“Ship design and scientific platforms– PART I”

Presentation by

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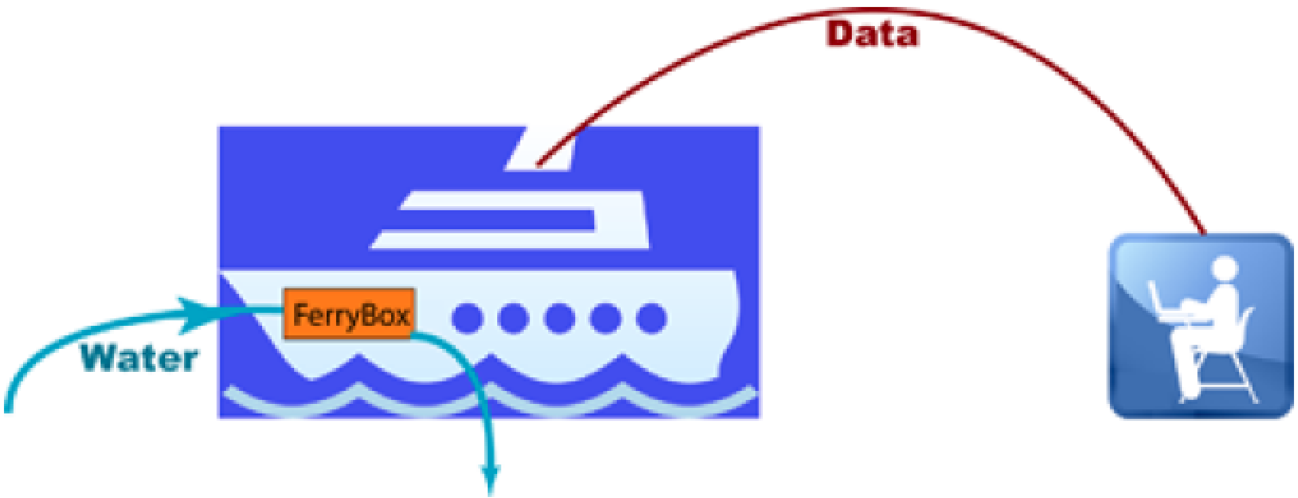
hcmr ΕΛΚΕΘΕ

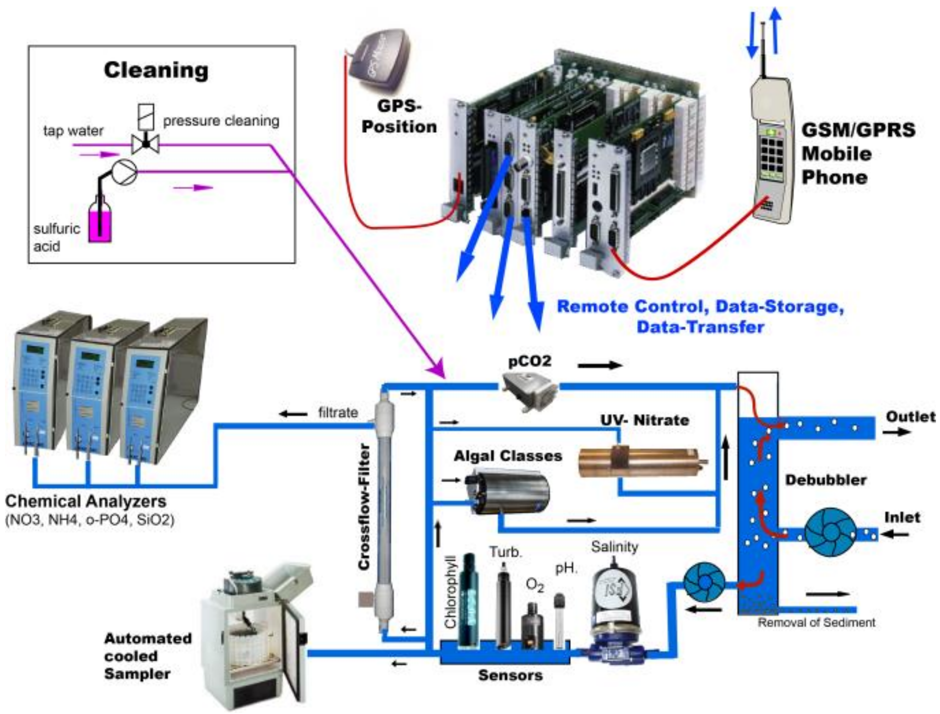
FerryBox Community

What is Ferry Box

FerryBox is an autonomous, low maintenance metrology system which has been developed especially for permanent deployment on ships, metrology platforms and river measurement points for long - term in situ monitoring of rivers, estuaries, coastal zones and open sea.



FerryBox Principle (1 / 2)



The figure shows as an example the scheme of the German FerryBox system.

The water is pumped from a subsurface inlet into the measuring circuit of multiple Sensors. A debubbling unit removes air bubbles, which may enter the system during heavy seas. At the same time coarse sand particles which may be introduced in shallow harbors and which settle and tend to block the tubes are removed as well. Coupled to the debubbler there is an internal water loop in which the seawater is circulated with a constant velocity of about 1 m/s. This already decreases the tendency for building bacterial slimes on sensors and tube surfaces. A small part of the water is filtered by a hollow-fibre cross-flow filter module for automatic nutrient analysis.

FerryBox Principle (2/2)

Ferry Box (open system)

Ferry Box (closed system)

