transport case, awaits for deployment. The electronic boards are dormant and the float's buoyancy control is 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, the float conducts a pre-programmed number of cycles of descent, submerged drift, ascent and data transmission. During these cycles it collects measurement data and transmits it to the satellite system.
- **(4) End of life**
  End of life begins automatically upon completion of the pre-programmed number of cycles.

5.2 Mission overview

The mission is the period during which the profiling float is launched at the experiment area until the transmission relating to the final cycle is completed.

During the Mission, the float conducts ascent and descent profiles, separated by periods of transmission and drifting at a predetermined depth. APMT float 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.

5.3 Deployment

5.3.1 Self-test

Once the magnet is removed the float performs a system self-test. Depending on the requirements of the deployment, the user can choose between a quick version and a full version with GPS positioning and data transmission.

Upon successful completion of the self-test the float generates a sound signal to inform it can be launched and starts its mission.

Self-test can be interrupted manually via local communication link prior to entering self-test process.

5.3.2 Initial buoyancy

APMT float can be either deployed in “floating” or “sinking” mode. It can also retrieve its maximum floatability during self-test.

5.3.3 Pressure activation

The float is able to be delivered to any ship “ready to deploy” without any specialized operator intervention.

The pressure activation starts with a successful self-test. The float enters a pressure test phase during which it monitors the pressure every two minutes. When the pressure exceeds the activation threshold, the float increases its buoyancy to reach the surface and starts the mission.

5.3.4 Real-time checking

During deployment, user has the possibility to use a real-time check by connecting a Bluetooth terminal to the float.

When real-time check is activated, the float sends time stamped information during startup and launch processes. At the end of the launch process, the float sends the final information to inform user if it can be launched or not.

