100% European Company (Italy)

Environment, Oceanography, Maritime Security

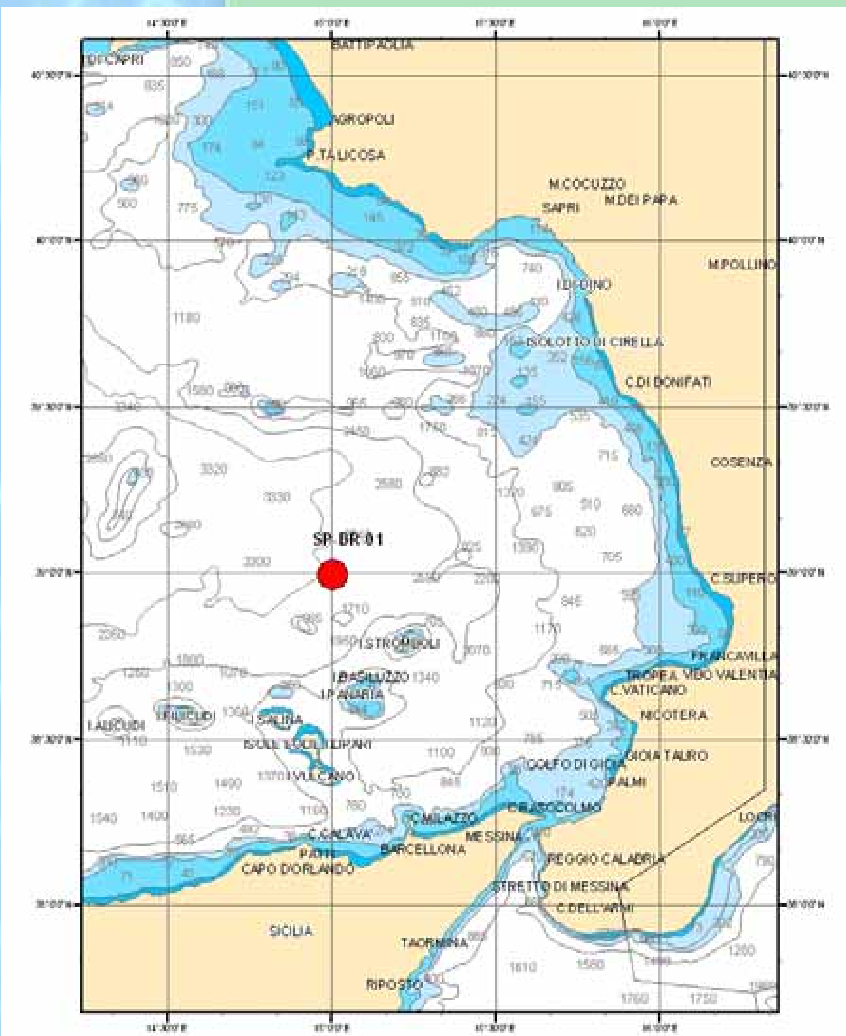
ISO9001:2000 Certified - NATO Clearance

Offices:

ITALY - Rome, Palermo, Genova

Factory:

ITALY - VIDOR (TV)



MeTAS - Mediterranean Tsunami Alarm System

Italian Environment Agency project, first of four deep sea stations.

Deployed between submarine Marsili Volcano and Stromboli's Island.

Depth -2000 m

津波

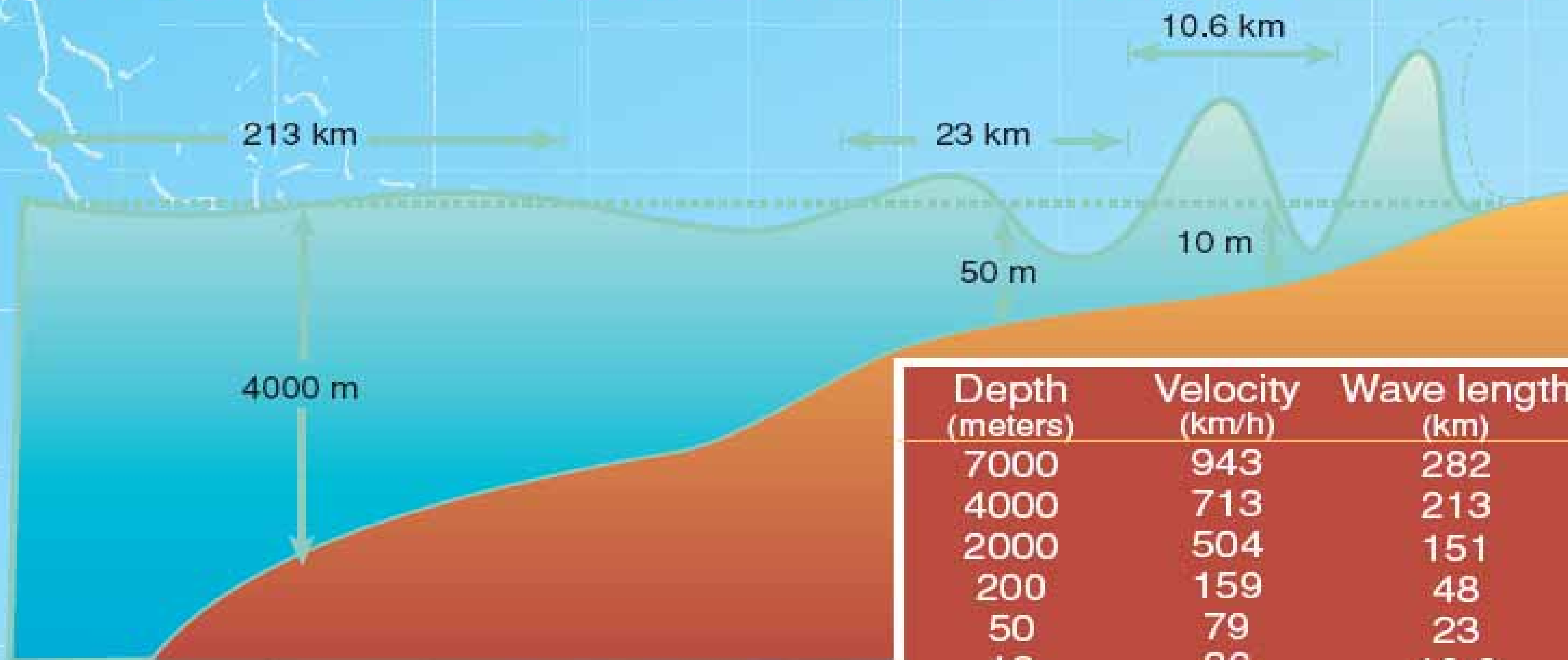
Tsunami (*tsoo – nah – mee*)

Tsu (harbor) & nami (wave)

- Tsunamis are gravity waves that propagate near the ocean surface.
- Most tsunamis spring from sudden shifts of the ocean floor. These sudden shifts can originate from undersea landslides and volcanoes, but mostly, submarine earthquakes parent tsunamis. **So tsunamis often are called seismic sea waves**.
- Compared with wind-driven waves, seismic sea waves have periods, wavelengths, and velocities ten or a hundred times larger.
- Tsunamis thus have profoundly different propagation characteristics and shoreline consequences

Tsunami at the beach

Tsunami Speed is reduced in shallow water as wave height increases rapidly.



Depth (meters)	Velocity (km/h)	Wave length (km)
7000	943	282
4000	713	213
2000	504	151
200	159	48
50	79	23
10	36	10.6

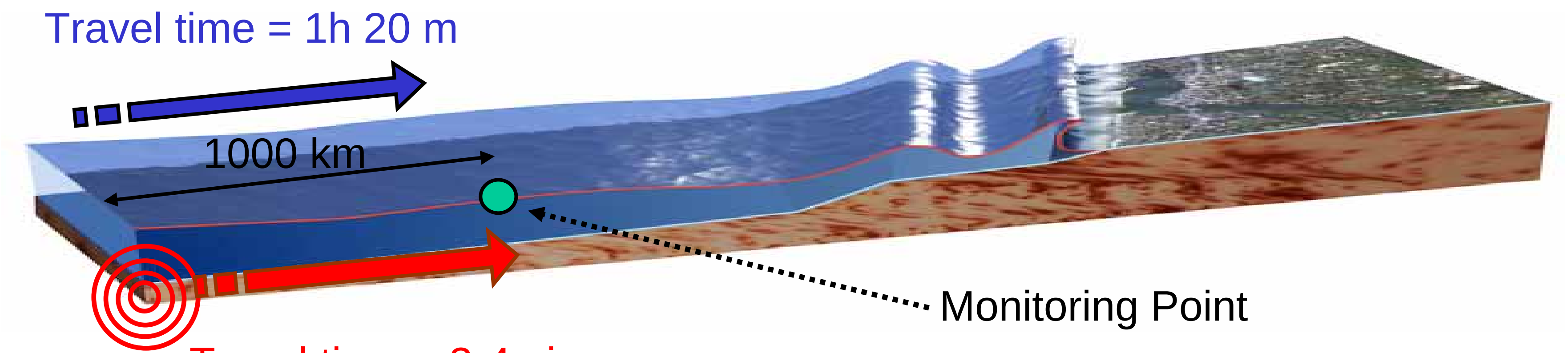
In the open ocean a tsunami is less than a few tens of centimeters (1 ft) high at the surface, but its wave height increases rapidly in shallow water. Tsunami wave energy extends from the surface to the bottom in even the deepest waters. As the tsunami attacks the coastline, the wave energy is compressed into a much shorter distance and a much shallower depth, creating destructive, life-threatening waves.

Tsunami Forecasting

- The ultimate goal of tsunami research is forecasting. Tsunami **forecasts** differ from tsunami **hazard** in that forecasting is case-specific, not statistical.
- A forecast predicts the strength of a particular tsunami given the knowledge that a potentially dangerous earthquake has occurred already. **Tsunamis travel at the speed of a jet**, but **seismic waves** that contain information about the earthquake faulting **travel 20 or 30 times faster.**
- To increase **prediction time** and **event detection reliability**, **seismic waves** and **sea waves** instruments shall be placed close to the source of the phenomena

→ need of monitoring nodes in open ocean

Tsunami Forecasting



- Seismic wave can be monitored with a broad band three components seismometer placed at the seabed

- Very low frequency sea wave can be monitored with a high precision and high stability pressure sensor located at the seabed too

Tsunami Forecasting

In order to forecast correctly a dangerous tsunami event the following data shall be available to onshore facilities:

a) seismic **wave forms** measured at the seabed and related to an earthquake just occurred in open ocean.

