TSUNAMI WARNING SYSTEM

Technical Specifications of

Underwater Module

Envirtech SpA
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Envirtech S.p.A. Cap. Sociale Euro 500.000 i.v.
Italy 30175 Venezia Marghera (VE) 4/A, Via Pacinotti
Phone +39 041 5313400 Fax +39 041 5313400
CCIAA VE 03852470107 - VAT: IT03852470107

Management
Italy 17031 Albenga (SV) 69/2, Via Patrioti
Phone +39 0182 559643 Fax +39 0182 570976

Branches:
Italy 31020 Vidor (TV) , 6/8 Via Sartori
Italy 30030 Chirignago (VE) 2, Via S. Caterina

e-mail info@envirtech.org
web-site www.envirtech.com

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1 SYSTEM OVERVIEW

The Tsunami Warning System (TWS) designed by Envirtech is composed of the following main subsystems:

- an ***Underwater Module*** (UM) to be installed at the sea bottom in open sea location for the accurate measurement of the tide and the identification of anomalous conditions.
- a ***Surface Buoy*** (SB) moored close to the UM to receive via acoustic link the measurement of UM to be transferred via satellite link to a Data Centre (DC) for visualization and analysis.
- a ***Data Centre*** (DC) on land composed of hardware and software infrastructures for the reception via satellite link of the data of SB and UM to be displayed, stored and analysed.

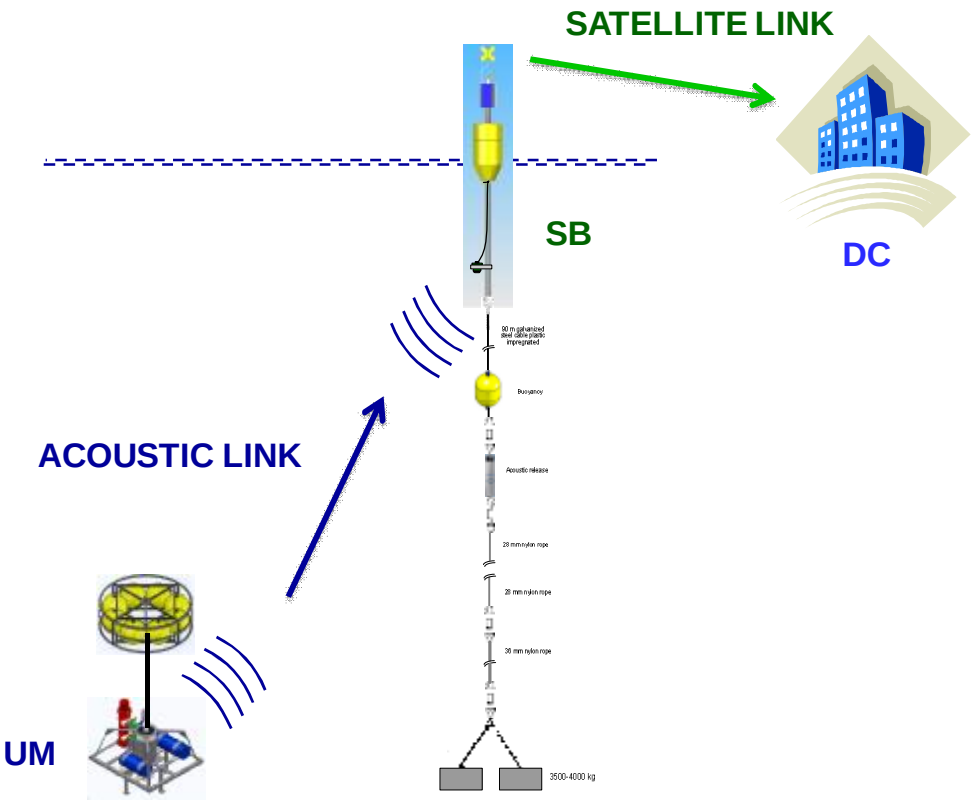

Fig. 1.1 – Envirtech TWS Overview

The present document deals with the architectural, functional and performance specifications of the Underwater Module (UM).