5.4 Navigation

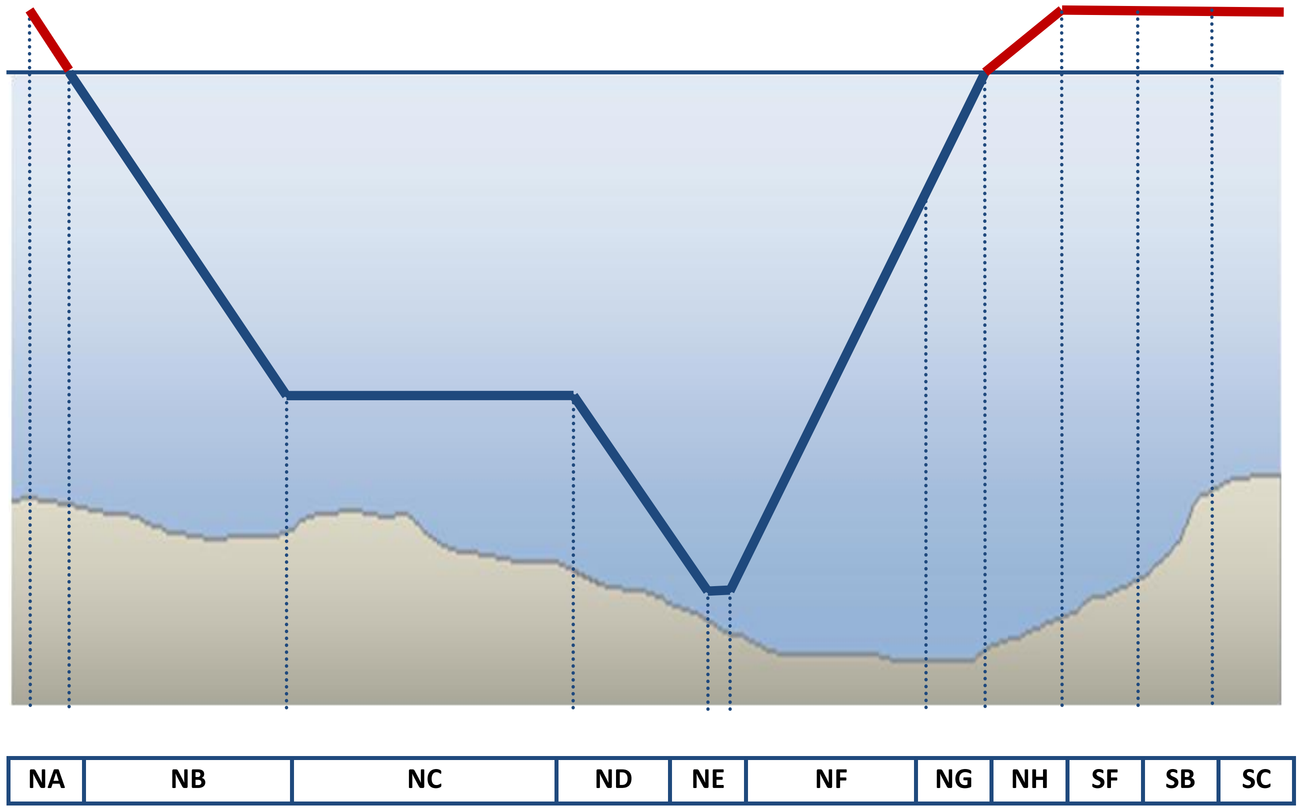
5.4.1 Pattern definition

A pattern is composed of elementary phases:

- **(NA) Emergence reduction**
  Before descending, float needs to reach a neutral buoyancy position.
- **(NB) Descent to “parking” depth**
  Float descends from surface to the desired “parking” depth.
- **(NC) Drift**
  During drift, the float drifts underwater at the current depth
- **(ND) Descent to “measurement” depth**
  Float descends from the current depth to the desired “measurement” depth.
- **(NE) Wait for ascent time**
  The float standbys at the current depth while waiting the scheduled ascent time.
- **(NF) Ascent**
  Float ascends from the current depth to the surface.
- **(NG) Sub-surface wait**
  When reaching the sub-surface depth the float stops hydraulic action and wait 10 minutes.
- **(NH) Emergence**

In order to achieve a good transmission phase, the float needs to find sufficient buoyancy.

- **(SF) Surface acquisition**
  In air measurements can be achieved for sensor calibration.
- **(SB) GPS positioning**
  Float acquires GPS positional and calendar information.
- **(SC) Transmission**
  Float transmits collected data and receives remote commands.



--- Figure 1. Representation of a pattern ---

5.4.2 Emergence reduction

Before descending, the float needs to reach a neutral buoyancy position. This is achieved by opening electro-valve.

5.4.3 Descent to "parking" drift depth

Descent takes the float from the sea surface to the drift depth. This is achieved by opening electro-valve for a variable time duration when the float's vertical speed falls below a preprogrammed descent-speed threshold. The float descends with an average vertical speed of 3 cm/sec (standard settings).

The electro-valve activation time duration is calculated by the float depending on the past action effect, the current depth and the distance to the target depth.

APMT float can detect a possible grounding during this phase and take corrective action.

5.4.4 Drift at “parking” depth

While the profiling float is drifting, it checks the external pressure periodically to determine whether there is need to adjust its buoyancy.

If the current depth differs from the desired depth by more than a preprogrammed tolerance and this difference is maintained, the profiling float adjusts its buoyancy to return to the drift depth. This is achieved by activating the pump or the electro-valve.

APMT float can detect a possible grounding during this phase and take corrective action.

5.4.5 Descent to “measurement” depth

The user may select a “measurement” depth for the ascent profile that is deeper than the “parking” depth. If this is the case, the float must first descend to the “measurement” depth before beginning the ascent profile.

APMT float can detect a possible grounding during this phase and take corrective action.

5.4.6 Ascent to surface

Ascent takes the float from the current depth to the sea surface. This is achieved by activating the pump for a constant time duration when the float’s vertical speed falls below a preprogrammed ascent-speed threshold. The float ascends with an average vertical speed of 9 cm/sec (standard settings).

Time synchronization in surface can be used to predetermine when the profiling float should be present in surface for transmission. Ascent time is calculated by the profiling float according to its typical ascent-speed. When the ascent time is reached, the profiling float enters ascent phase.

APMT float can detect a possible hanging during this phase and take corrective action.

5.5 Data acquisition

5.5.1 Standard sensors

Measurements of standard parameters can be done during descent, drift, ascent and surface phases.

Each sensor is managed independently. The water column can be divided into 5 different depth intervals in order to adapt the management of sensors to the experiment. Each depth interval is managed independently.

The parameter set allows a very precise definition of sensors sampling strategy during navigation phases. It is possible to personalize the acquisition mode and the depth resolution to:

- **Save energy**
  By using a low resolution strategy with pulsed power mode and large depth slice.
- **Survey interesting water area**
  By using a high resolution strategy with continuous power mode and small depth slice:
  - Maximum resolution is 0.5 dbar in arithmetic mean processing
  - Maximum resolution is 0.1 dbar in decimated raw processing
- **Disable a sensor**
  Power-off the sensor during the entire depth interval.