b) low frequency components of sea waves detected with pressure sensor

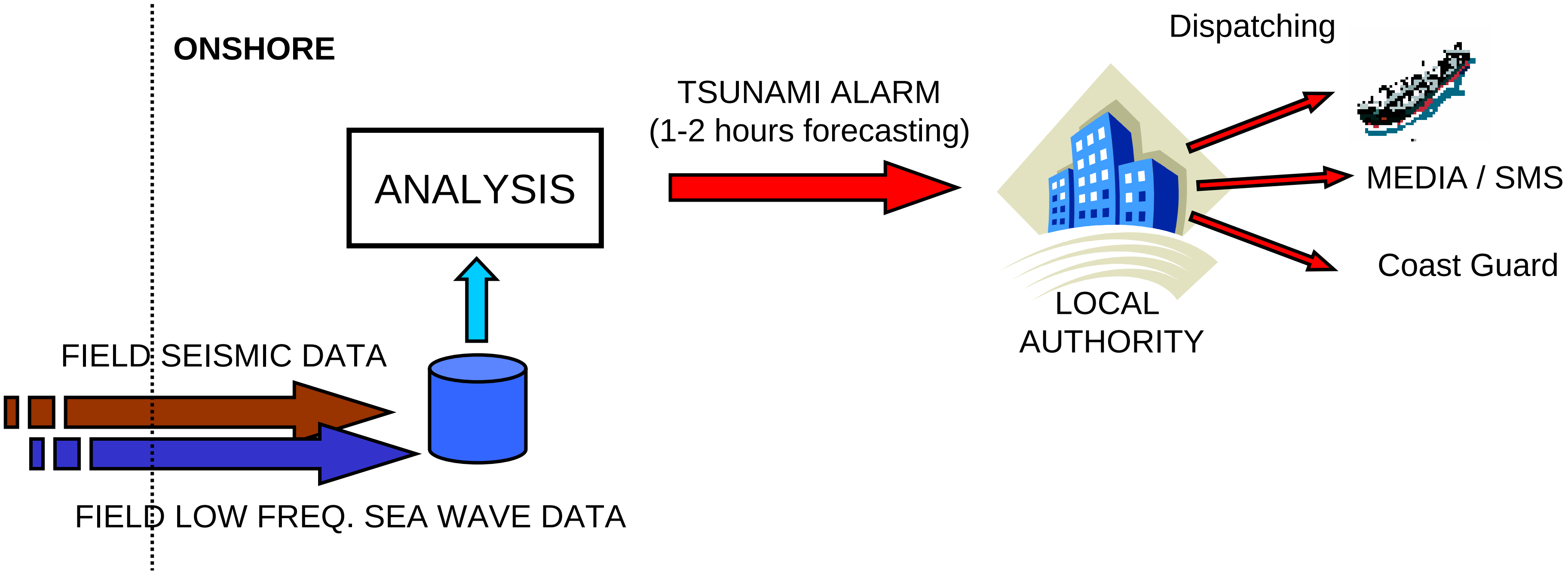
Seismic events can be detected in the monitoring node and only the frame of data related to the event has to be transferred to onshore processing systems.

Sea wave data can be transferred to onshore processing systems or processed directly in the monitoring node to detect the tsunami wave in open ocean.

These data should be acquired by widely distributed monitoring nodes in open ocean and data connected with onshore facilities.

Tsunami Forecasting

In many situations the time between the arrivals of the seismic waves and the sea waves has the order of hours: this time could be spent analyzing seismograms, estimating earthquake parameters (namely location, moment, mechanism and depth), and forecasting the expected height of the oncoming wave with the aid of computer models of tsunami generation.



Tsunami Detection Algorithms with pressure sensors data

It is a classical problem of on line event detection.

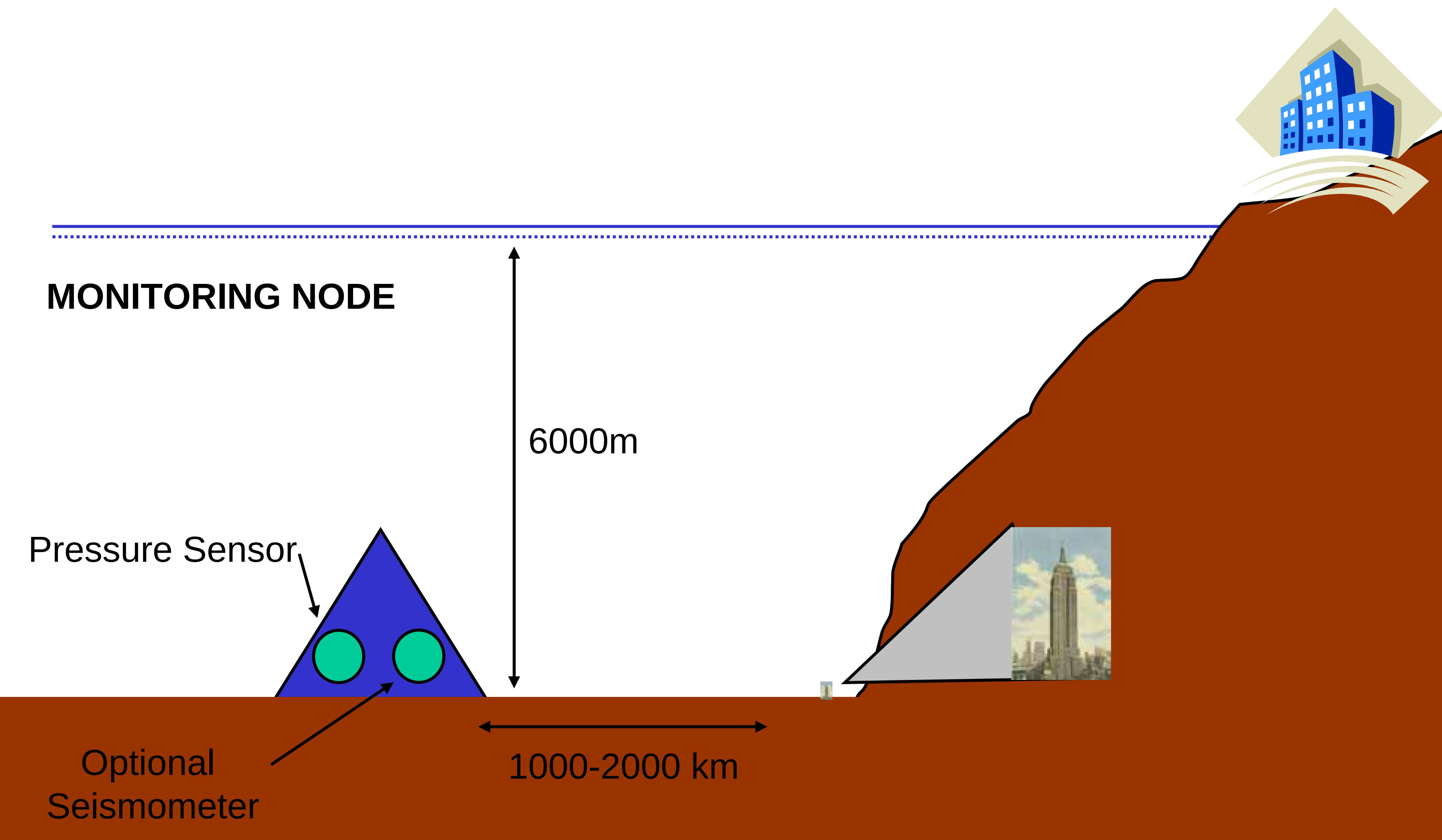
The *five intuitive performance indexes* for designing and evaluating a suitable algorithm are the following :

1) ***mean time between false alarms*;**
2) ***probability of false detection*;**
3) ***mean delay for detection*;**
4) ***probability of non detection*;**
5) ***accuracy of the change* time and magnitude *estimates*.**

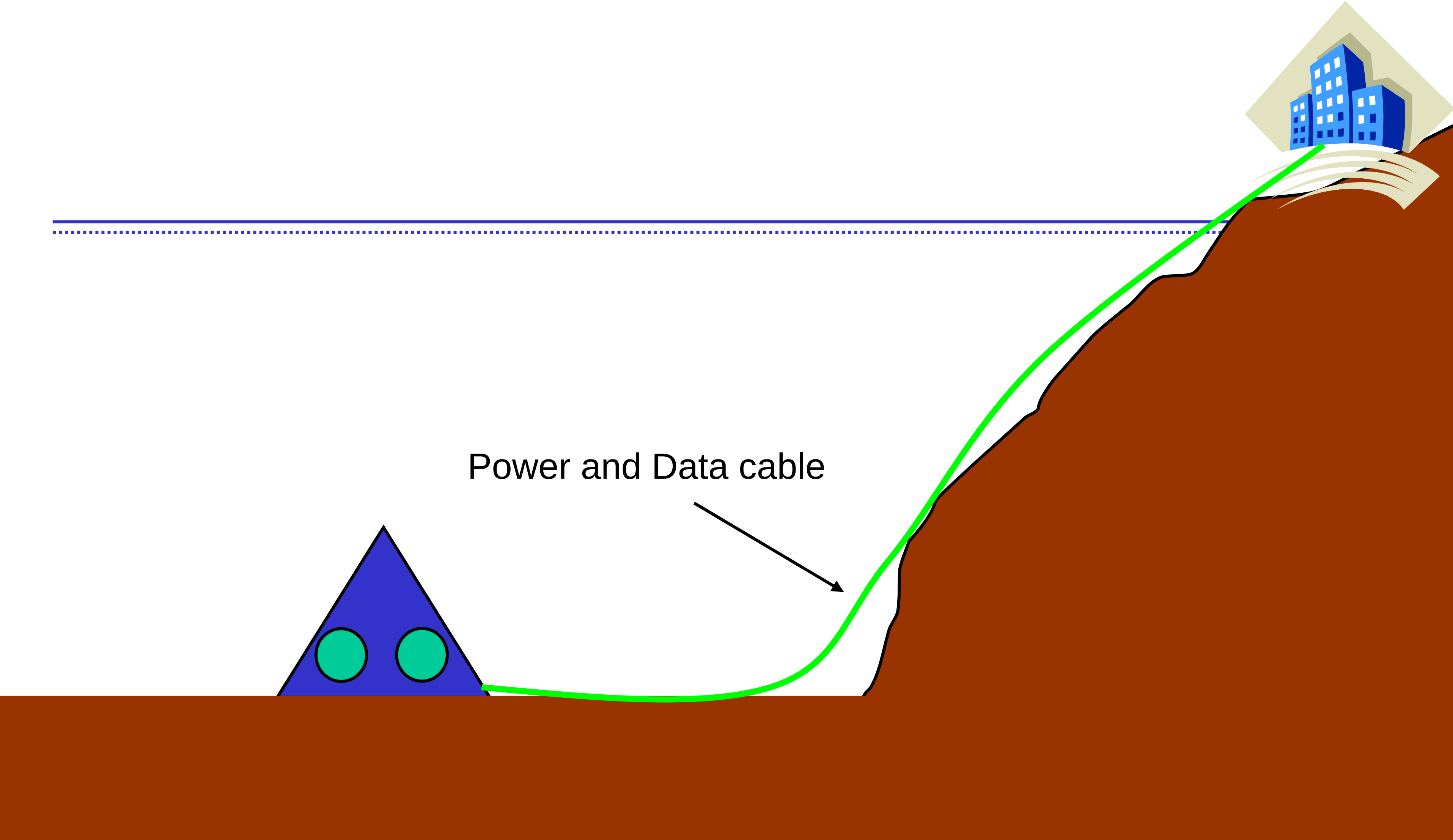
These performance indexes summarize the concept of ***detectability*** of an event.

Another property of change detection algorithms is of great practical importance, and that is the ***robustness***. Algorithms that are robust with respect to noise conditions and to modelling errors, and that are easy to tune on a new signal, are obviously preferred in practice.