Pictures of commercial available FerryBoxes

FerryBox Sensors

Operational Standard Sensors

- ✓ Temperature
- ✓ Salinity
- ✓ Oxygen
- ✓ Turbidity

Sensors that need major improvements

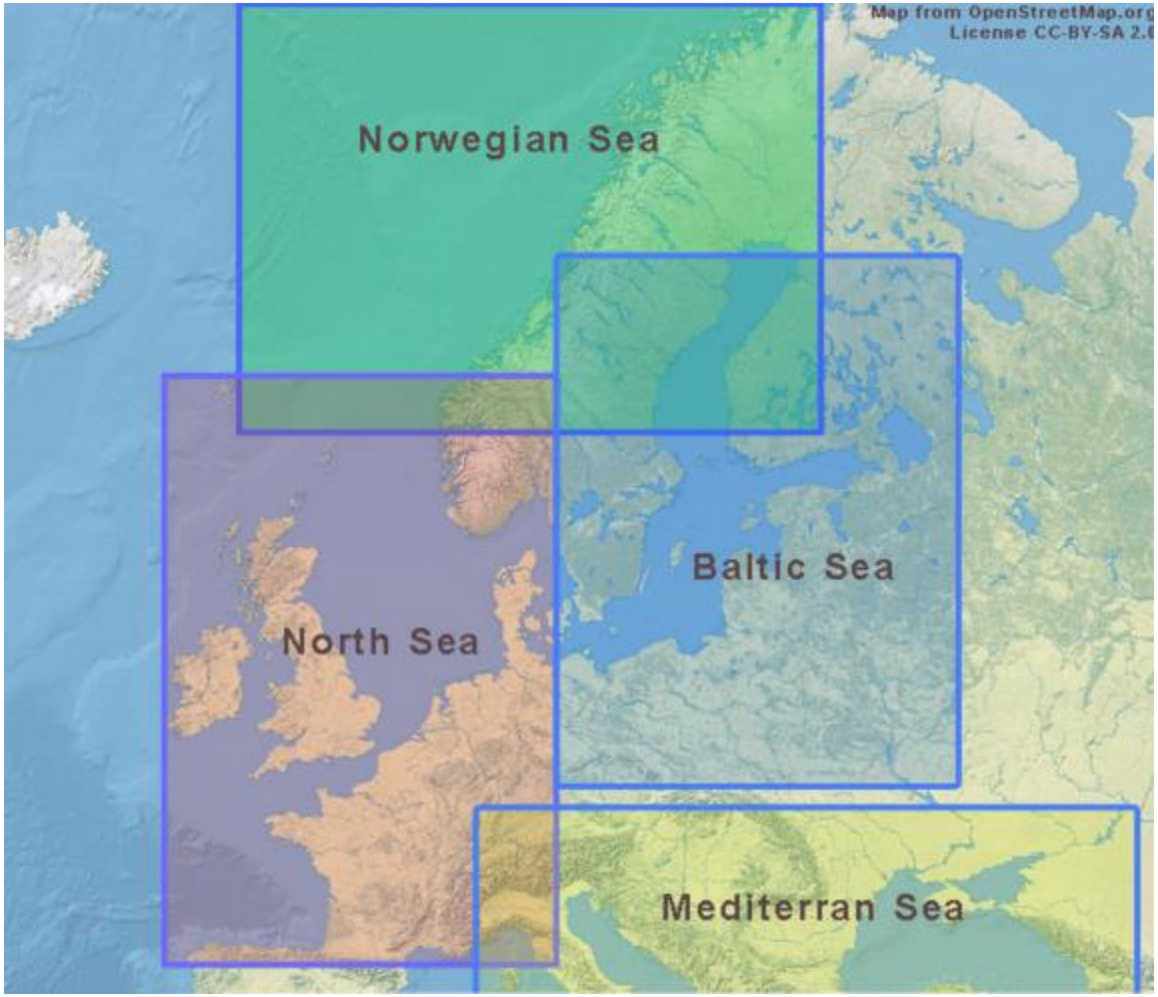
- ✓ Chlorophyll-a-concentration
- ✓ pH/pCO2
- ✓ Nutrients-Nitrate
- ✓ Nutrients-other
- ✓ Phytoplankton- Groups
- ✓ Phytoplankton and zooplankton by morphology

Sensor systems that are "on the horizon"

- ✓ Algal species by genetic sensors
- ✓ Organic micro-pollutants by genetic sensors

FerryBox Ship Routes

- ❖ ***North Sea & Atlantic***
- ❖ ***Baltic Sea***
- ❖ ***Northern Atlantic***
- ❖ ***Mediterranean Sea***



Ship Type

Ship type and its primary use will influence where and how easily a Ferrybox can be installed and operated.

- All ships tend to be different even ships of the same class supplied to the same company.
- Ships need to be inspected carefully to find the most appropriate location for equipment.
- The category of regulations applied on board varies.
- Water inlet must be ahead of outlets for black and grey water from the ship (sewage and other contamination).
- Work by the crew or for the ship's operators may interfere with the Ferrybox installation.

Ship types: Cargo ships, car/ passenger ferry, Ro/Ro Ship, Container ship, Merchant ships

Inlet (1/2)

The source of water used should be as close as possible to the Ferrybox installation. This is to avoid contamination both by heat, fouling of the line and other potential changes in water properties. Some sensors like inlet **temperature** or **oxygen** can be placed just after the inlet valve.

Different ships may present different opportunities for obtaining water depending on the size and design of the ship.

A direct intake with a penetration through the hull may be possible this will require the Ferrybox system to have a dedicated pump to drive or pull water through the system and then return it through a hull outlet to the sea. If the Ferrybox is above the ship's water line the ship's drainage system can be used.

Inlet (2/2)

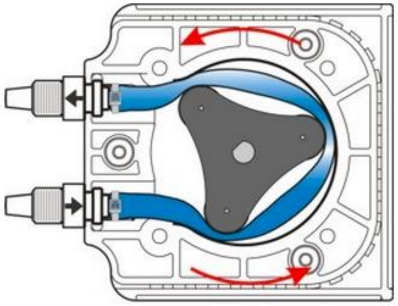
Water can also be drawn in from the sea chest. This may be more accessible than a simple hull penetration and the sea chest is designed to reduce air bubbles being pumped into the ships internal cooling water systems.

Connection to internal ship circuits system is possible and can be made at any time the expertise available. Suitable designs can avoid the installation of dedicated water pumps. A key point is to know the quality of the water.

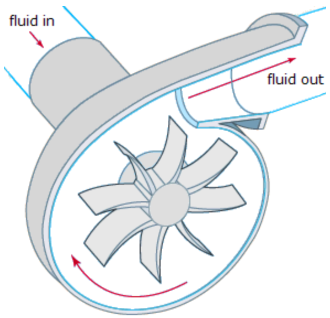
Pumps and Valves

Pumps

If the system is designed with an independent water take off point different types of pump are available, for example peristaltic or impeller pumps.



Peristaltic Pump



Valves

For direct penetrations through a hull or into the sea chest the use of ball valves at the inlet and outlet are recommended, as these make it possible to clean the parts through the hull when the ship is in dry dock.

Choice of System

A basic design point which affects where and on what ship a system can be installed is if the water circuit is open or closed.

In a **closed** circuit, water is pumped through the system using a single pump and no free water surface is involved reducing the risk of leaks and flooding. The system is more acceptable to a wider range of ship operators.

In an **open** system, water is pumped into the ship's systems such as CO2 equilibrator form where it flows into a reservoir tank which then has to emptied and pumped out of the ship using a second pump. This generates a higher risk of leaks and flooding and may be less acceptable to some shipping companies.

Sensors

Temperature

In most cases the sensors for temperature and salinity operated without major problems.