During acquisition phases, raw data are stored in memory and then processed to obtain the required resolution by sub-sampling data within defined depth slice. In each zone, raw data can be processed to extract the arithmetic mean, the median, the standard deviation or not processed.

All transmitted samples are time stamped independently.

5.5.2 Acoustic noise sensor

Measurements of acoustic noise can be done during ascent phase only. Sensor management can be adapted to the experiment by user with up to 10 acquisition depths.

Before ambient noise measurement, the float waits it has stabilized in the water column and then stops SBE 41's pump and density control system to ensure no internal noise occurs.

5.6 Surface session

5.6.1 Emergence

The emergence consists in providing sufficient buoyancy to the float to perform a session at the surface. The operation is achieved by a fixed pump action.

5.6.2 GPS positioning

APMT float determines its location at the beginning of the surface session. The GPS position is then transmitted in the technical file related to the current profile. GPS date/time can also be used to synchronize the float's clock or determine its clock drift.

5.6.3 Transmission

APMT float starts transmission session with the data file/packet containing the current GPS position. Then the float transmits non transmitted data files/packets (from current and past profiles) stored in its memory.

In Iridium RUDICS communication, APMT float transmits its entire configuration file after any configuration changes or during the first transmission session. APMT float can also send relevant time stamped information necessary to understand its operations.

5.6.4 Remote control

In case of bidirectional communication link, the APMT float provides the user to transmit commands remotely (via satellite) to modify the mission relevant parameters after deployment.

Remote control of the float is achieved by transmitting orders to the float by creating a command file on the float’s back office server. The command file is downloaded at the end of each transmission session end then interpreted by the float.

5.6.5 Pressure drift compensation

After a successful surface session (completion of a GPS positioning and/or transmission) the float starts a pressure compensation mechanism. Then the pressure offset drift is stored for the next transmission.

5.7 End of life

The float enters this phase by different sources:

- The preprogrammed number of cycles is reached
- A user selectable event occurs (e.g.: low battery voltage)
- A non selectable event occurs (e.g.: the profiling float fails to sink after launching)
- A remote command sent by an operator through satellite communication

When entering end of life, two scenarios are available.

5.7.1 Recovery mode

The “recovery” mode consists in performing GPS positioning and transmissions at regular and user configurable intervals. In this phase, the float stays on surface and transmits its position and technical parameters. This mode is intended to facilitate recovery of the float from the ocean.

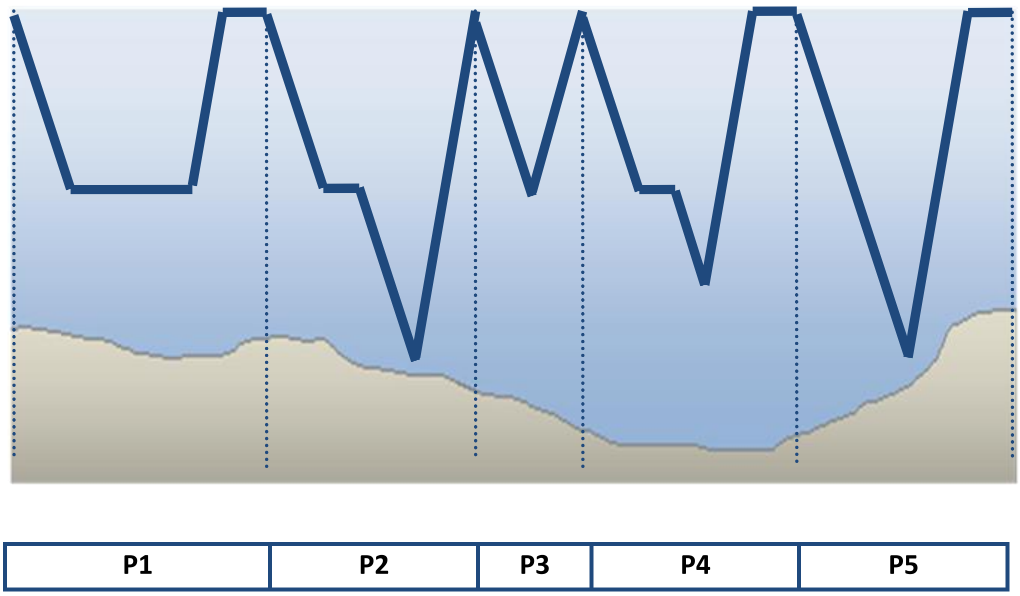
5.7.2 Scuttling mode

The “scuttling” mode consists in destroying the float at the end of the mission. After the last data transmission completion, the content of the internal memory is cleared and the float uses hydraulic electro-valve action until self-destruction.