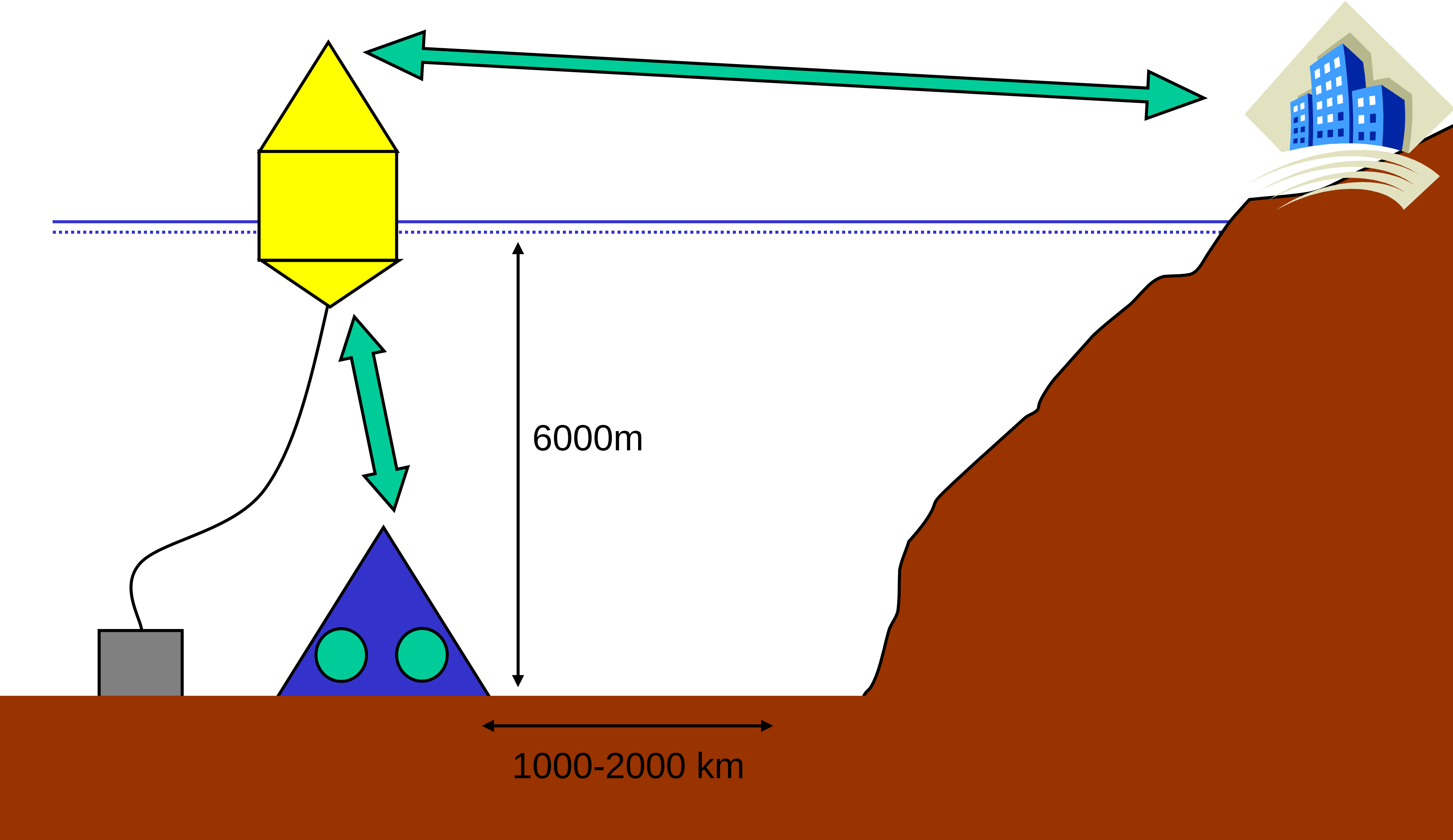
Monitoring node at sea: conceptual layout



Monitoring node at sea: conceptual layout

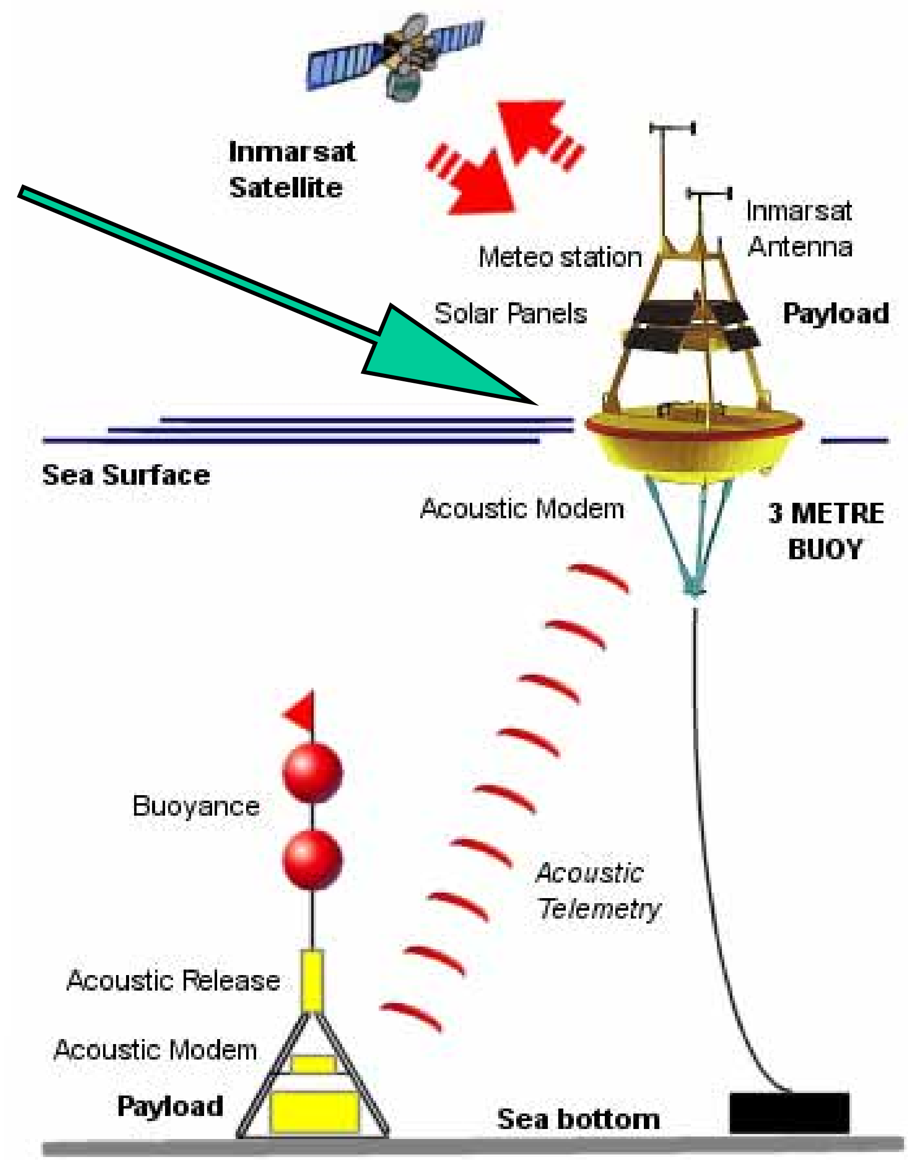


Monitoring node at sea: conceptual layout



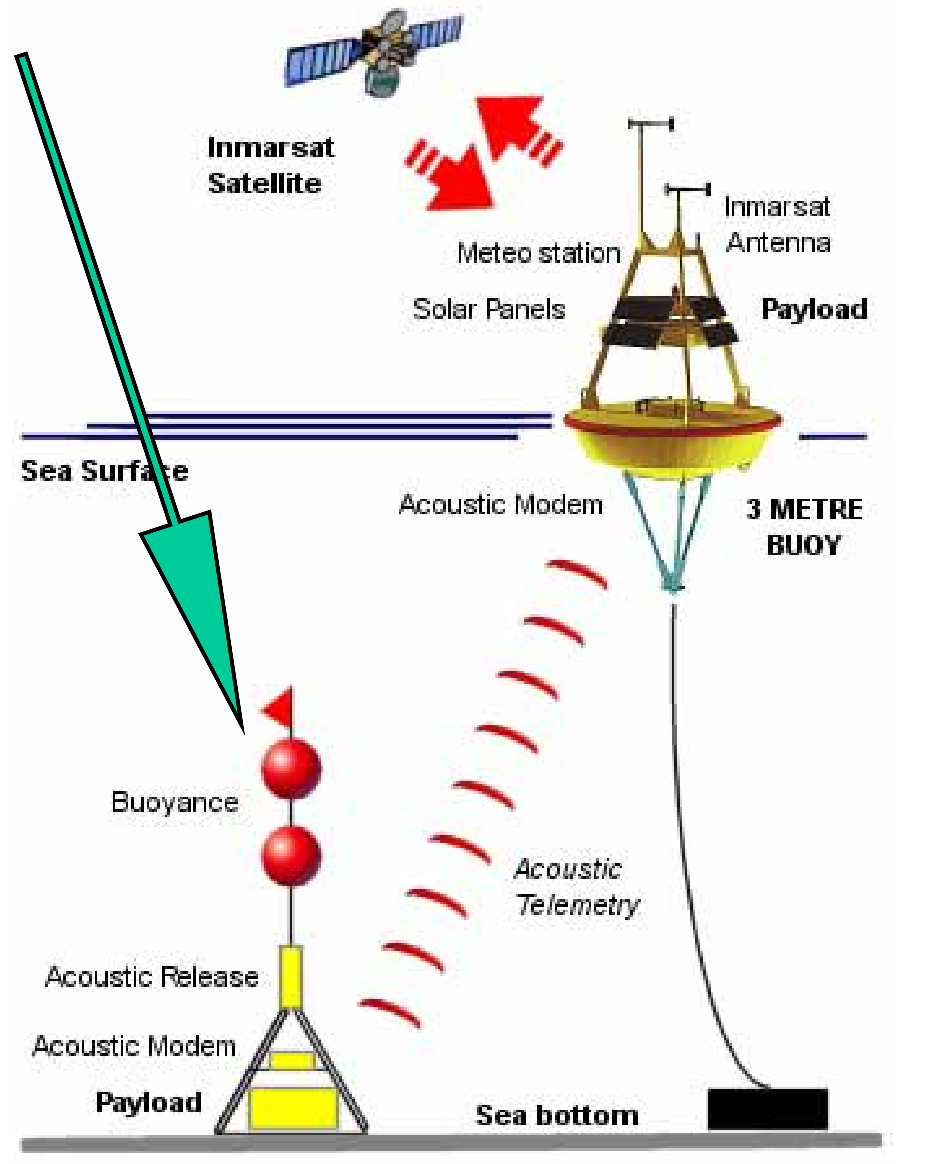
RB – Relay Buoy

- Bidirectional redundant communication system relied on Inmarsat-C satellite link.
- Autonomous power supply: solar panels with charge regulator and gel battery accumulator (4 weeks of autonomy without sun)
- Meteo sensors (T, H, P, Wind speed/dir)
- Predisposed to host a directional tide sensor and water quality probes
- Data Acquisition and Communication Unit



