# BI-DIRECTIONNAL SATELLITE COMMUNICATIONS ON NEW PROFILING FLOATS.

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## Introduction

Argos is the well known satellite communication system which has been used for several years for profiling float applications. It fits the need for ocean global coverage, combined with open seas, as spending a few hours at surface to transmit data is acceptable for such applications. Several new requirements appeared these last years for profiling float applications:

- First, the performances of these instruments, for Argo deployments, could be affected in marginal seas where specific requirements are needed. In particular, it is critical to reduce the transmission time at surface to lower the risk of thefts, trawling or impacts in these highly trafficked seas, to delay the time for beaching on the shores, and to have better estimates of subsurface currents with a given reduced cycling period (e.g. 5 days).
- For coastal applications, one main objective is to realize successive profiles at the same location in order to delay beaching. The float is on standby between each profile, standing on the sea floor. It behaves as a "virtual mooring". Moreover, in shallow waters, operation at low depth and proximity of the coast increases the development of bio-fouling. These constraints require minimizing the drift of the float at, i.e. reduce the time spent to transmit data.
- The remote control of the float is a major improvement that gives new possibilities to the users, for example to adapt mission parameters to specific events that are monitored. It is now possible on floats by using the downlink capabilities of the satellite transmission systems.

In order to answer to these requirements, we have adapted two recent satellite transmission systems on our floats: Iridium and Argos 3. The first system, Iridium, is a 66 satellites Low Earth Orbit system, which gives a global and permanent earth coverage, with 2 ways communication. Messages transmitted from the float are delivered to the user by email. The Arvor float has been fitted with an Iridium modem coupled with a GPS receiver and a high pressure antenna, for Argo marginal seas requirements. The Arvor-C is dedicated to coastal applications; it has also been equipped with the same communication system.

But the first generation of the Iridium constellation, in operation since 1998, is coming to its end in the next few years, and some satellites will stop their operation before 2014. This will have impacts on the Iridium system coverage, which will not be permanent anymore. Information on this degradation of the system and its impacts are difficult to find. A new program is underway, called Iridium Next. Satellites are planned to be launched between 2013 and 2016, but funds are still to be found! This is why it is important to maintain Argos transmission system and particularly its new generation, Argos 3, on our floats.

The second system, Argos, now offers new improvements. Among the 6 non-stationnary polar orbit satellites, one (Metop-A) is fitted with the operational third generation transmitting system (Argos 3), which gives low and high rate data transfer with acknowledgement, and a two ways communication. This communication mode is being designed in order to be embedded on Arvor, for marginal seasrequirements. In 2011, two other Argos 3 satellites will be launched: Saral and Metop B, and in 2012, Metop C. To sum up, there will be five Argos 3 satellites in operation by the end of 2012. The coverage will not be permanent, but the time interval between two satellites will be highly reduced, which offers interesting perspectives in terms of data transmission performances. This will allow our floats to respond to the new demands as explained before, and will save energy as transmission duration will be reduced.

Moreover, the integration of Argos 3 on Arvor floats only concerns the low data rate transmission of this system. But Argos 3 satellites also embed a high data rate transmission, which is not fully in operation today, but gives perspectives of performance improvements in the near future. Hereafter, we introduce the work done in 2009.

## ARVOR: Iridium satellite transmission

All of the standard Arvor specifications have been maintained, and some specific features have been added as following.

The transmitting algorithm has been modified and data has been gathered in 200 bytes SBD (short burst data) messages. The software drivers of the iridium modem and the GPS receiver has been improved (compared to previous one used on ProvBio). The technical message contains more information about the behavior of the float and includes the last CTD raw data before stopping the CTD pump at the end of the rising profile. This is useful for the knowledge of the surface properties. The parameters of the mission (period cycle, parking depth, profile depth…) can be remotely modified during operation by the downlink capability of the satellite transmission.

The first Arvor-i was given to OGS in order to be deployed in the south of Cyprus. It was launched from the Tara ship in early December. The float was programmed to cycle every day from 700 m depth. Up to early march, this float has done 90 cycles. The 2nd float was launched in Adriatic Sea on February 2010 (figures 1 and 2).

**Figure 1:** Arvor-I

Only 3 minutes are needed to transmit the data when the float is at surface. The total time at surface is around 30 minutes, including the time to increase the buoyancy for good satellite transmission, the duration of the transmission, and then the time spent to reduce buoyancy to start a new cycle (to be compared to more than 8 hours today with Argos). The objective to reduce the time at surface has been reached.