5.8 Advanced features

5.8.1 Cycle definition – Multi-profile

During a cycle, the float can make up to 10 successive patterns with different parameters for each (“parking” and “measurement” depths, time synchronization, profile duration, GPS positioning and transmission session).



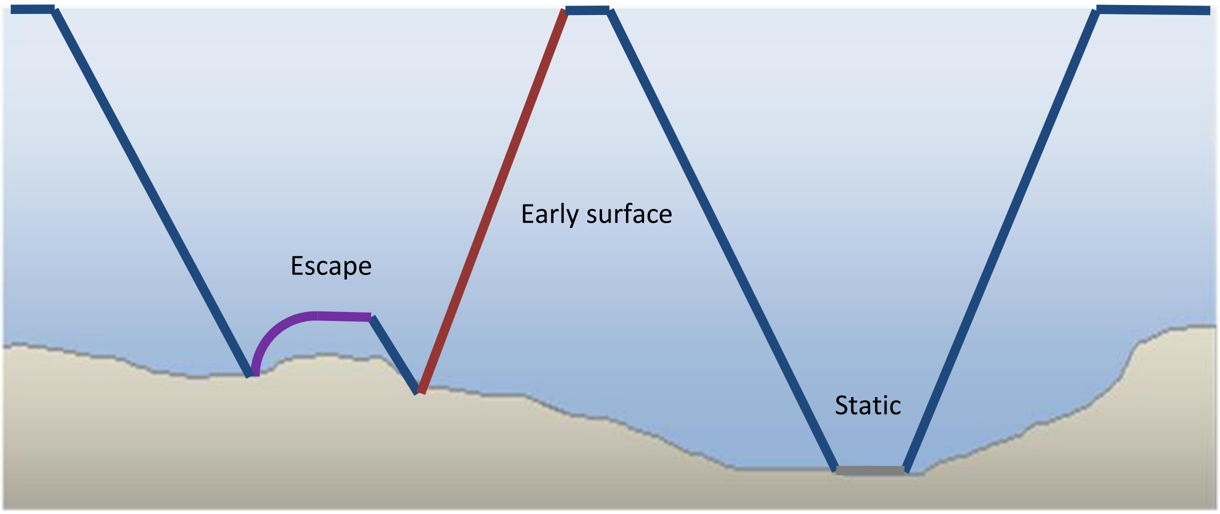
--- Figure 2. Representation of a “5 pattern” cycle ---

5.8.2 Grounding

The grounding during the descent consists in detecting the absence of movement of the float despite a large displacement of oil to descend.

Upon detection of grounding, user can configure different strategies:

- Escape mode: set point correction
- Static mode: stay on seabed
- Early surface mode: ascent immediately