UM – Underwater Module

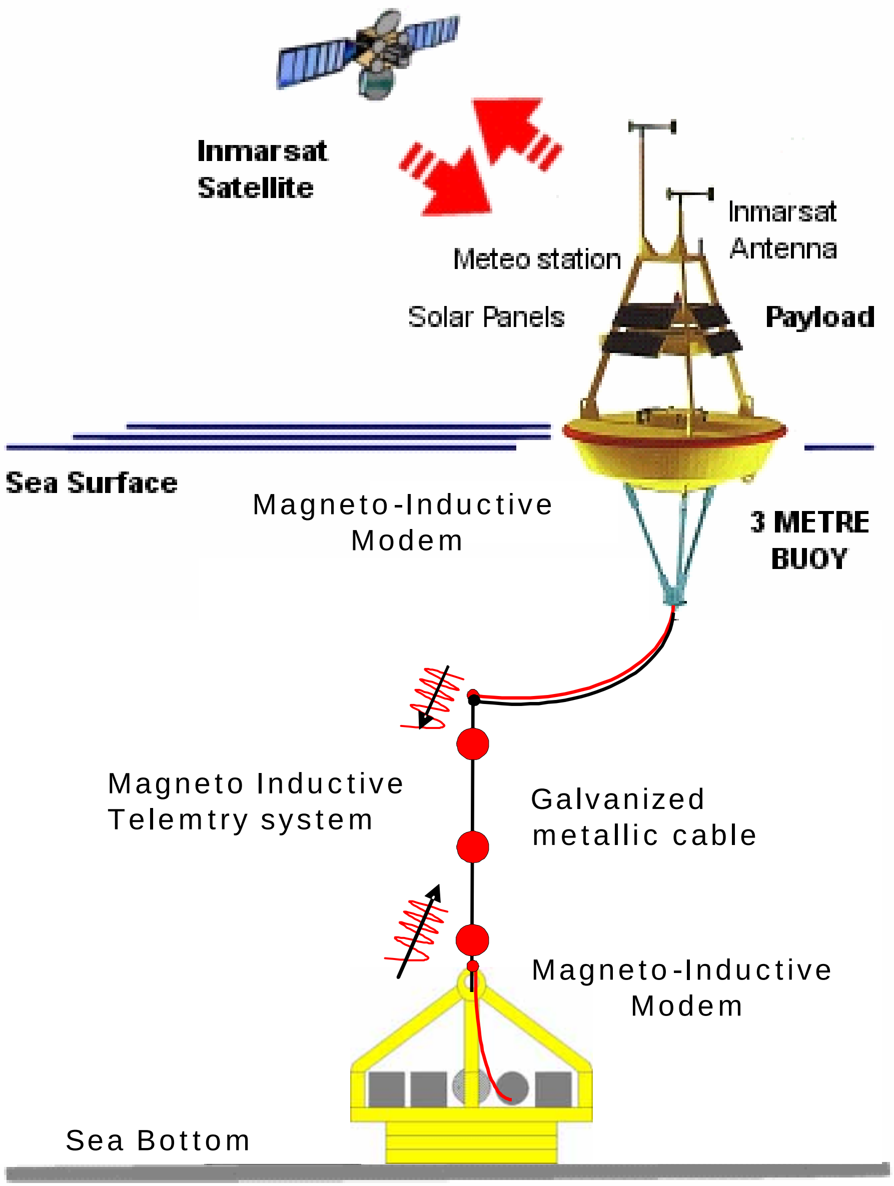
- Alluminium frame and titanium vessels for dry subsystems.
- High stability and high resolution pressure tranducer + three components broadband seismometer + high precision clock (rubidium clock)
- On line Tsunami detection procedure with remote control/tuning of related configuration parameters.
- Bidirectional Acoustic Vertical Transmission System relied on ceramic transducer and Modem with "Spread Spectrum Modulation" technology.
- Max operative depth: 6000 mwd
- Autonomous power supply: Primary Lithium battery with autonomy > 12 months.



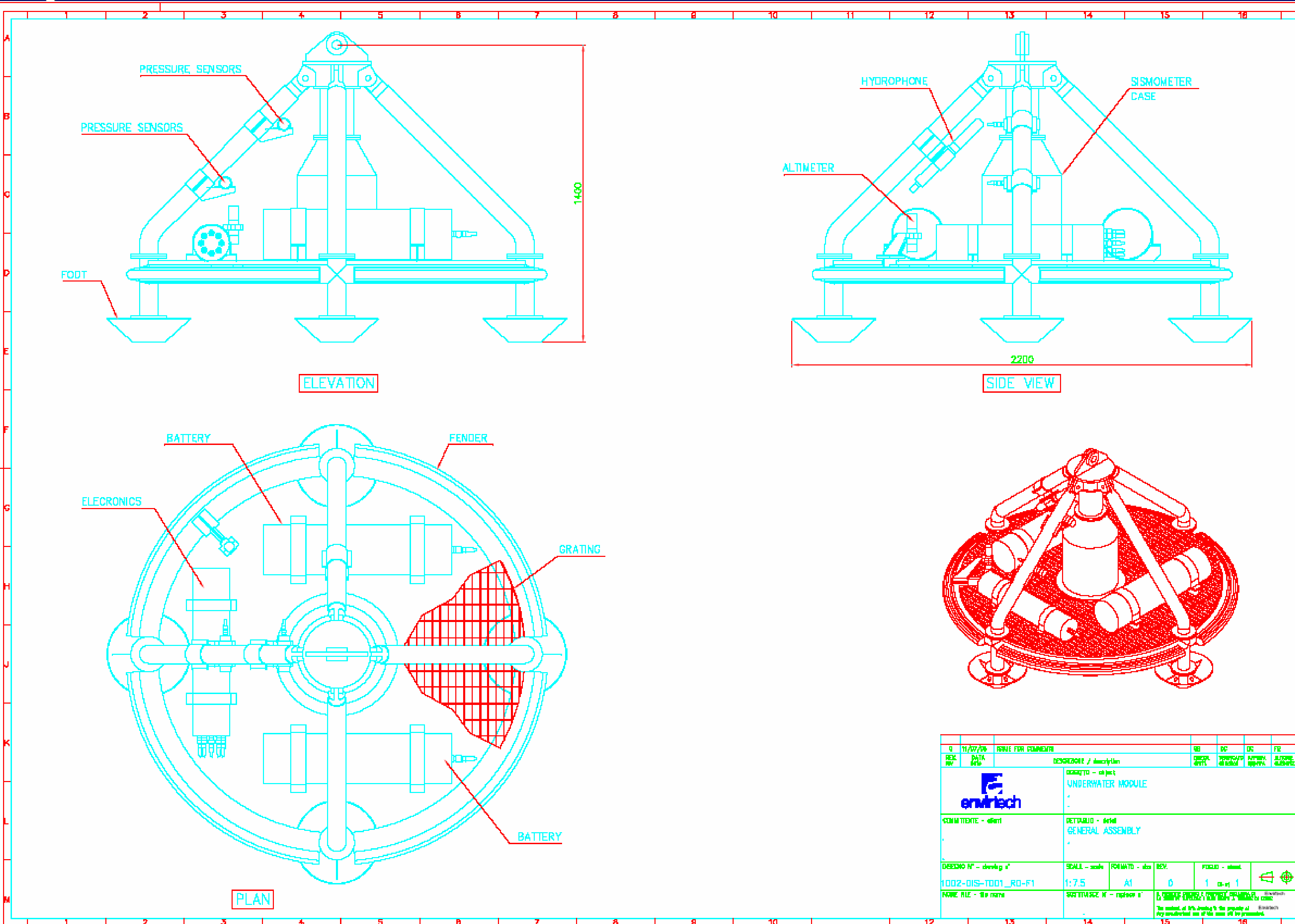
Magneto-Inductive Telemetry System

In this architecture the ATS-V (Acoustic Transmission System – Vertical) is replaced with a magneto inductive telemetry system through the mooring cable of the buoy:

- **the cable has to be metallic;**
- **the Bottom Station is also the dead-weight for the buoy;**
- **the cable has to be size to support the installation and recovery operation of the Bottom Station;**
- **the cable requires some buoyancy along its length to reduce the mechanical stress in water;**
- **an acoustic controlled mechanical release allows leaving the lower part (working as dead-weight) at the sea bottom to facilitate the bottom station recovery.**



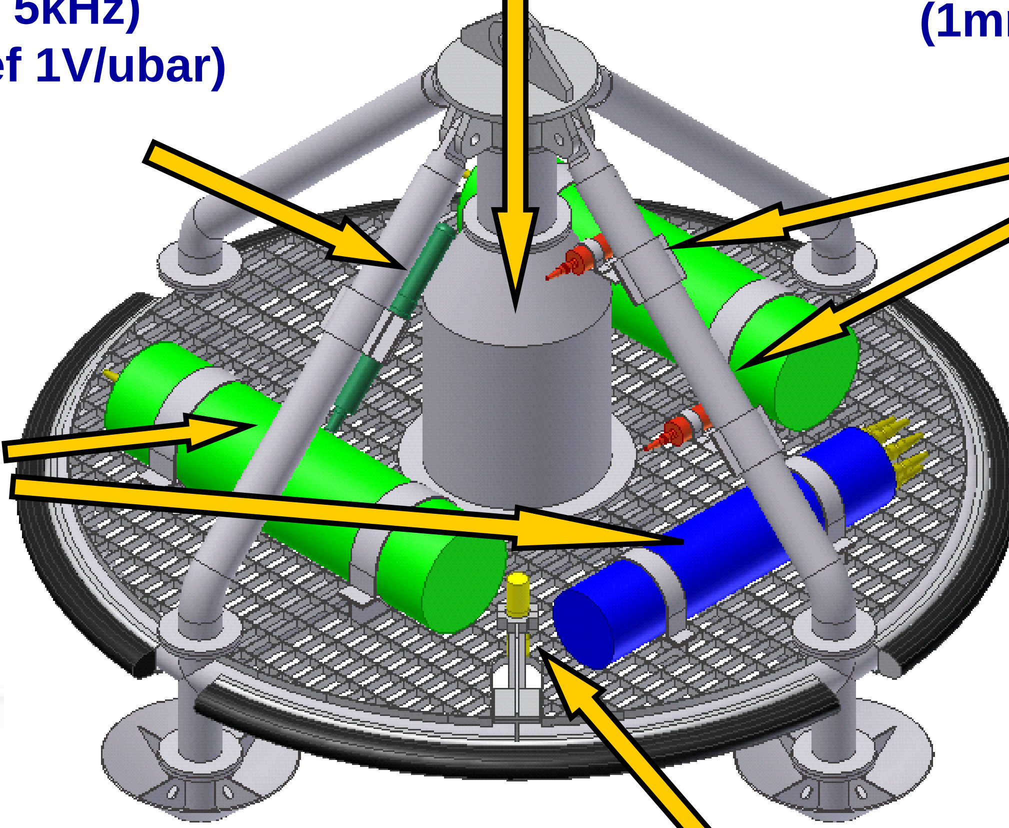
Underwater Module



Hydrophone
(0Hz - 5kHz)
(-92 dB ref 1V/ubar)

Seismometer
Housing

Pressure sensors
(7000 m full scale)
(1mm of resolution)



Titanium Vessels
(6000 mwd)

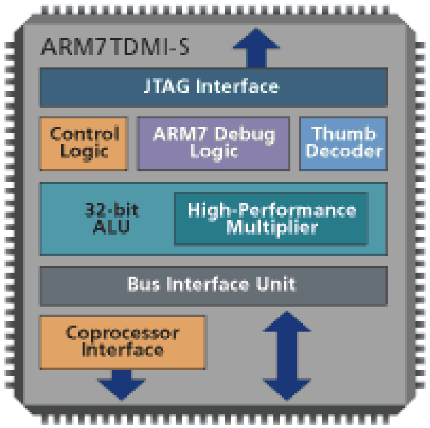
Altimeter (0.3 - 50m)