**Figure 2**

Arvor-I deployement

## Arvor-C: A Coastal Autonomous Profiling Float with Seabed Stationing Capability for Real-Time Monitoring of Coastal Seas

A growing number of users, from private individuals to professionals, need forecasts or real time information about the coastal seas. Operational Coastal Oceanography programs require good quality time series of real time *in situ* data, in order to develop numerical models to make predictions, or to provide real time information.

A major breakthrough in coastal observation has been made by Ifremer, the French Research Institute for Exploitation of the Sea. The autonomous profiling float Arvor-C (figure 3) was designed to make repetitive *in situ* measurements along profiles from the seafloor to the surface, providing complete three-dimensional high rate data. The Arvor-C is a vertical untethered profiling float, easy to set up and ready to be deployed. It behaves like a virtual mooring, for short to long term observations. It can take measurements at the same location for each profile thanks to the optimized time of ascent and descent through the water column, the short time of transmission at the surface, and its seabed stationing capability.

In standard mode, the Arvor-C operates autonomously. One of the major features is its Iridium™ satellite bi-directional link: firstly, it offers a fast uplink to transfer data when surfacing after each profile, and secondly, it provides a downlink remote control to reconfigure the mission parameters during operation. For example, users can increase the number of profiles per day and the sensor sampling frequencies when a bloom is detected. The Arvor-C provides a standard set of measurements (pressure, temperature and conductivity), as well as a set of technical information. Multidisciplinary sensors can be integrated on this vertical vehicle, which is designed as an open platform. Additional sensors are being currently fitted to measure dissolved oxygen, turbidity and fluorescence.

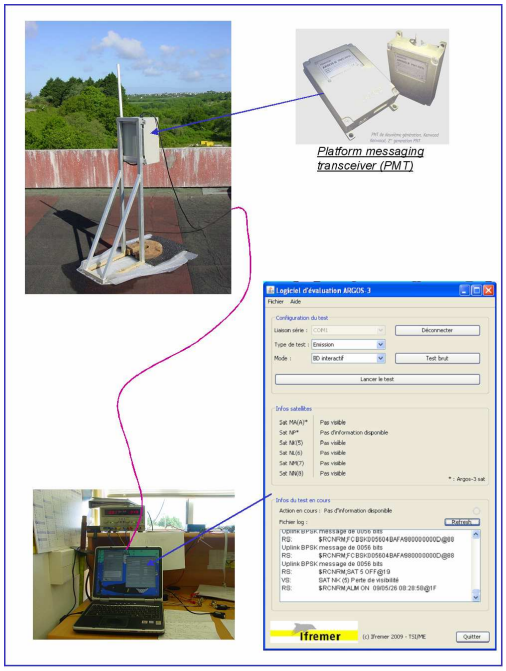
The Arvor-C was successfully deployed during the ASPEX cruise in the Bay of Biscay, and it has provided CTD profiles since July 2009. Every cycle, a few minutes at surface are needed to transmit the data.

**Figure 3:** Arvor-C

## ARVOR with Argos3 satellite transmission

In order to have an alternative way to improve communication performances on floats, assessment of the new PMT (Plateform messaging transmitter, supplied by CLS-Argos) has been done. Tools have been designed to understand and evaluate Argos3 performances (figure 4). The aim was to find an appropriate methodology for using Argos3 on floats. The capability of transmitting one profile during one satellite pass has been assessed (less than 15mn).

- An electronic waterproof case has been fitted with one PMT (Argos3 modem) with an aerial antenna and placed on a flat roof at Ifremer to have a clear view of the horizon. It is driven by a computer.
- Evaluation software has been designed to do the trials. The aim was to test random protocol (Argos2 mode), interactive mode (Argos3 low data rate mode) or "pseudo-ack" mode (based on satellite pass predictions). Assessment has been done on transmission performance (error rates, influence of satellite elevation and orientation, power balance, scheduling strategy for the float to surface, using pass prediction tables), and downlink communication.




Argos3 test platform

**Figure 4:** Argos3 test platform

Thanks to these tests, we determined the most suitable algorithm for the implementation in a profiling float. The specifications of the software have been written, using UML description. Finally, the software has been written on the embedded processor target, and partially tested. In other respects, the design of a new double band and pressure resistant antenna has started. The whole test of the embedded software is ongoing using a wide set of transmission configurations. A first lab demonstration was performed at the end of January by transmitting more than 1 kbyte of data, from a float electronics platform, using a unique Argos3 satellite pass. Two Arvor floats should be ready in spring 2010. These floats will be tested in pressure tank and in the pool at Ifremer. Then, they will be deployed in the Mediterranean Sea.