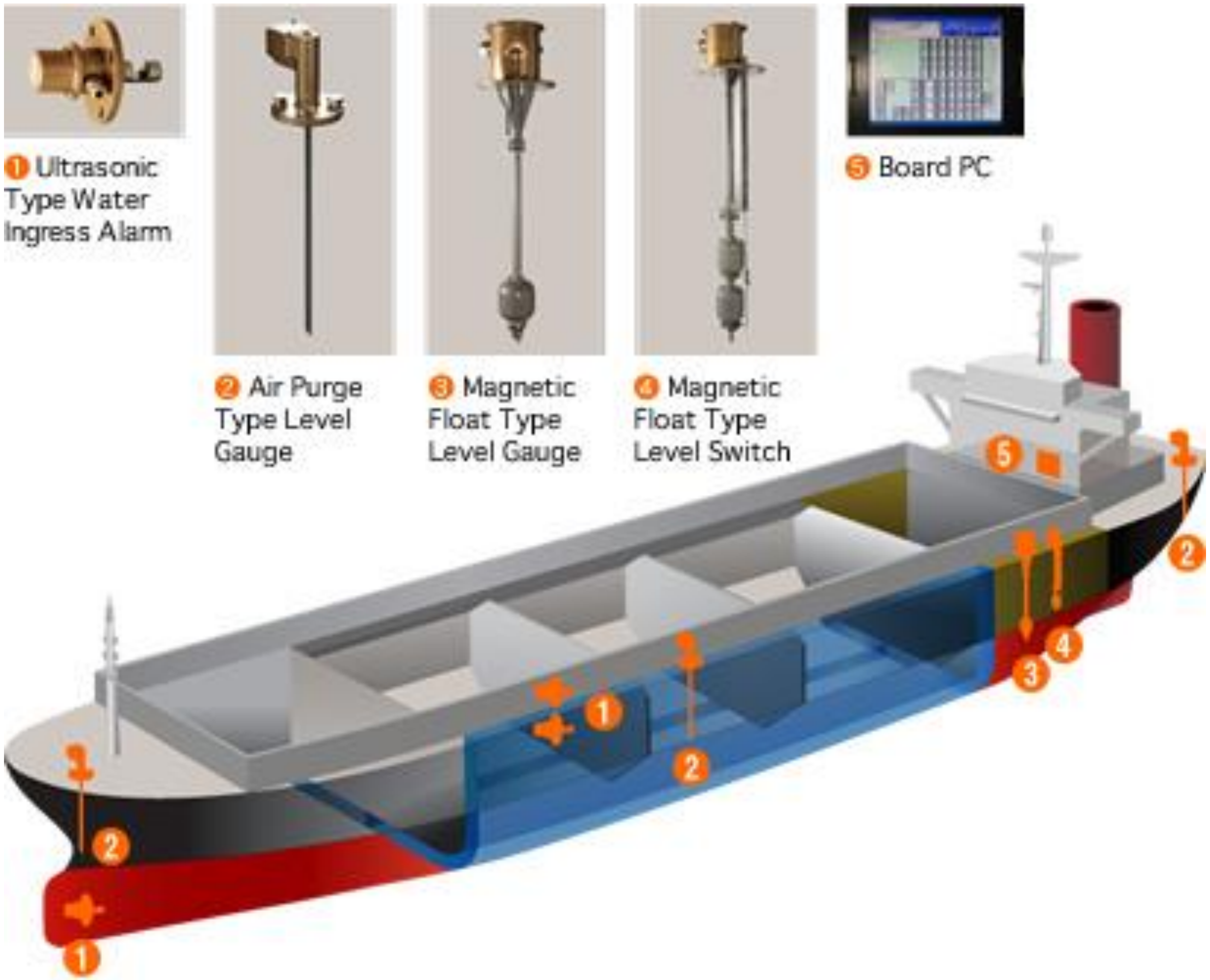
Salinity

The salinity sensor requires a high accuracy and long-term stability, for instance to discriminate between different water masses which differ only little in salinity (<0.1).

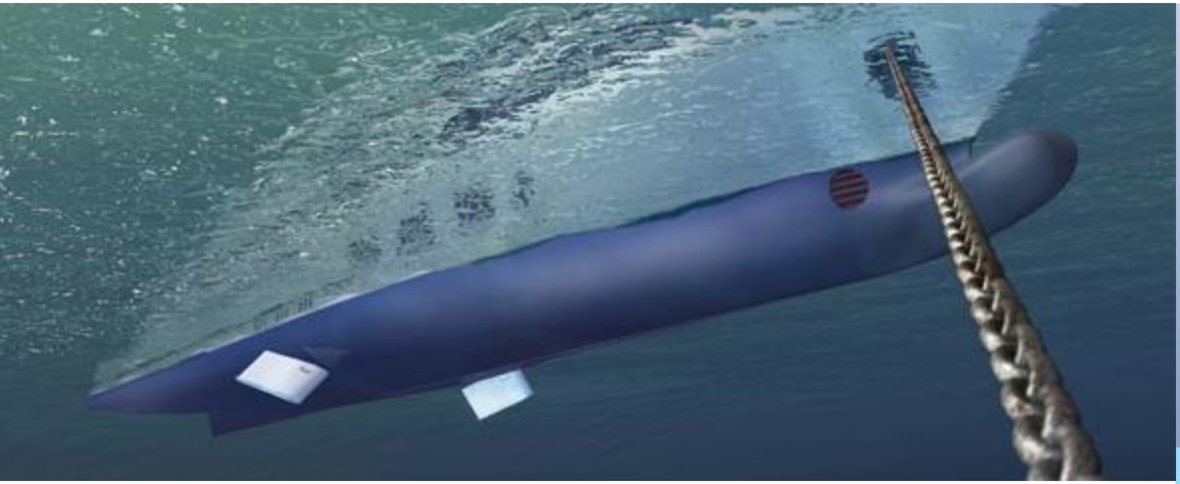
Turbidity

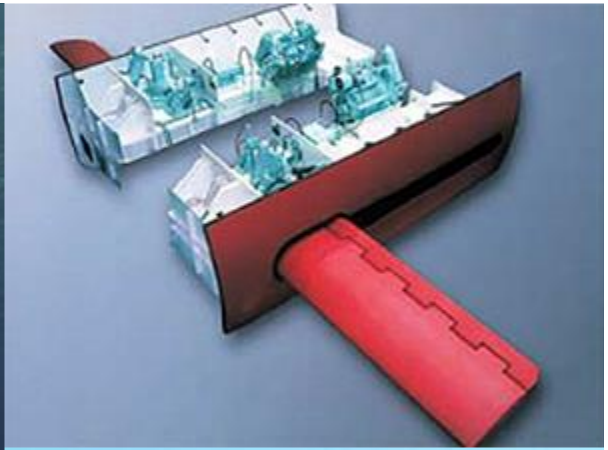
For optical turbidity measurements the signal is very sensitive to biofouling.