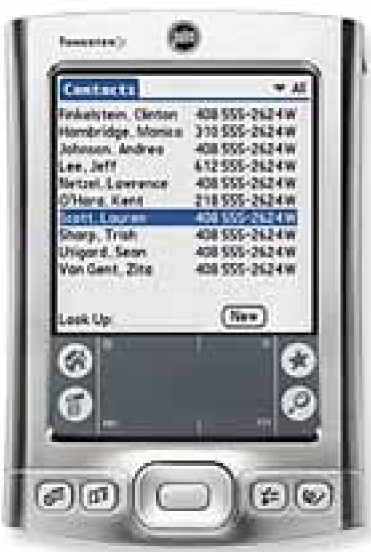
Primary Lithium battery (1000 Ah @12V) for 15-18 months of autonomy

Battery Vessel

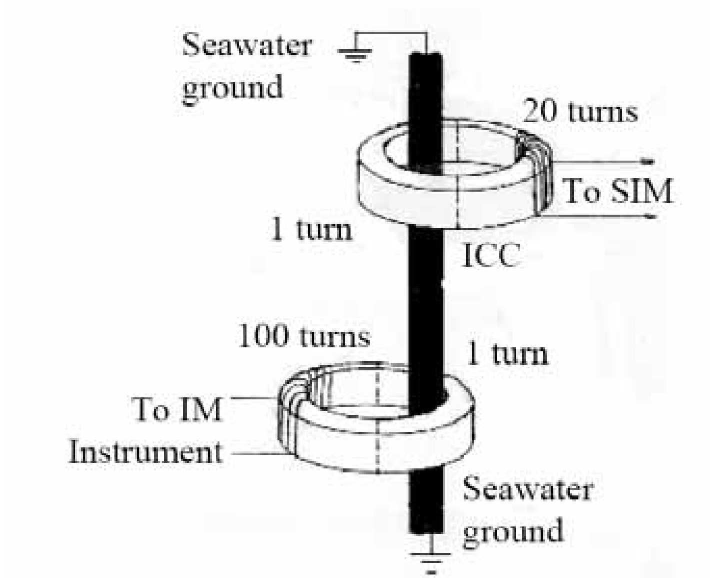
Electronic Vessel

The Electronic system architecture relies on low power ARM microprocessors



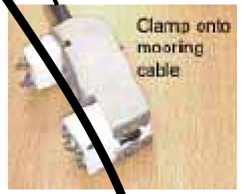


Communication segment: Magneto Inductive modem



The principle

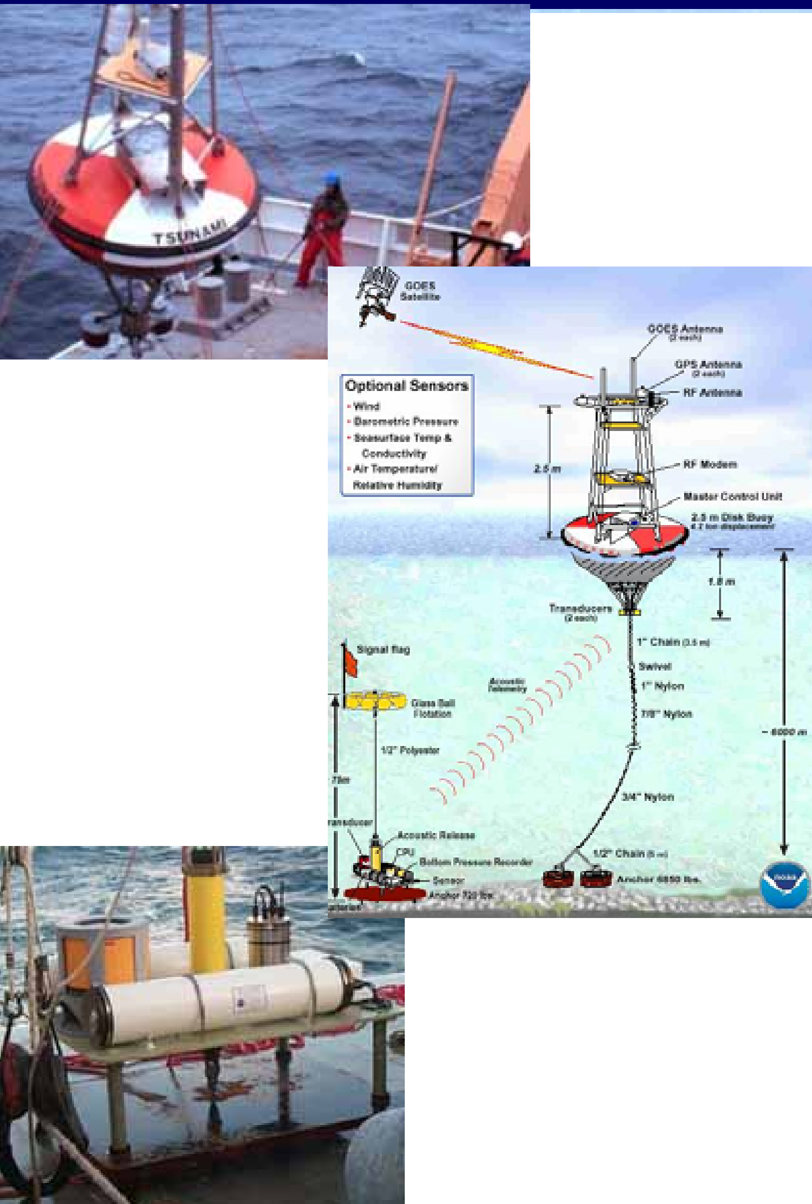
Surface modem

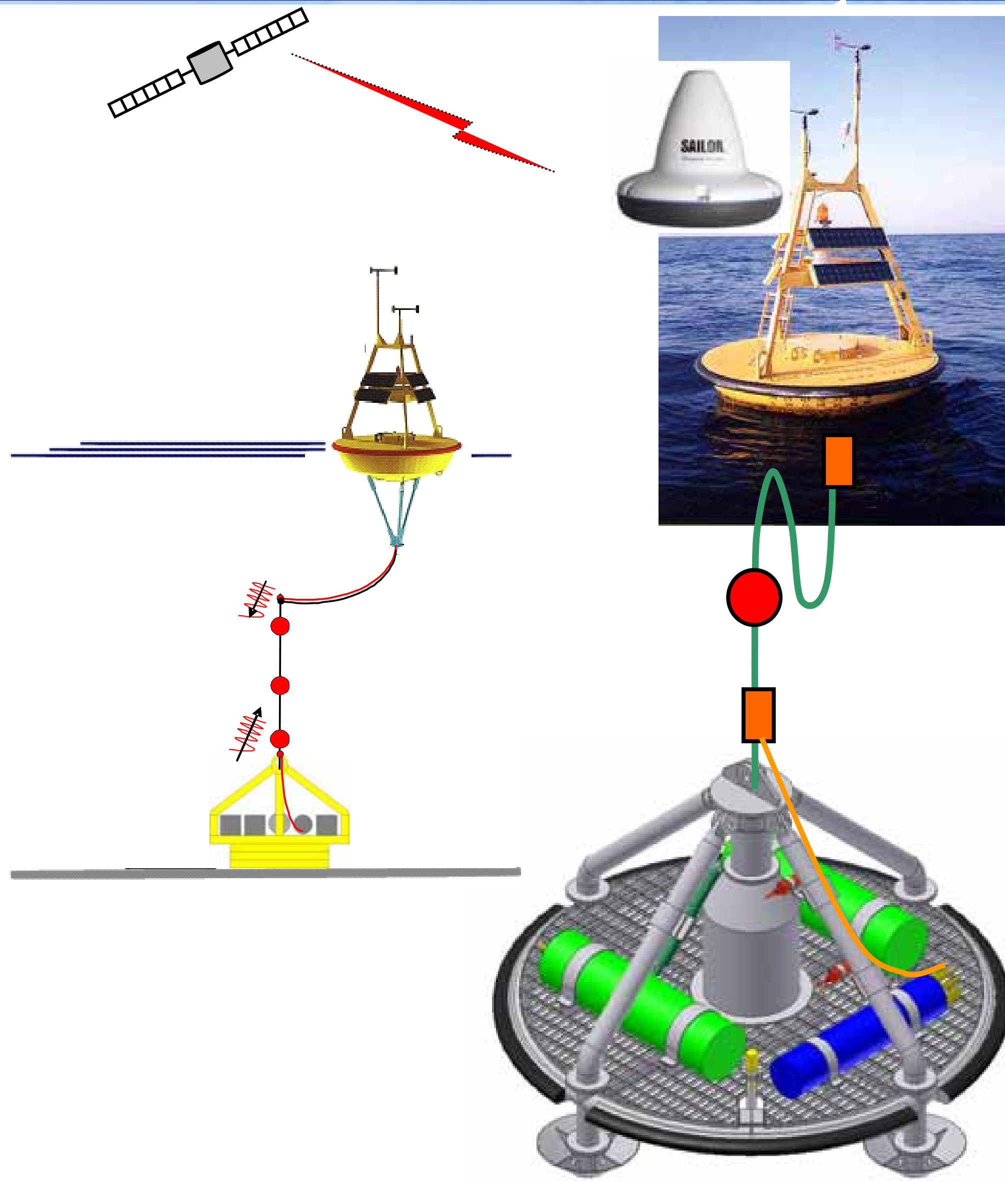


Reliable data link through the metal core (1200 bps)

Mooring cable

Underwater modem


TSUNAMI
GOES Satellite
GOES Antenna
GPS Antenna
RF Antenna
Optional Sensors
- Wind
- Barometric Pressure
- Seasurface Temp & Conductivity
- Air Temperature/ Relative Humidity
2.5 m
RF Modem
Master Control Unit
1.8 m
Transducers
1" Chain
Signal flag
Swivel
1" Nylon
7/8" Nylon
Glass Ball Flotation
1/2" Polyester
3/4" Nylon
Acoustic Release
CPU
Bottom Pressure Recorder
Sensor
1/2" Chain
Anchor 6850 lbs.


SAILOR

Comparison with DART 2/2

	DART	MeTAS
Installation	Buoy installation with dedicated mooring line and dead weight. Underwater module installation with dedicated cable	Underwater module installation with the buoy mooring cable. Possibility to monitor in real time the Underwater Module during the deployment. Simple connection of the buoy after the UM deploymet.
Recovery	Pop up recovery of UM. Relaese of the buoy moorign line.	Disconnection of the buoy. Recovery of mooring line and UM
Communication	Acustic link at 100 bps.	Magneto inductive link at 1200 bps. Possibility to introduce Acosutic link as back up.
Instrumentation	The UM frame hosts only pressure sensor	The UM frame can host pressure sensor, hydrophone, seismometer.
Functionalities	The Acosutic link does not allow software udating and periodical time sinchronisation of UM clock.	Remote software updating of UM. Possibility of precise GPS time tagging of UM data series.

Communication segments: Satellite Data Link

At present more than 1000 Inmarsat mini-C has been deployed in Envirtech applications.