2 UM ARCHITECTURE

The UM is an instrumented unit composed of a mechanical frame integrating the following main parts:

- a high resolution pressure sensor for the accurate detection of variation of the height of the water column;
- an electronic unit for pressure data acquisition, processing and logging: this unit integrates a tilt sensor to verify the stability of the UM at the sea bottom and other diagnostic sensor to verify the status of the whole system;
- an acoustic modem for the communication with the Surface Buoy (SB);
- a battery unit to supply the electronic unit, the instruments and the acoustic modem.
- the installation/recovery subsystem composed of buoyancy line, acoustic release and ballast: this subsystem makes the UM a free fall installation and pop up recovery system.

The block diagram of the underwater module for the real time monitoring of the water column is reported in picture 2.1.

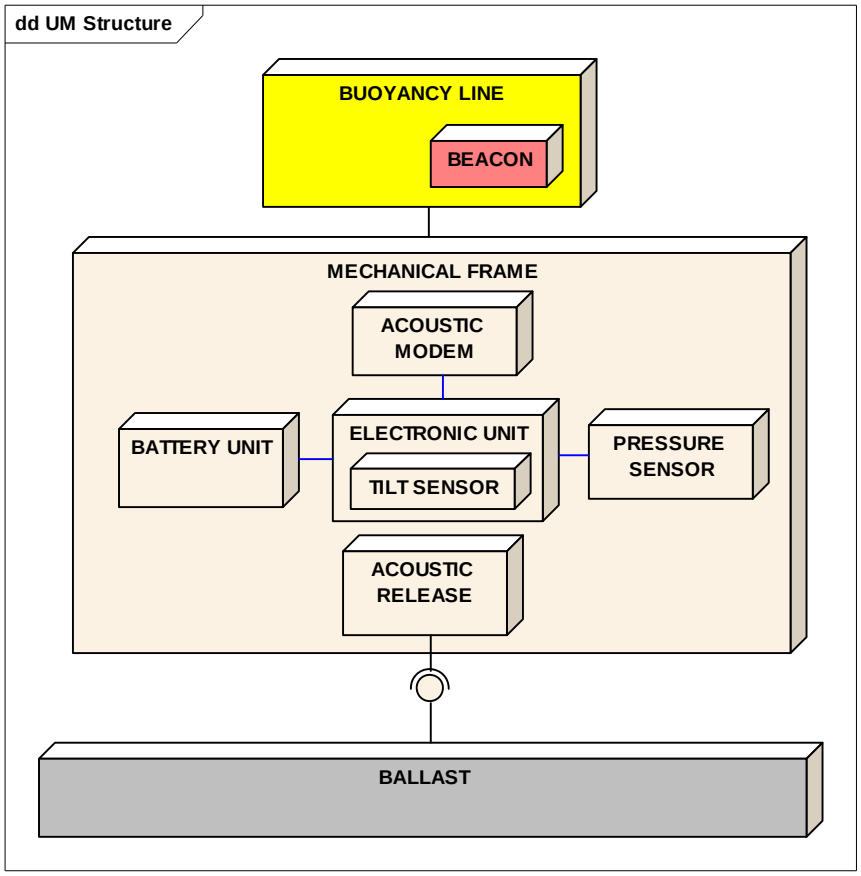

Fig. 2.1 – UM Block Diagram

The components of UM are listed in the following table

Device/Component/Part	Description
Ballast	Composed of a squared metal block to keep the UM stable at the sea bottom.
Buoyancy line	A line composed of a synthetic rope and syntactic foams able to lift the system on surface at the release of the ballast in the recovery phase.
Beacon	A device equipped with ARGOS satellite transmitter providing the position of the UM after the recovery on surface.
Mechanical Frame	A light and robust metallic frame in stainless steel suitable for the marine environment. It integrates mechanically all the components in the present table.
Acoustic Release	A mechanical release with acoustic interface to allow disconnecting the ballast at the reception of an acoustic coded command from a surface deck unit.
Pressure sensor	High resolution pressure sensor electrically connected to the Electronic Unit
Electrical Unit	An electronic acquisition system integrated in a titanium canister.
Tilt Sensor	An high precision tilt sensor integrated in the Electronic system
Battery Unit	A primary battery pack with dedicated diagnostic electronic system integrated in a titanium canister
Acoustic Modem	An underwater acoustic modem for the data link with the surface buoy