Ships and Sensors

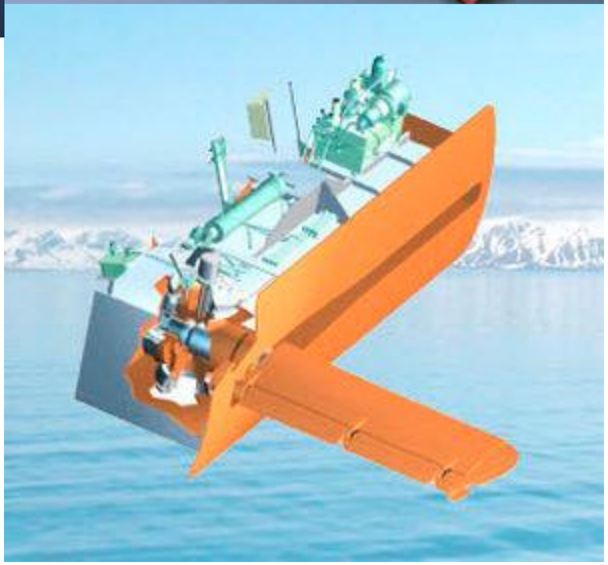


Ships and Sensors

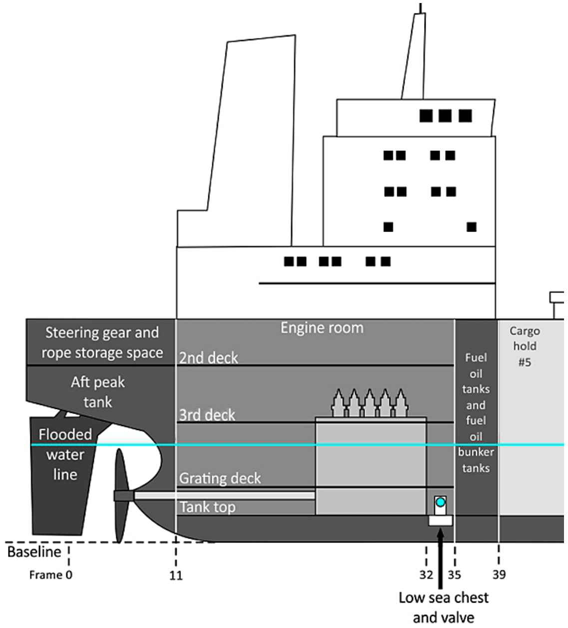




Stabilizers



Ships and Sensors



TF - Tropical Fresh Water

F - Fresh Water

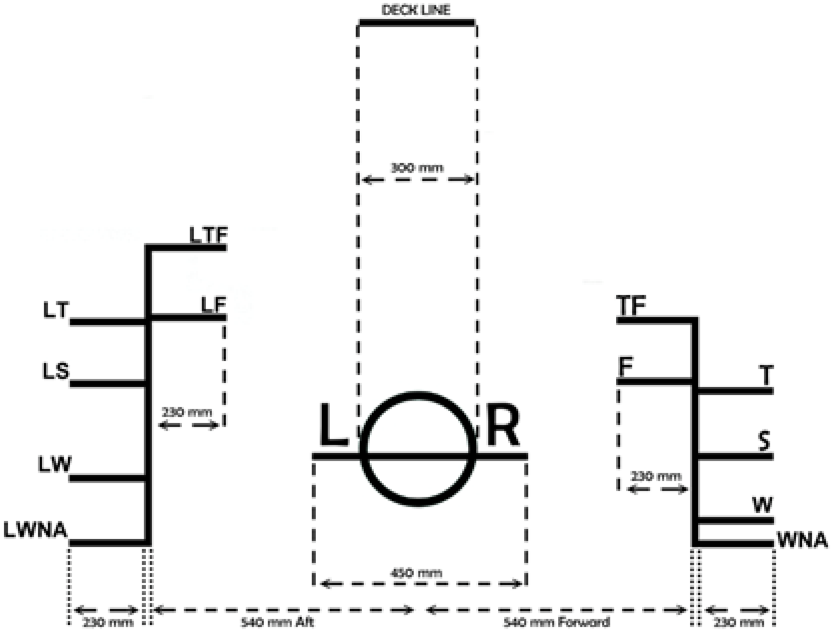
T - Tropical Seawater

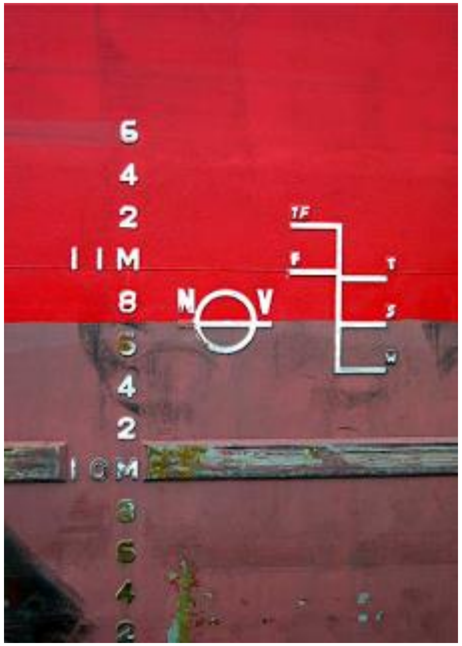
S - Summer Temperate Seawater

W - Winter Temperate Seawater

WNA - Winter North Atlantic

Sea Water Line

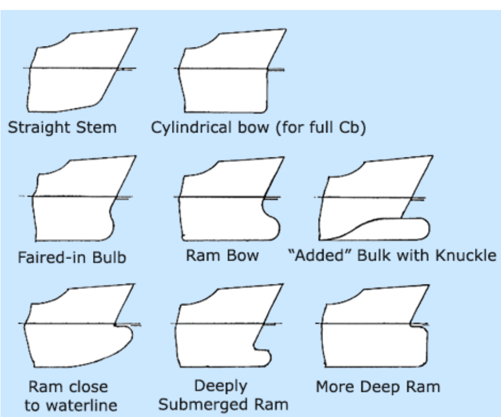




Ships and Sensors

An ADCP mounted under the keel of the ship is an effective tool to monitor ***water*** and ***sediment transport*** through channels/straits.

The instrument is attached to the hull of the ferry 30 cm below the hull itself to prevent problems with air bubbles and interference with the turbulence of the ship. This technique ***measures the current field below the moving ferry***.