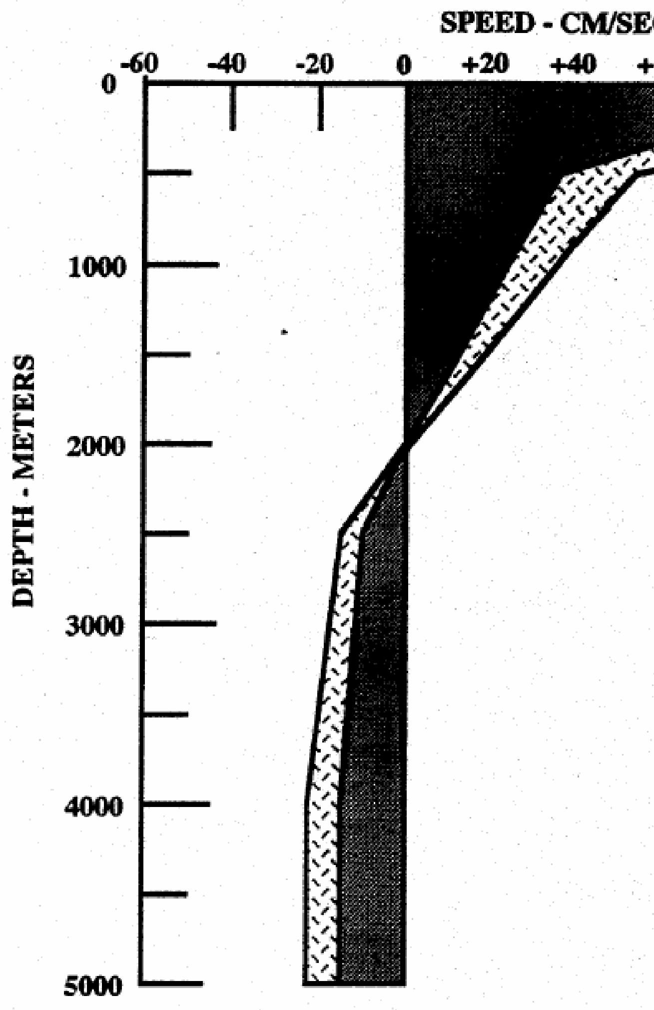
TT-3026LM EasyTrack® is the World's first Inmarsat mini-C system, comprising Transceiver, Antenna and 12-channel GPS receiver in one single unit.

The EasyTrack® is the 4th generation Inmarsat-C system from Thrane & Thrane, and weights only 1.1 kg (2.4 lbs) and is less that 15 cm (6") high.

EasyTrack® offers global data communication via the Inmarsat-C Satellite Network, and supports all Inmarsat-C services including E-mail, position reporting & polling, fax, telex, X.25, as well as between Inmarsat-C mobiles.

E-mail - Fax - Position reporting and polling - Telex - Mobile-to-mobile communication EGC (Safety Net and Fleet Net)

Input design data



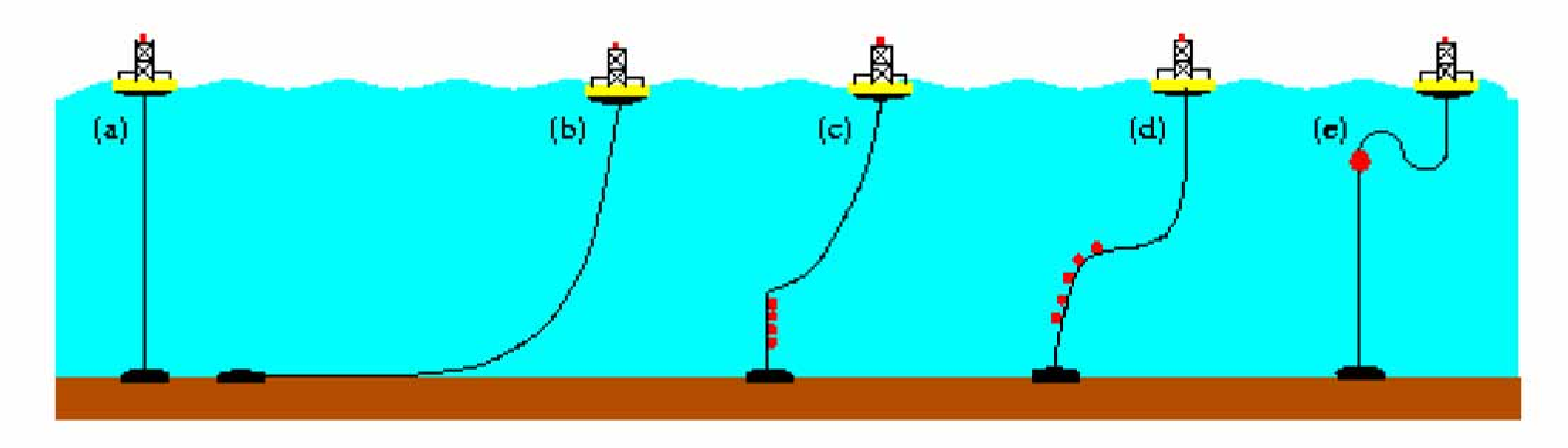
= Max Design Current

Depth-Meters	Speed-Cm/Sec
0	75
200	75
500	35
900	25
1600	10
2050	0
2500	-10
4000	-15
5000	-15

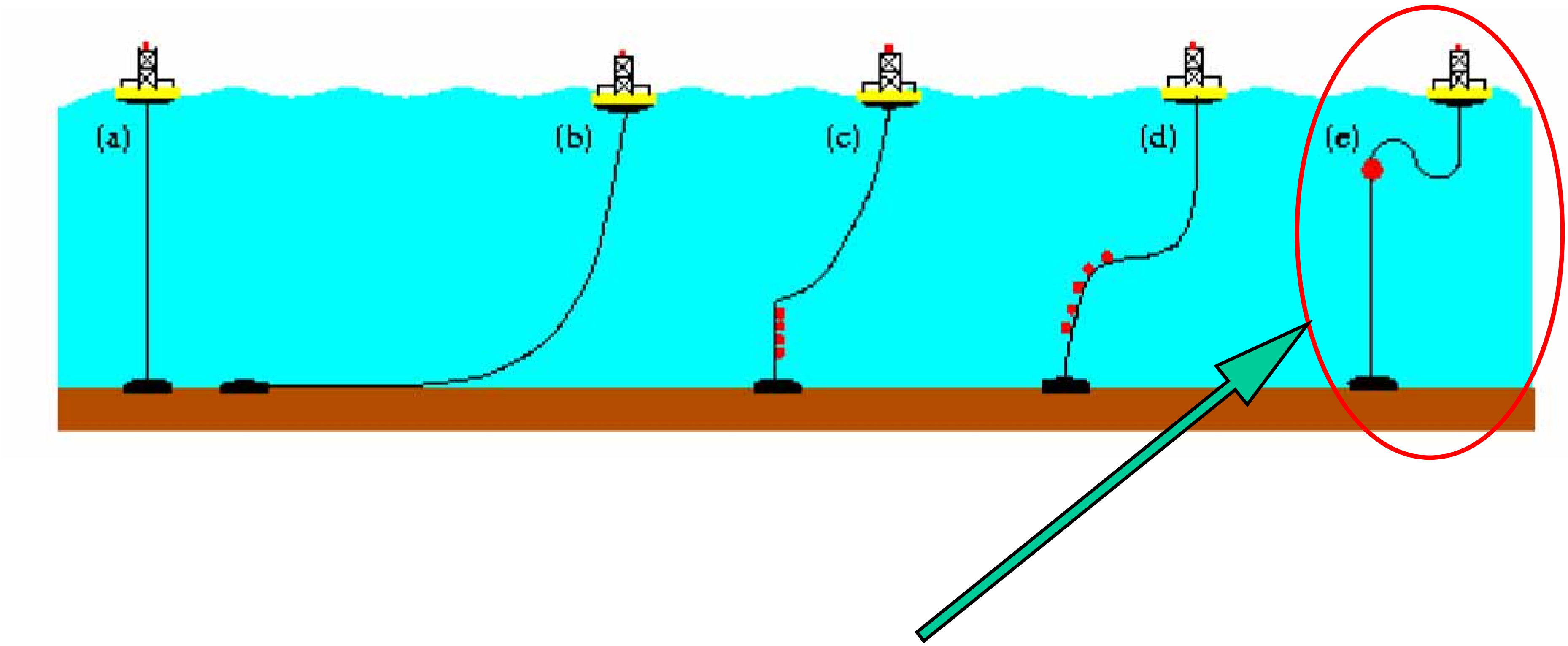
= Max Design Current X 1.5

Depth-Meters	Speed-Cm/Sec
0	112.5
200	112.5
500	52.5
900	37.5
1600	15
2050	0
2500	-15
4000	-22.5
5000	-22.5

Possible Mooring layouts



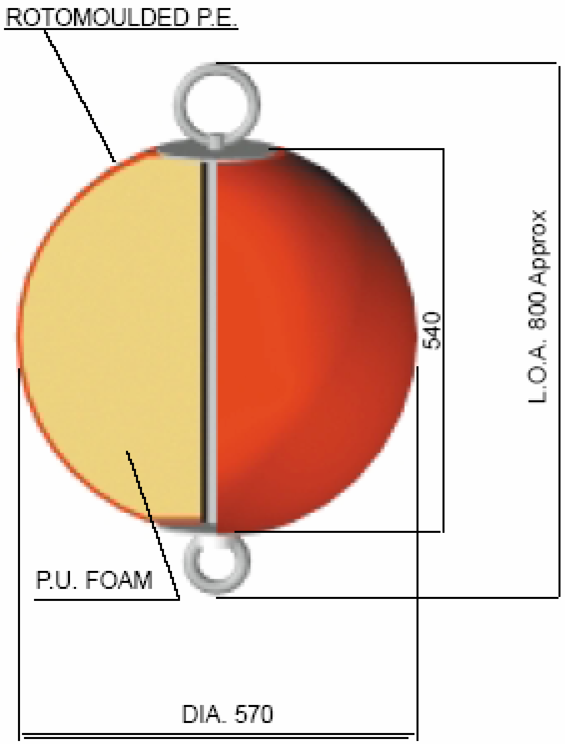
Possible Mooring layouts



To nullify the effect of the dynamic of the surface buoy on the lower part of the mooring line and on the underwater module, the configuration (e) has been identified.