A drawing and a picture of the UM are reported hereinafter

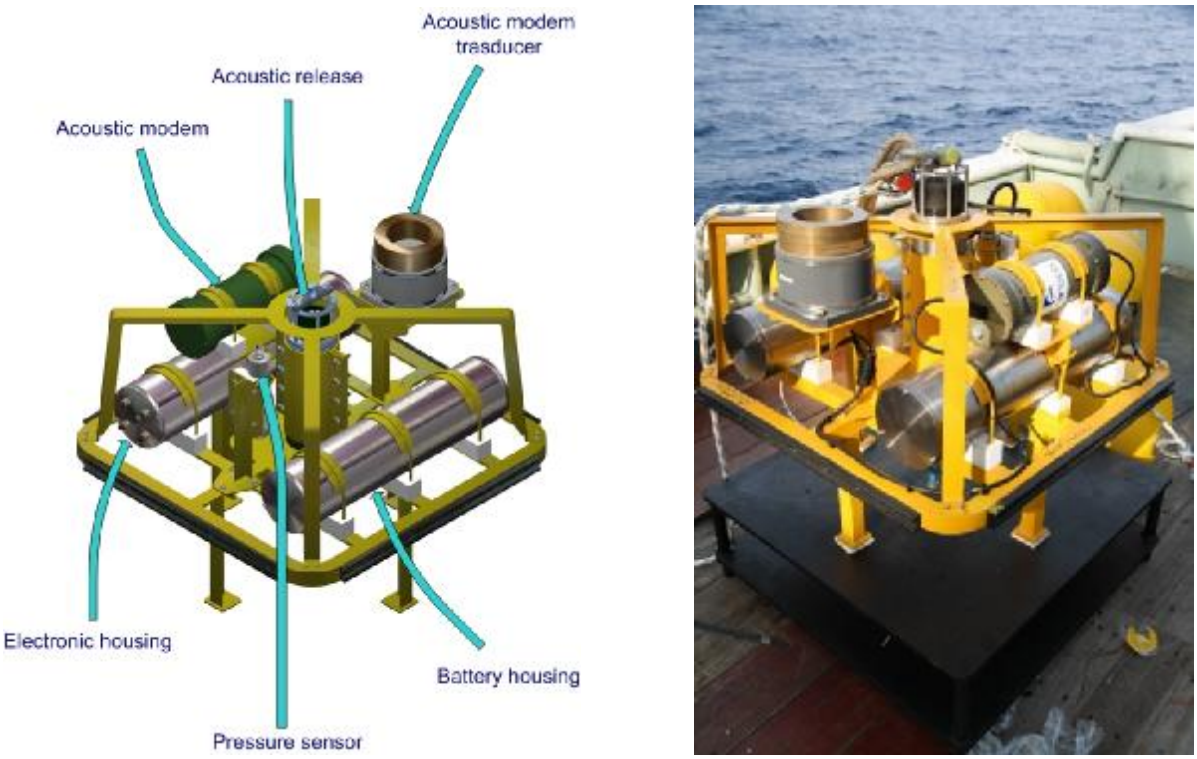

Fig. 2.2 – UM Drawing and Picture

3 UM FUNCTIONALITIES

The main functionalities provided by the UM are summarized hereinafter:

- Possibility for the UM to operate in *Maintenance Mode, Normal Mode, Alarm Mode*;
- In Normal Mode the software acquires, logs and process every 15 seconds the pressure data to detect events over the normal tide signal;
- Automatic switch in Alarm Mode in case of detection of an event and automatic sending of pressure data via acoustic link;
- Automatic switch to Normal Mode after 3 hours of the UM in Alarm Mode;
- Hourly acquisition and logging of UM Status Message composed of
    - 4 averages on 15mins of the tide data;
    - Seawater temperature;
    - Status sensors (internal temperature, pressure and water intrusion alarm) of Electronic housing;
    - Status sensors (battery voltage and current, internal temperature, pressure and water intrusion alarm) of Battery housing;
    - Heading and Tilt sensors data.
- Sending in Normal Mode every 1 hour, 2 hours, 3 hours, 4 hours, 6 hours (depending on the user settings) of the hourly UM Status Messages.
- Management of data request of past pressure data stream.
- Management of request of current status data composed of
    - Current Pressure;
    - Seawater temperature;
    - Status sensors of Electronic housing;
    - Status sensors of Battery housing;
    - Heading and Tilt sensors data;
- Management of commands to
    - Set alarm detection threshold;
    - Period for sending UM Status Messages;
    - Switch UM in Maintenance, Normal and Alarm mode;
- Management of bi-directional acoustic link with the Surface Buoy to send messages and to receive commands and data requests.