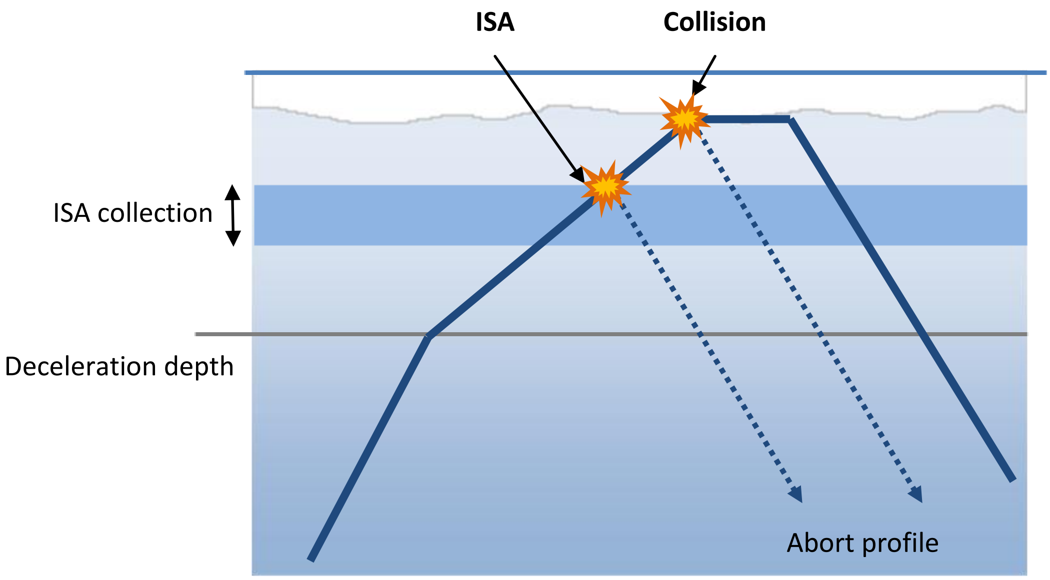
--- Figure 3. Grounding strategies ---

5.8.3 Under Ice capabilities (on-demand option)

The main objective of the under-ice algorithm is to prevent the float from being damaged by knocking the underside of the sea ice or crushed in surface by free-floating ice blocks. The second objective is to save energy when surfacing is not efficient.

Ice capabilities are based on:

- Decelerating for surface approach
- Detecting ice by Ice-Sensing Algorithm
- Detecting ice by hitting the underside of ice
- Aborting profile (keep data in memory until next transmission)



--- Figure 4. Under ice strategies ---

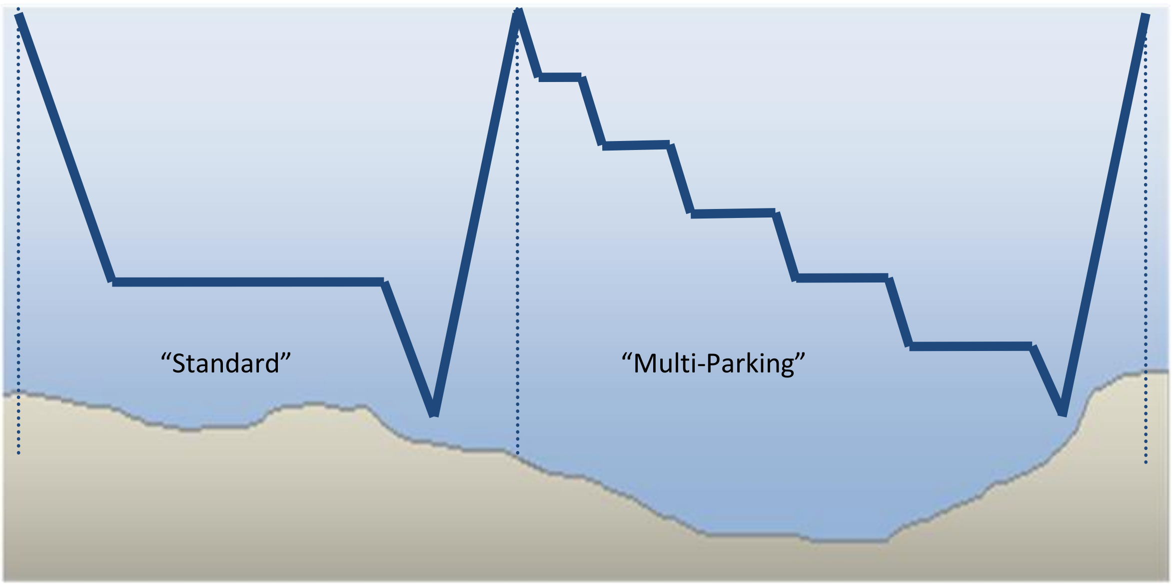
5.8.4 Multi-Parking capabilities (on-demand option)

The “Multi-Parking” option is designed to allow the acquisition of data over time at different depths during the same dive of the float. This makes it possible to observe the evolution of water layers in an area on a limited time scale.

The “Multi-Parking” behavior consists in repeating descents and submerged drifts stages before reaching the measurement depth and then ascending to the surface. Up to 5 different parking stages can be used in a profile.

During the drift at a parking depth, the float checks the external pressure and adjusts its buoyancy to stay close to the target depth.

Data can be collected during each descent and parking drift stage.



--- Figure 5. Overview of “Multi-Parking” behavior ---

5.8.5 Scrip-programmed actions

Prior to deployment, user can predefine automatic "one-shot" command interpretation. This feature can be used by detecting 2 kinds of deadlines:

- **On cycle number**
  Example 1: change cycle period after the 3rd cycle completion.
- **On date**
  Example 2: switch between summer/winter configurations.
  Example 3: enter end of life.

It is also possible to predefine automatic "periodic" command interpretation:

- **Once every N cycles**
  Example 4: activate HYDROC sensor once every 5 profiles.