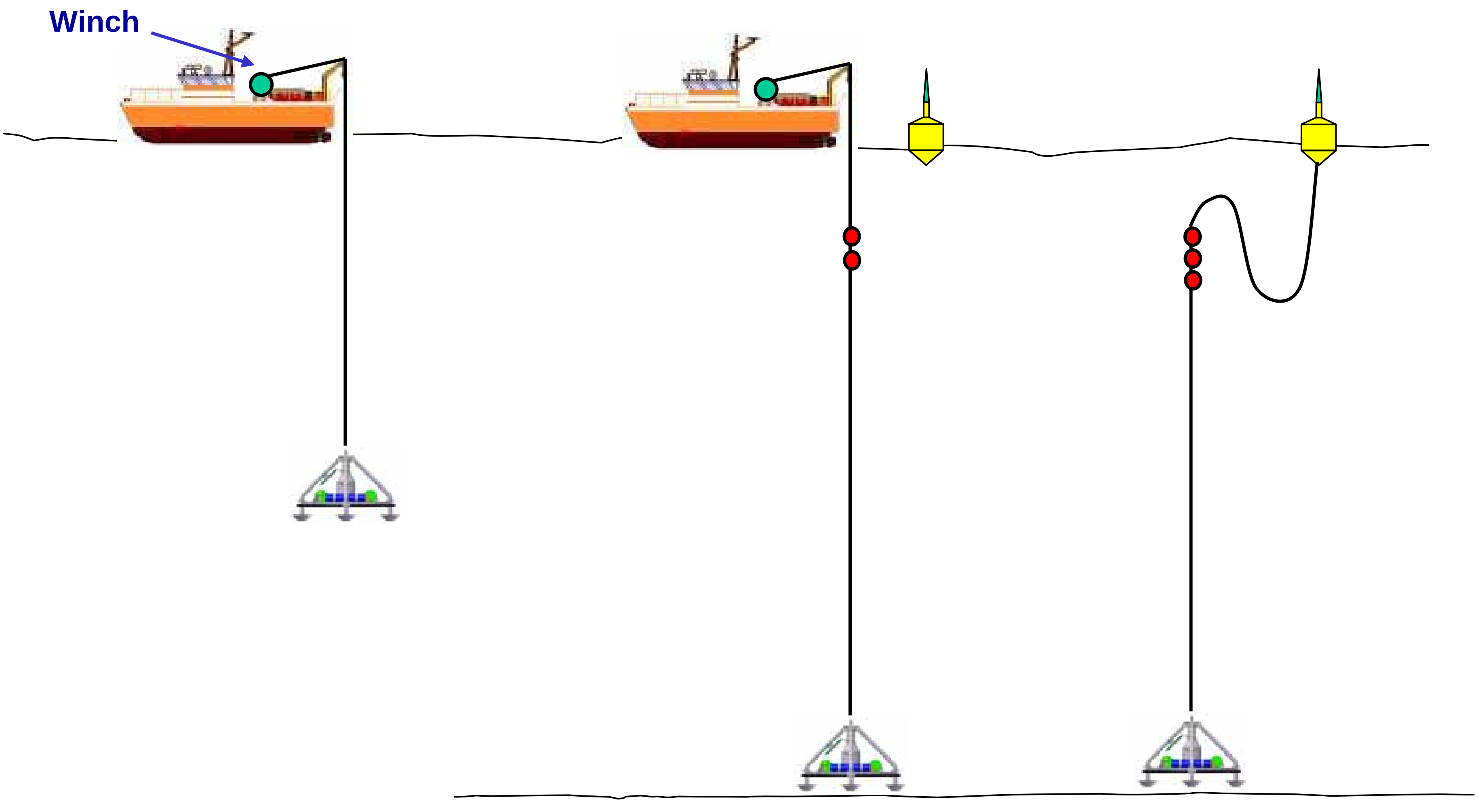
Buoyancy for mooring layout

TYPE	Nett Buoyancy in Kg	Weight in Kg	Diam in mm.	Length in mm.	L.O.A. in mm.
SFE 5770	70	25	570	540	800
SFE 6090	90	26	600	580	840
SFE 8190	195	42	770	715	975
CIL 57050	100	25	570	500	760
CIL 57070	140	35	570	700	960
CIL 57150	320	65	570	1500	1760
CON 90400	390	80	910	940	1200
CIL 90500	540	100	910	980	1240
CIL 90600	620	130	910	1180	1440
CIL 90700	680	130	910	1280	1540
CIL 90850	850	160	910	1480	1730



SFE 5770

SAMPLE OF INSTALLATION



UNIVERSITATIS RV

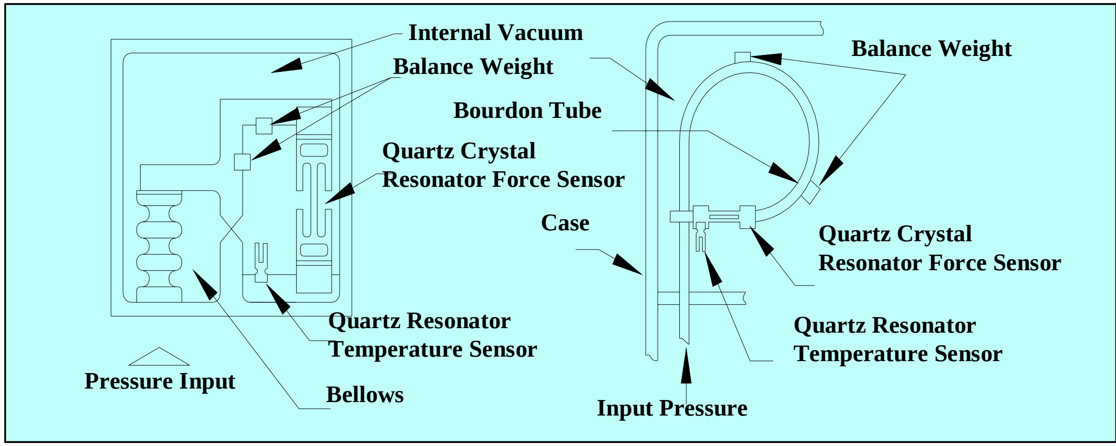
CoNISMa
Consorzio Nazionale Interuniversitario per le Scienze del Mare

Main data

- Length: 44.80
- Large: 9.00 m
- Max Displacement: (3m) 700 ton
- A frame: 7m H, 10 tons

Pressure Sensor

- Quartz Crystal Resonator Pressure Transducers
- 24 bits ADC
- Sensitivity of 5 mm of water at depths of 6000 meters

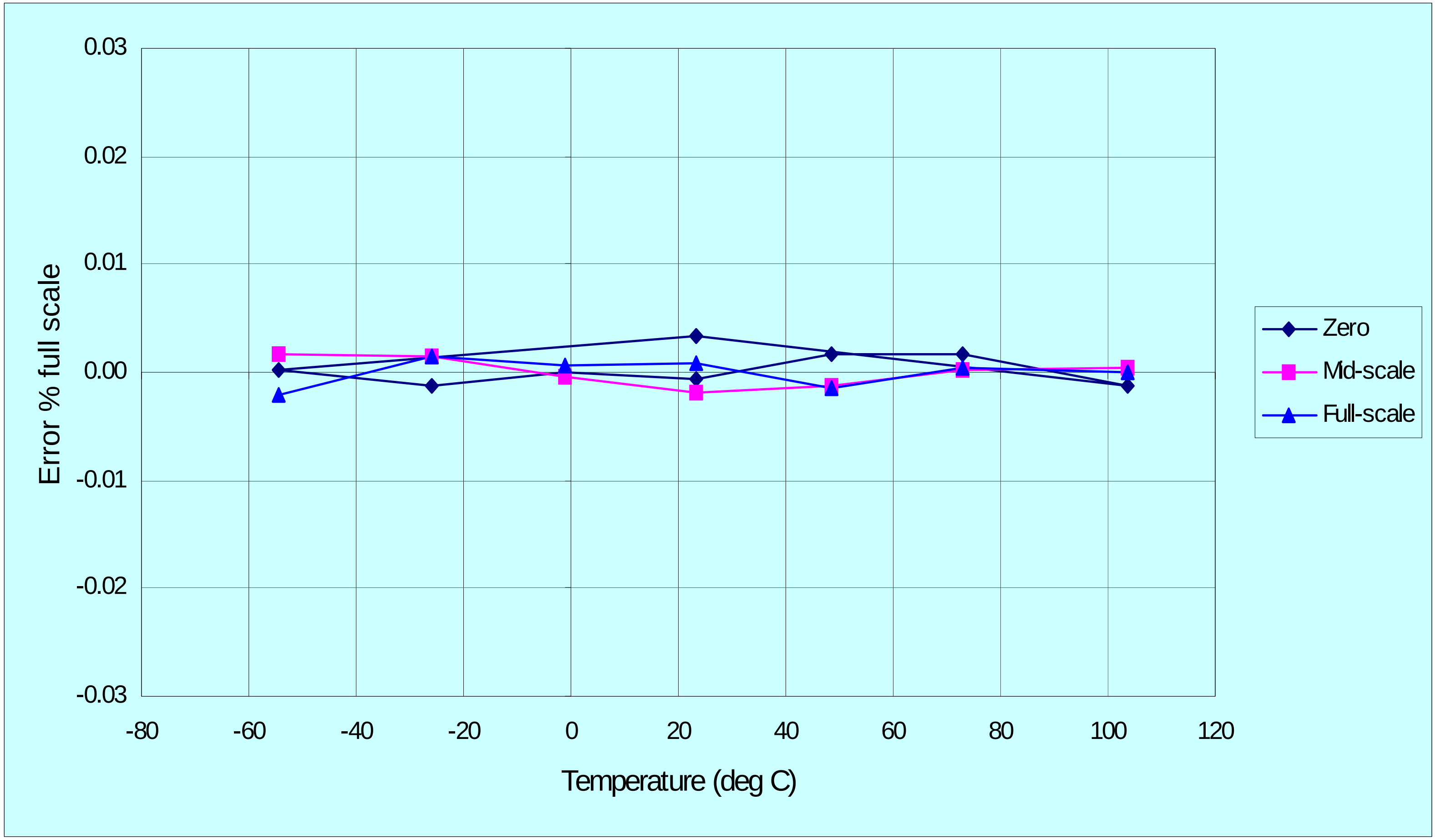


Seismometer

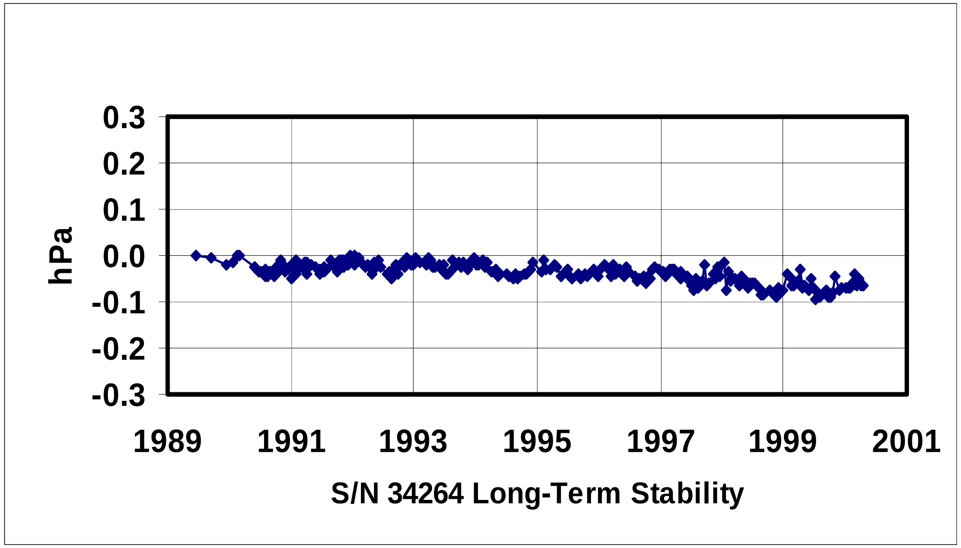
- Three components (EW, SN, Z)
- Broadband (100 samples/sec)
- 24 bits Digitizer
- Resolution: up to 0.05 nm/sec/count
- Rubidium precision clock with stability 10^{-9}