The installation of the UM is free fall and the recovery for maintenance and re-installation is pop-up. This is made possible by the buoyancy line + an acoustic release + a ballast.

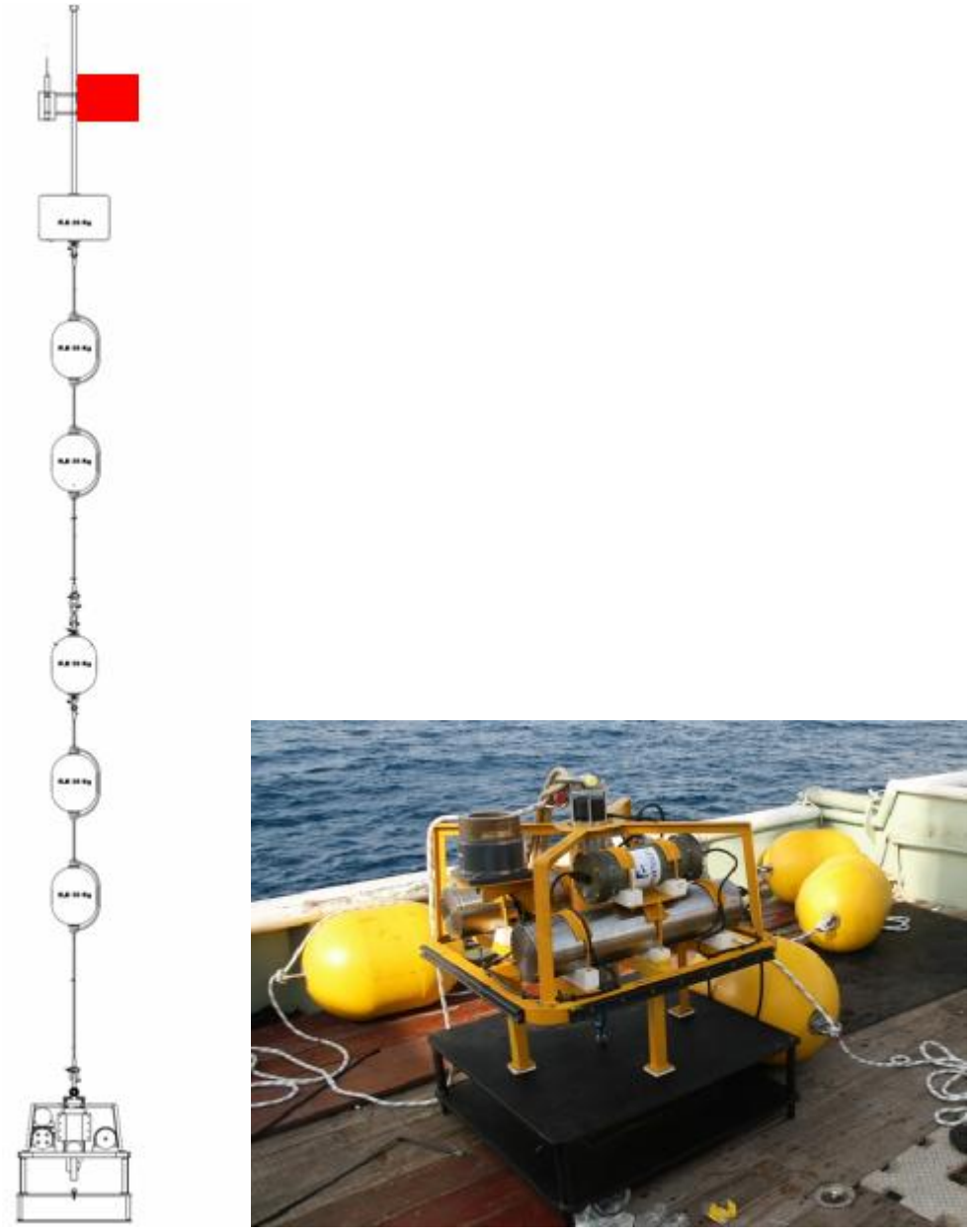

Fig. 3.1 – Drawing and picture of UM with related installation and recovery system