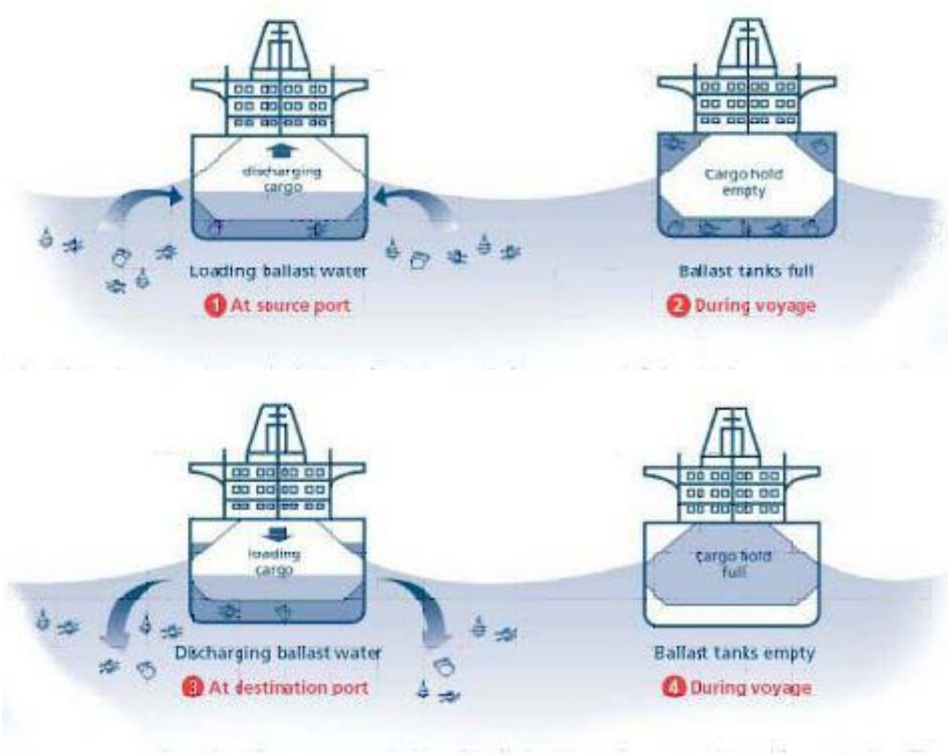
Bulbous

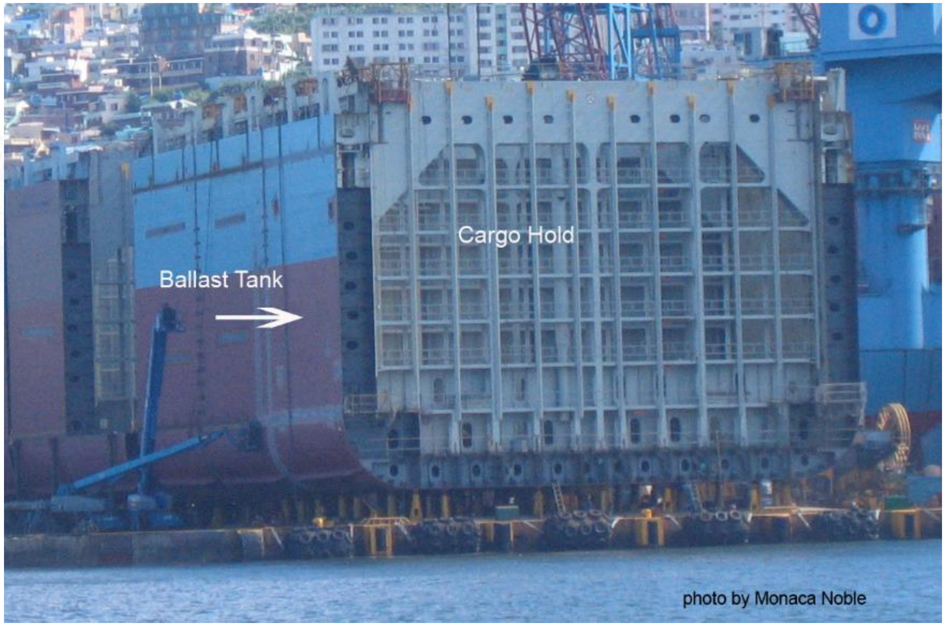
Ships and Sensors

Bow thrusters

Ships and Sensors

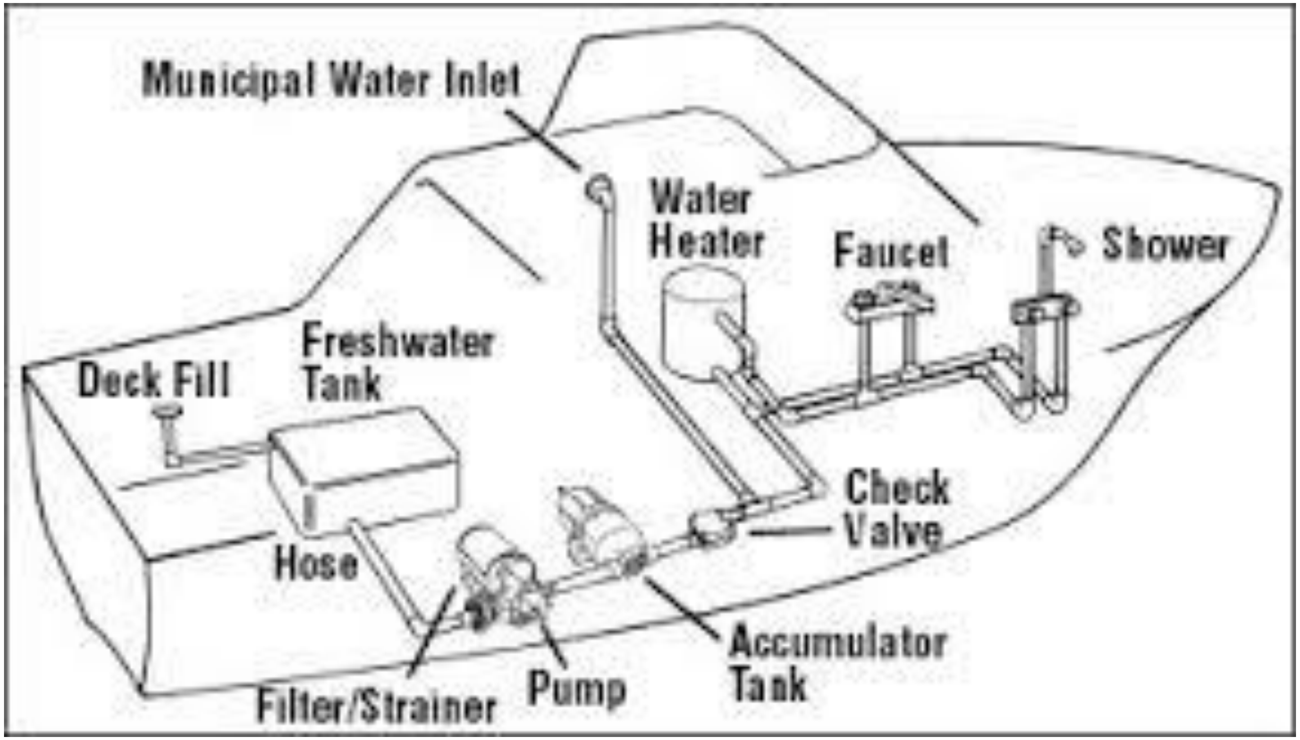
Ballast tanks