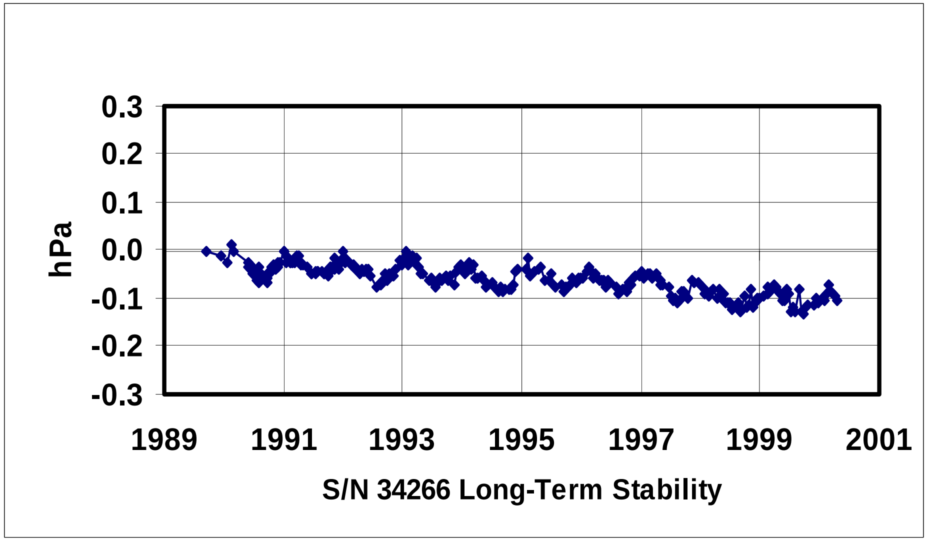
Total Error Band

(Over Temperature at Various Pressures)



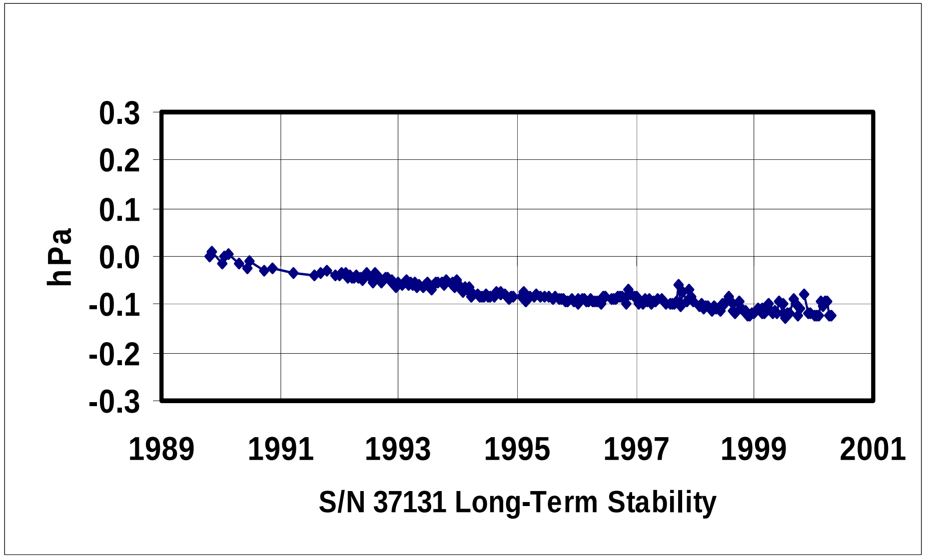
Long Term Stability



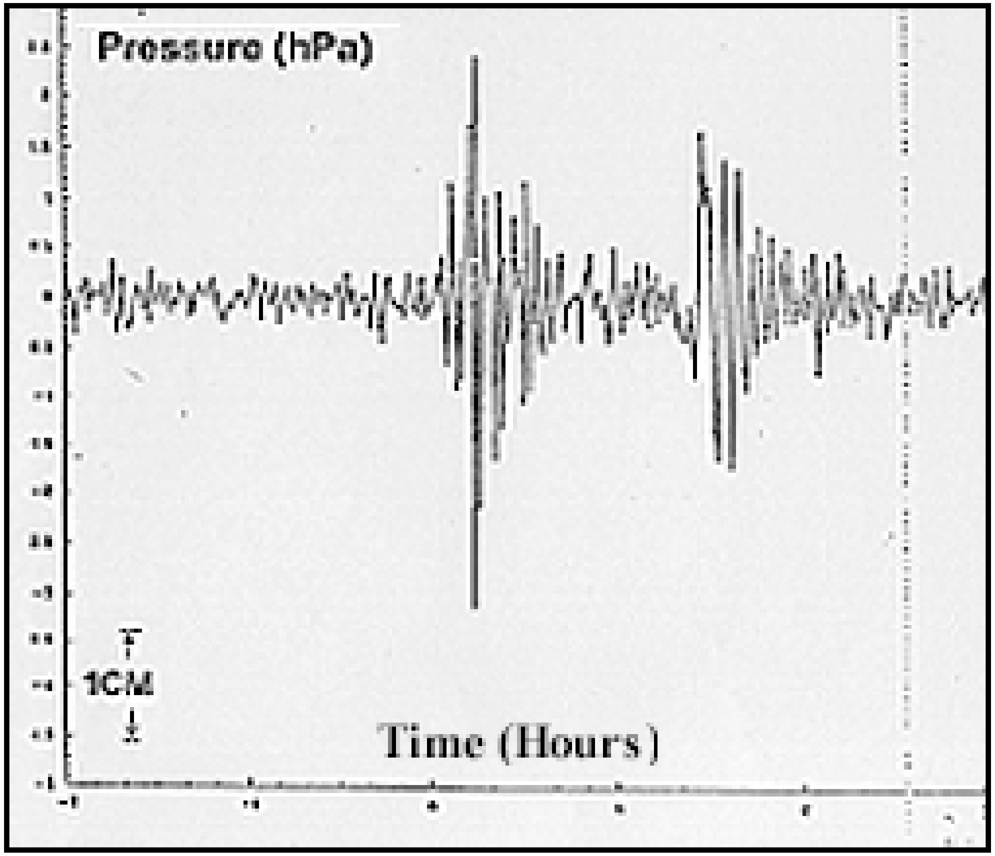


Drift Rate= ***-0.007 hPa***

= (-0.0002 inHg) per year



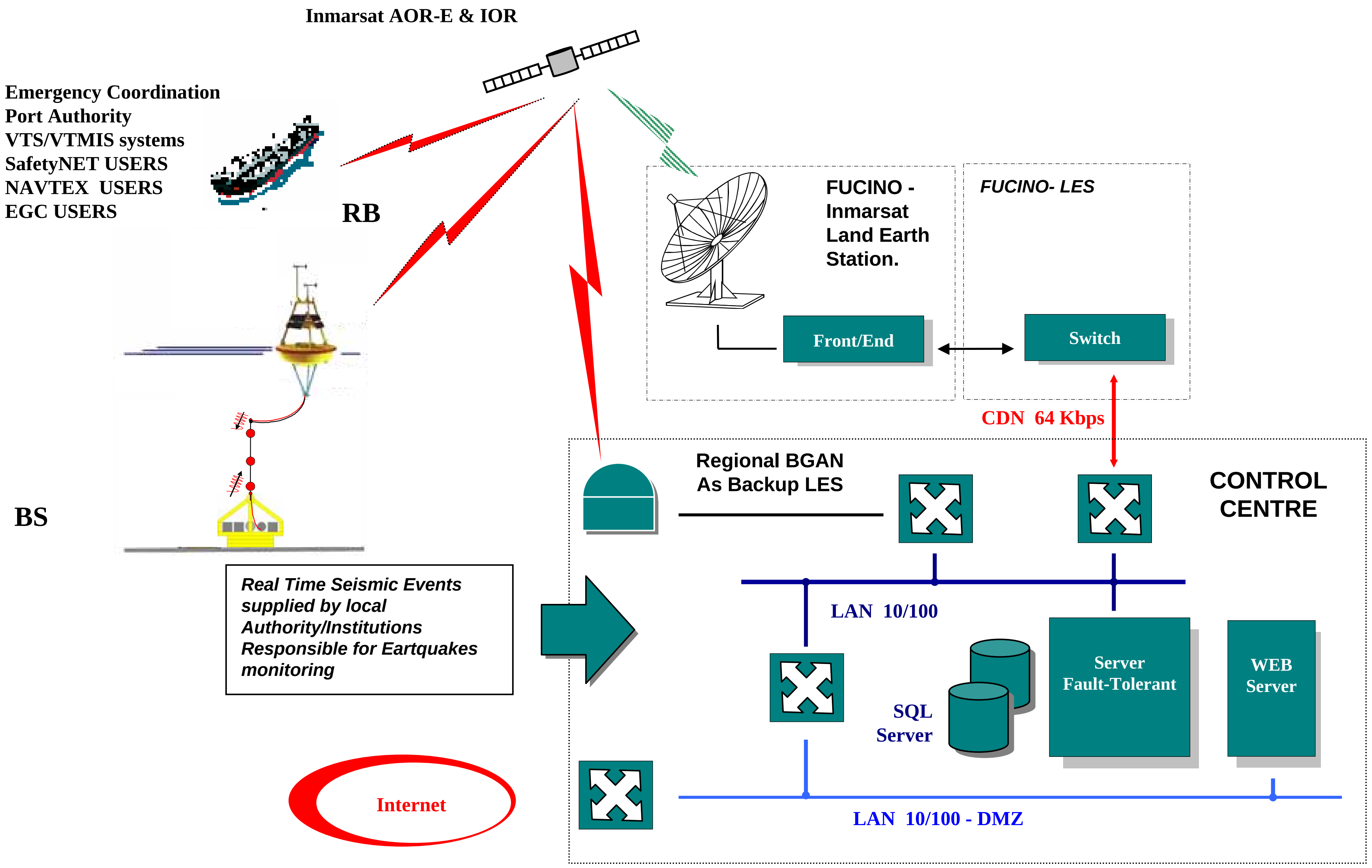
Tsunami Detection (Earthquake Generated Tidal Waves)



Sensitivity of 1 mm of Water at Depths of 6000 meters

Main elements of a Tsunami Warning System

- ***Hardware***
  - *Network of Tsunameters in open sea*
  - *Onshore Control Centre (1 + 1 backup)*
- ***Software***
  - *Data Modelling (a priori knwoledge of the phenomena)*
  - *Real time data processing (to detect the tsunami event)*
- ***Operative services***
  - *Sites survay*
  - *Installation*
  - *Operation*
  - *Maintenance*


Inmarsat AOR-E & IOR
Emergency Coordination
Port Authority
VTS/VTMIS systems
SafetyNET USERS
NAVTEX USERS
EGC USERS
RB
BS
FUCINO - Inmarsat Land Earth Station.
FUCINO- LES
Front/End
Switch
CDN 64 Kbps
Regional BGAN As Backup LES
CONTROL CENTRE
Real Time Seismic Events supplied by local Authority/Institutions Responsible for Eartquakes monitoring
LAN 10/100
SQL Server
Server Fault-Tolerant
WEB Server
Internet
LAN 10/100 - DMZ

Nowadays technologies of the offshore industry provide reliable mechanical and electrical components for the

- Construction
- Installation
- Maintenance

of long term (more than 1 year) geophysical monitoring nodes at abyssal depth (6000 m) in open ocean equipped with

- Marine version of broad band seismometer, hydrophone, high resolution quartz pressure sensors;
- Communication segments (acoustic, magneto inductive, satellite).

Thus it is possible to extend the geophysical monitoring network from the land to the ocean (3/4 of the Earth globe) to improve the forecast of earthquake at sea and the arrival of *"killer tsunami"*.