4 TECHNICAL DESCRIPTION

The Envirtech UM Poseidon class is an autonomous system suitable for the real time detection of perturbation on the normal tide (e.g. tsunami). It can be installed up to 6000mwd in Open Ocean.
The system is composed of a robust mechanical frame in stainless steel AISI316 suitable for the marine environment, integrating the following main parts:

- Pressure sensor Paroscientific Digiquartz with a pressure measurement resolution better than 1mm of H_2O in a water column of 7000m. The sensor is temperature compensated and provides also high resolution temperature measurement (0.001°C).
- Spread Spectrum modulation acoustic modem providing a 5000 bps bidirectional data link with a surface modem on a relay buoy.
- Autonomous power supply unit composed of primary lithium battery pack, protected in Titanium housing: this battery, used in military application, assures an operative life of 24 months with the system sending an acoustic message per hour
- Data Acquisition and Control system protected in Titanium housing integrating a low power microelectronic system for the real time data acquisition and the pressure data processing. The electronic system includes switch board, voltage conditioning board, heading and tilt sensor (able to measure heading, pitch and roll with a resolution of 0.1 deg) and diagnostic board monitoring battery voltage and current, internal pressure, temperature and water intrusion in the Titanium housings.
- A recovery system relied on a buoyancy line, composed of 6 deep sea syntactic buoys and an acoustic release unlocking a metal or concrete ballast of 220kg for the recovery of the system on surface. The acoustic release can be actuated by a dedicated deck unit with coded commands.
- The electronic unit has a proper mass memory (CF card) to store all the data acquired in 24 months.

The software in the CPU provides the following main functionalities:

- The acquisition of the pressure sensor (1 sample every 15sec);
- The acquisition of the heading & tilt sensor;
- The acquisition of the diagnostic boards;
- The real time clock;
- The data storage;
- The real time detection of anomalous events on the normal tide. The following algorithms can be implemented:

- Mofjeld Algorithm that allows to detect variations of the water column in the typical Tsunami waves period range (2-90min);
- Innovative algorithm relied on the neural network to improve the Mofjeld Algorithm in the detection of tsunami events.
- Others algorithms on user request.

- Periodical transfer to the surface relay buoy (every hour or three hours) of a message containing tide data, tilt data and diagnostic data.
- In case of detection of an event, alarm messages are transferred to the surface relay buoy every few minutes. This functionality allows the rapid user validation of the collected data and the estimation of the possible danger scenarios.

The following paragraphs detail the specification of each UM component.

4.1 Mechanical Frame

The mechanical frame is depicted in picture 4.1 with detail of the ballast on the bottom of the unit