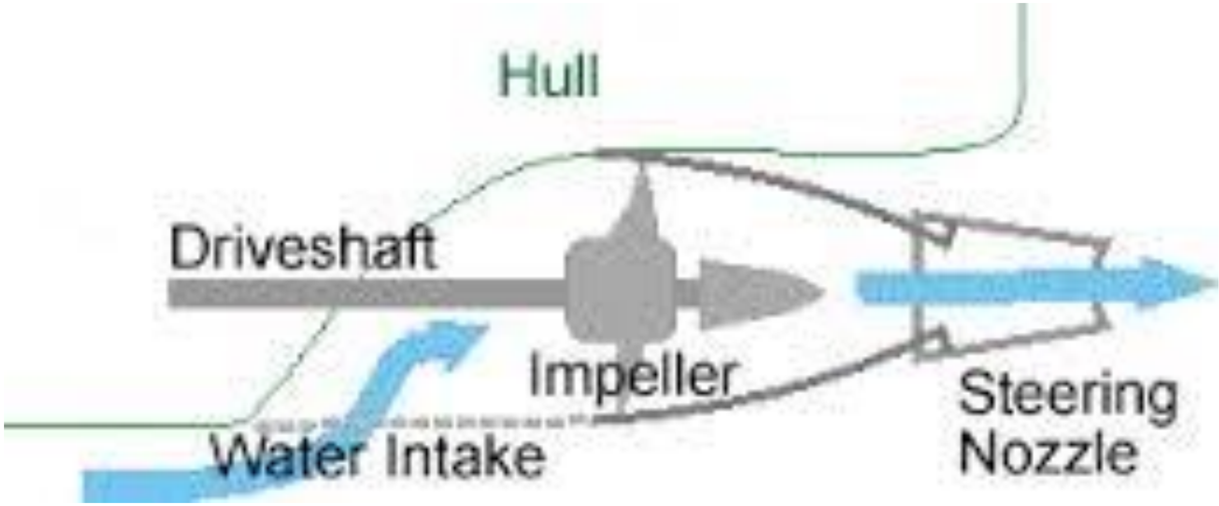
Ships and Sensors

Fresh water tanks



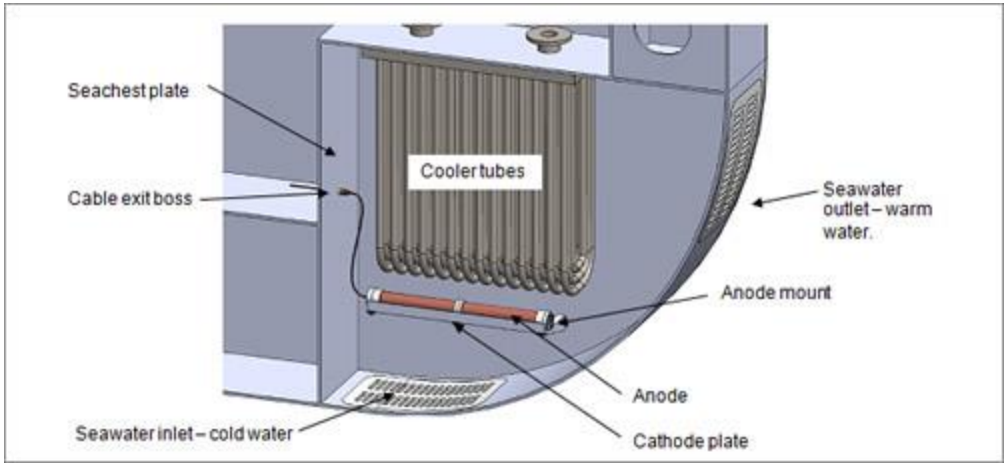
Ships and Sensors

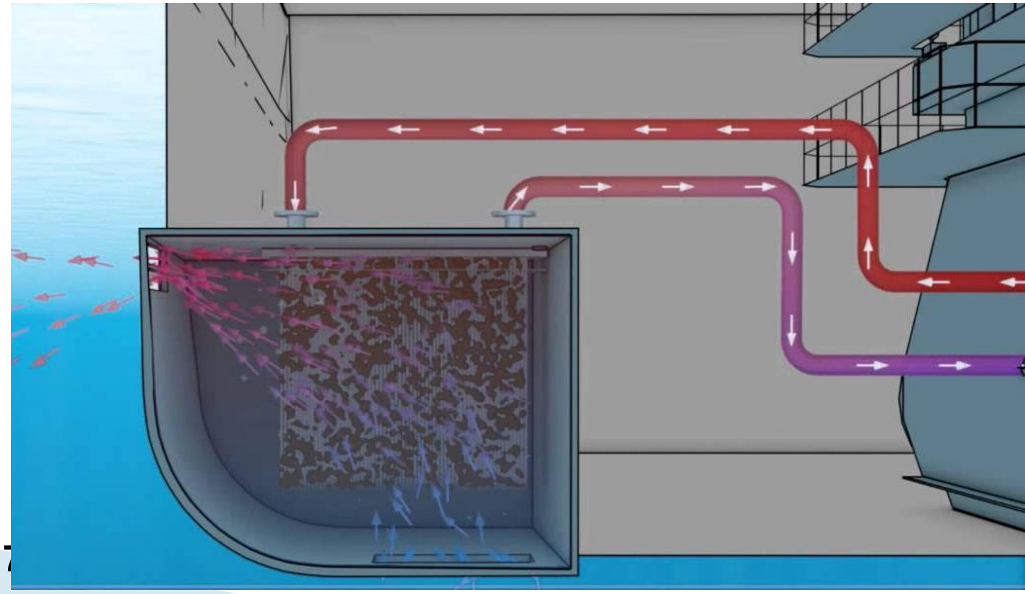
Cooling water intake (water jet)