5.8.6 Memory extension (on-demand option)

APMT float can embed an additional memory card (µSD format). When installed, the float can keep in this memory all non transmitted data files/packets during a no transmission long period (permanent or temporary transmission link failure or under ice period...).

6 Configure and diagnose

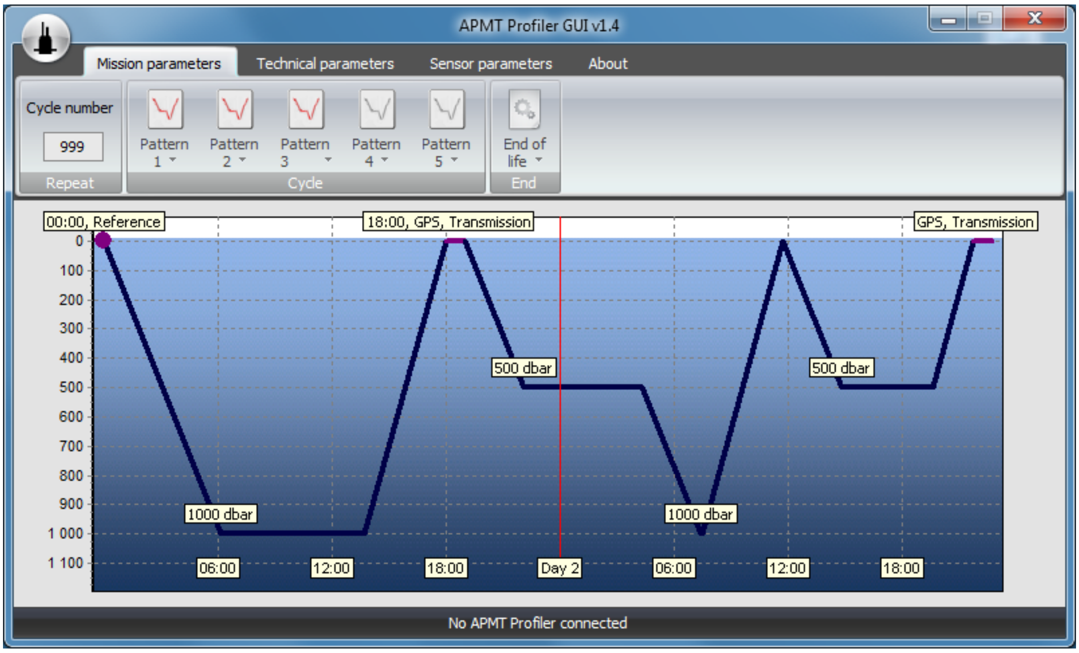
The float integrates a Bluetooth interface which is used to configure and diagnose.

The APMT float uses versatile embedded software. Configuration and diagnosis are based on two standards protocols from its embedded IP stack:

- **FTP (File Transfer Protocol)**
  This protocol is used for downloading/uploading files from/to the embedded file system.
- **TELNET (Terminal Network protocol)**
  This protocol is used to interpret commands on the embedded system.

The APMT float's configuration is described in a configuration text file. This file is organized in section of several parameters. Each section contains all parameters related to a specific aspect of the system.

A user friendly Graphical User Interface is available for mission and sensor parameters adjustment and float configuration over Bluetooth link.



7 Where to find information

Information on APMT floats are organized in several documents:

- **33-16-051_APMT_General_Overview**
  This document contains a general description of the float and its main features.
- **33-16-045_APMT_Quick_Start**
  This document contains the instructions to configure and diagnose the float.
- **33-16-055_APMT_Sensors**
  This document presents the list of sensors available on the float and their characteristics.
- **33-16-048_APMT_Parameter_Set**
  This document describes all the float's parameters and detailed description of their use.
- **33-16-047_APMT_Command_Set**
  This document describes all the float commands available locally via the Bluetooth link or remotely during the mission.
- **33-16-050_APMT_Graphical_User_Interface**
  This document contains an introduction to the Graphical User Interface. This software helps the user to prepare the mission and to define the acquisition of the sensors.
- **33-16-060_APMT_Deployment**
  This document contains the instructions to handle, configure and launch the float.
- **33-16-046_APMT_File_Management**
  This document describes the file system of the float and the different types of files. The technical and sensor's data encoding formats are described for users who wish to decode files themselves.
- **33-16-056_APMT_Under_Ice_Capabilities**
  This document presents the under ice behaviour and the related settings.
- **33-16-062_APMT_Multi_Parking_Capabilities**
  This document presents the multi-parking behaviour and the related settings.

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