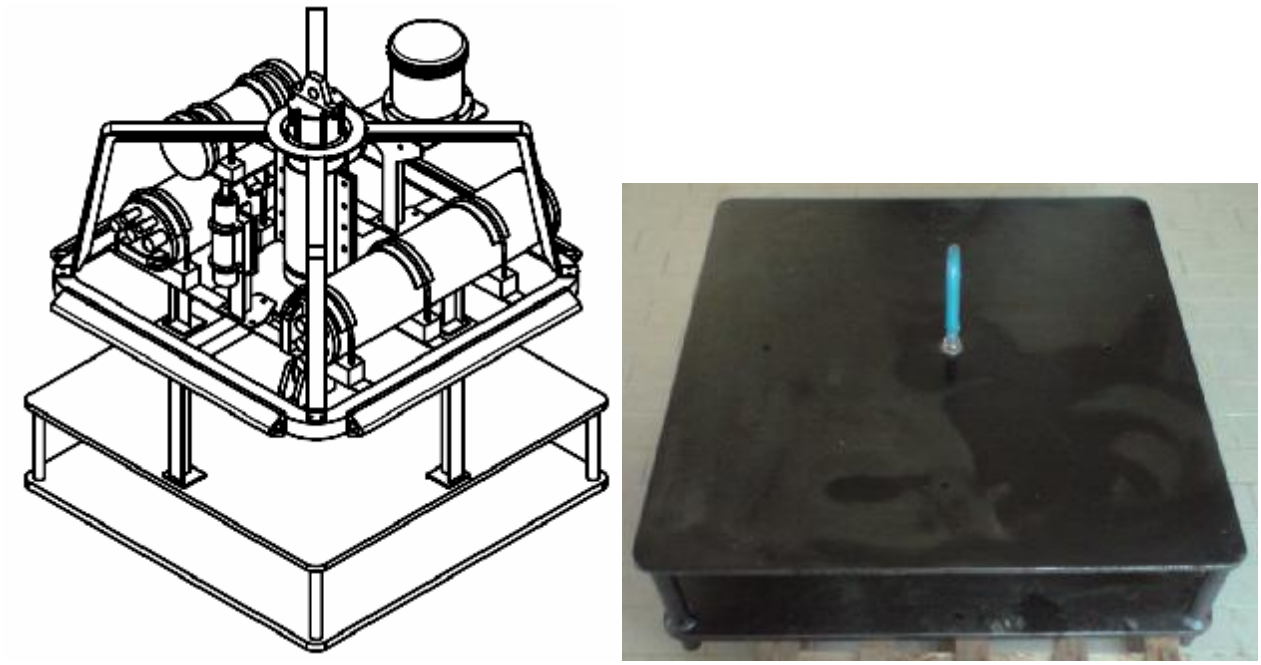

Fig. 4.1 – Frame of UM and Ballast picture

The material of the frame is stainless steel AISI316L.

Main parameters of the UM are the following

- Sizes: 900x900x800 mm
- Weight in air of UM: 180kg
- Weight in water of UM: 110kg
- Ballast weigth in air: 220kg
- Ballast weigth in water: 185kg

Thus the forces/speed in the installation and recovery phases are the following

- Net force in free fall: 886 N
- Max speed at installation: 1.2m/s

- Net force at recovery: 857 N
- Max speed at recover: 1.3m/s

4.2 Pressure Sensor

Pressure sensor is depicted in Fig 4.2.

Fig 4.2 Paroscientific Digiquartz Pressure Sensor

Technical specifications:

- Range: 7000m
- Resolution: 0.1 ppm @ 1sample/15sec
- Built-in Temperature sensor.

4.3 Acoustic Release

Acoustic release is depicted in Fig 4.3

Fig 4.3 - Oceano 2500 Light Acoustic Release

Technical specifications:

- Super Duplex Stainless Steel
- Working Load Limit: 2500kg
- Autonomy: 6 years
- Depth: up to 6000m

4.4 Acoustic Modem

It is depicted in Fig. 4.4

Fig 4.4 - UWM 10000 Acoustic Modem

Technical specifications:

- Modulation: Spread Spectrum
- Data rate: 5000 bps
- Slant range: 10000m
- Depth: up to 7000m

4.5 Battery Housing

It is depicted in Fig 2.4

Fig 2.4 Titanium Battery Housing

Technical specifications:

- Battery pack for electronic system (14.4V 518Ah 1Amax)
- Status board to monitor
    - Internal temperature
    - Internal pressure
    - Water intrusion

4.6 Electronic housing

It is depicted in Fig 2.5

Fig 2.5 Titanium Electronic Housing

Technical specifications:

- Battery pack for acoustic link (25.2V 104Ah 5Amax)
- ENV-UM-ELE composed of
    - CPU board
    - Status board
    - Switch board
    - DC/DC board

5 UM COMPLIANT TABLE

ID	Requirement	Note
1	Material of the frame shall be AISI316L	
2	Material of the protective housings for electronic and battery shall be Titanium grade 5	
3	The buoys of buoyancy line shall be in syntactic foam: the use of glass sphere is not allowed	
4	Acoustic release of the recovery system shall be independent by the acoustic modem for data link UM-SB	
5	Primary battery for UM electronic and acoustic modem shall be Lithium battery	
6	Acoustic Modem shall provide a slant range of 10000m	
7	Pressure sensor shall provide a resolution of at least 1ppm on a range of 7000m with a sampling period of 15sec	
8	Electronic and battery housings shall be equipped with internal status sensor to monitor internal pressure, temperature and water intrusion	
9	The UM shall be configurable to send a normal tide message every N hours with N = 1,2,3,4,6. Tide shall be provided as 15mins averaged values	
10	In case of Alarm detection the UM shall send every 5 or 10 minutes the raw samples spaced of 15 secs. The process shall last at least 3 hours for every alarm detection	