Ships and Sensors

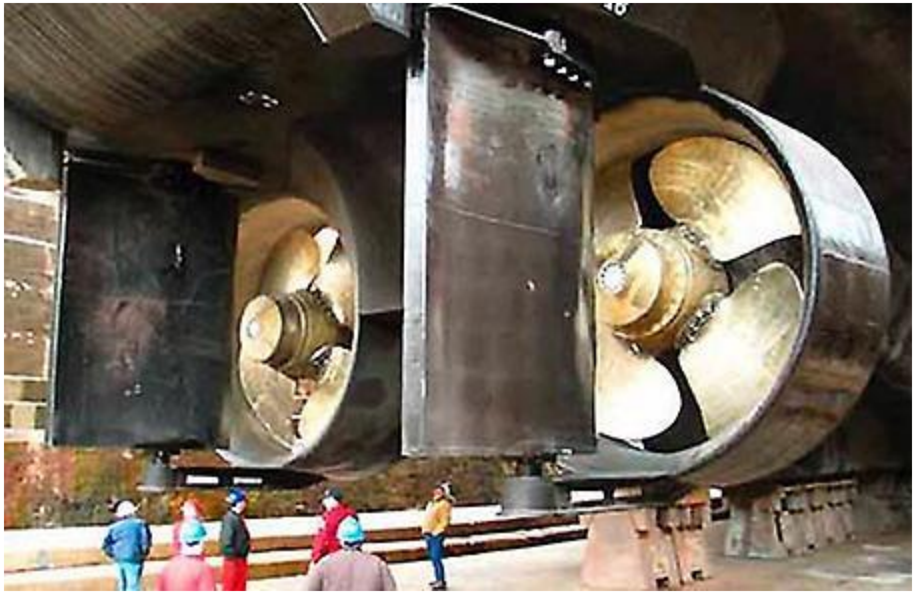
Anti fouling systems

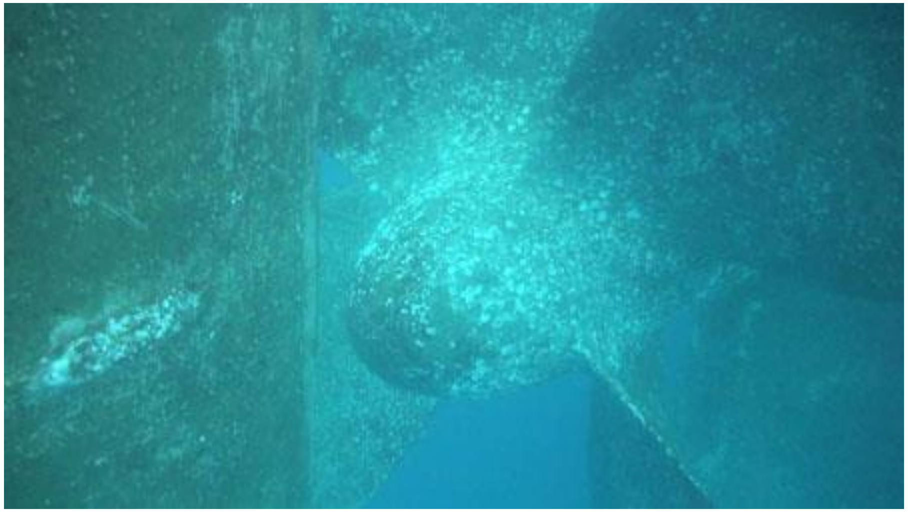




Ships and Sensors

Ship Propeller and Rudder





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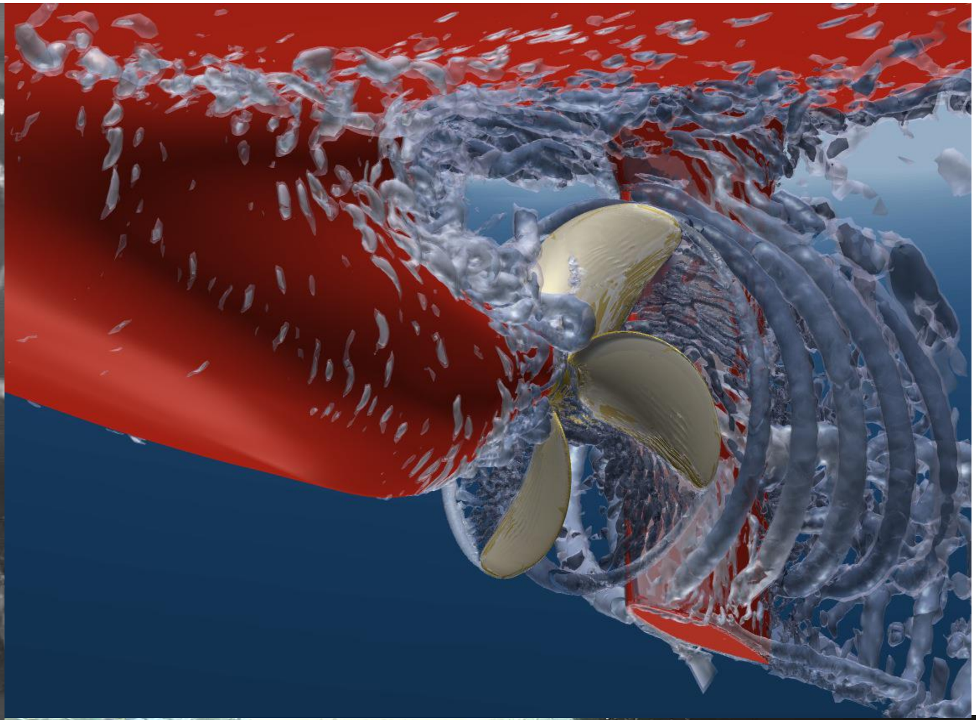
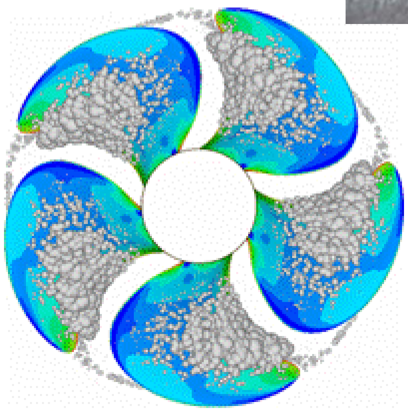


Ship Propeller

Ships and Sensors

Cavitation

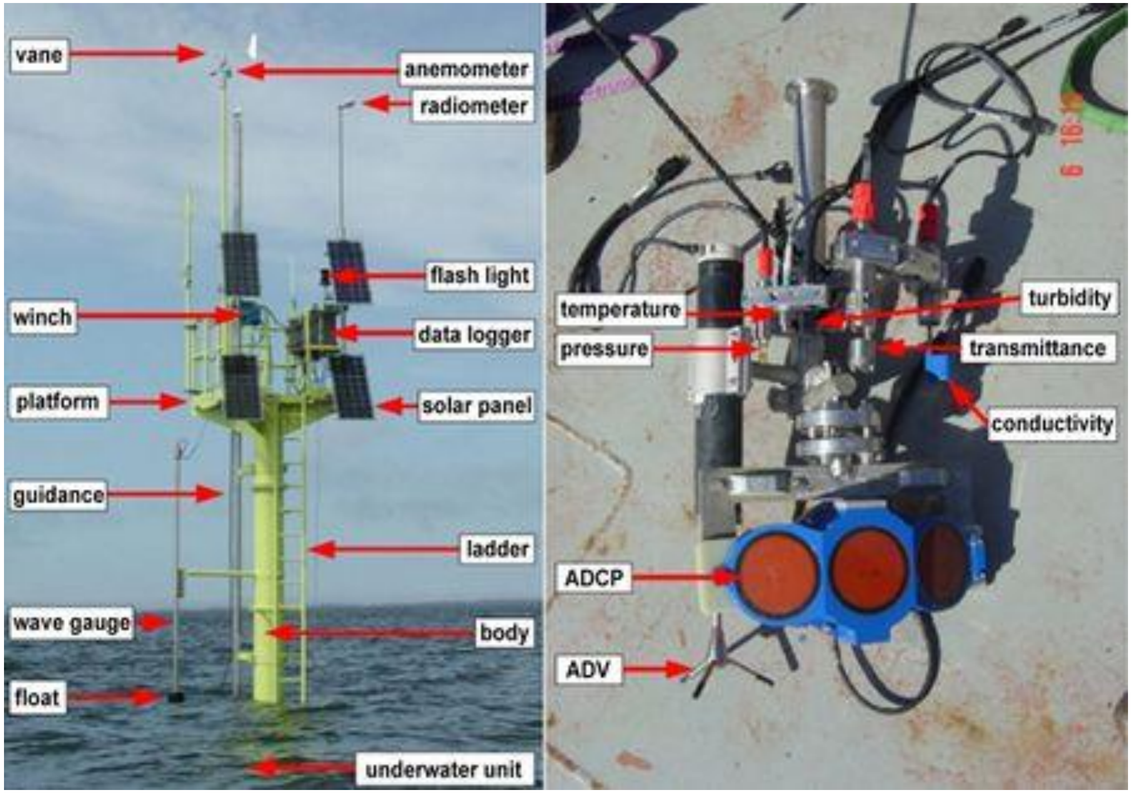


Ships and Sensors

Shells
Algae

Other floating bodies …

Wadden Sea Pole (and censors)

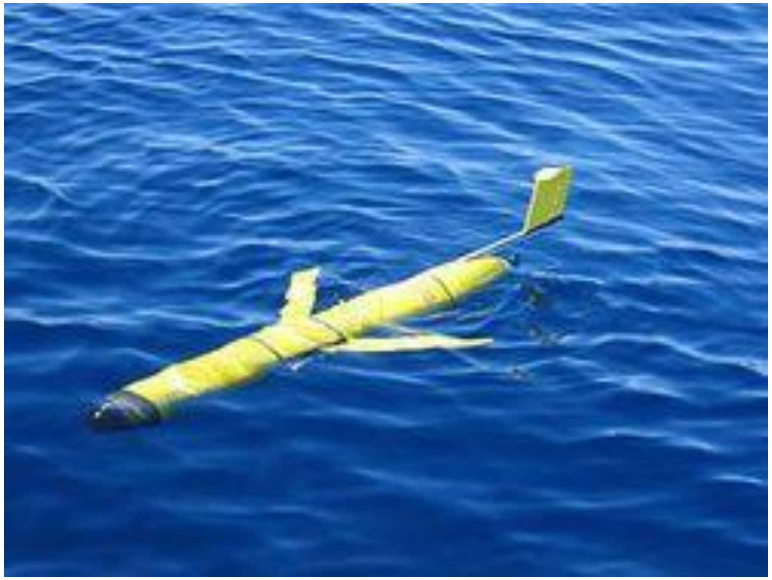


Other floating bodies …

Underwater glider

The underwater glider, is an autonomous underwater vehicle. It works buoyancy driven and is extremely energy efficient.

The underwater glider, is a relatively new measurement platform and originally developed as a low-cost, long-endurance device for observing the oceans.

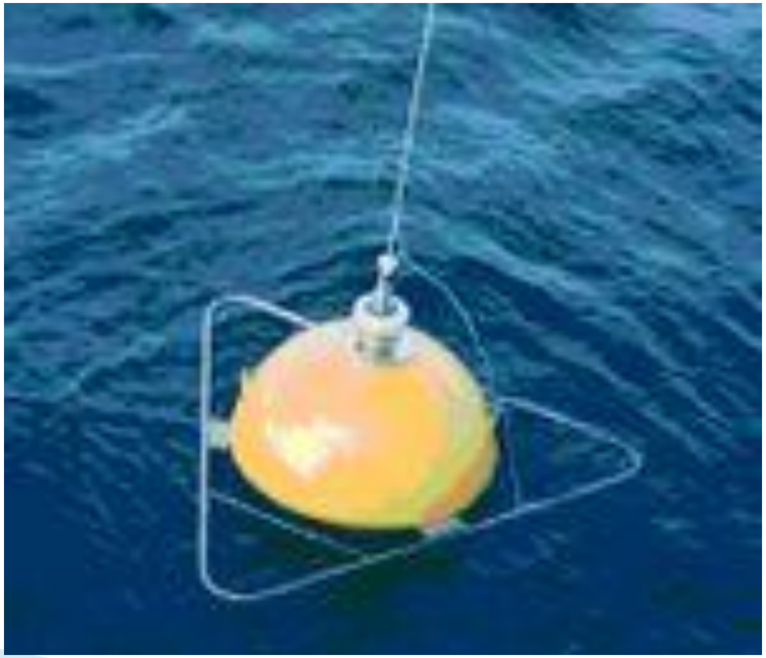


Other floating bodies …

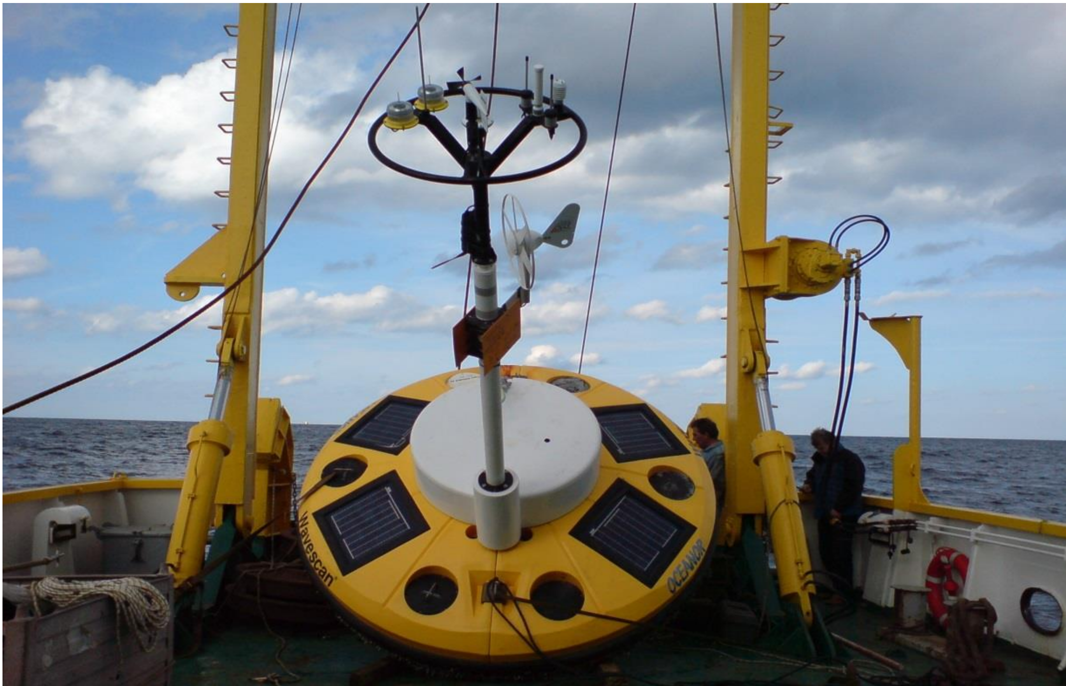
Waverider buoy

Data from the buoy are: wave height, wave length and wave period.

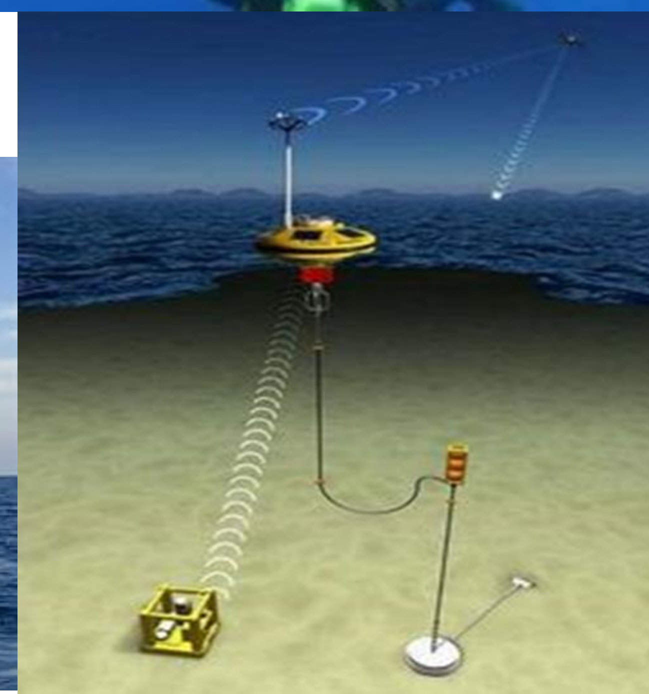
A Waverider buoy follows the movements of the sea surface, and determines the wave height by measuring the vertical acceleration of the buoy. At the heart of all Waverider buoys is an accelerometer, mounted on a horizontal, stabilised platform suspended in a fluid filled sphere in the bottom of the Waverider buoy.



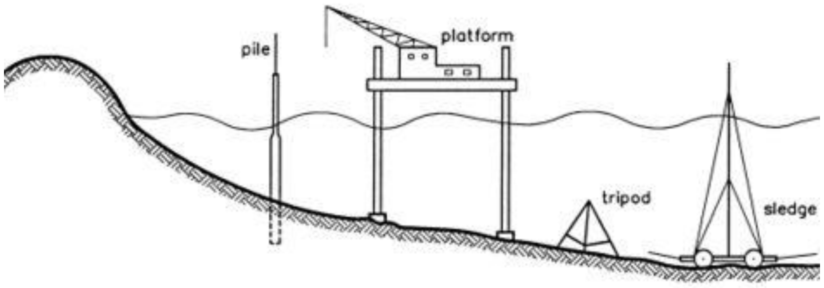
Other floating bodies …



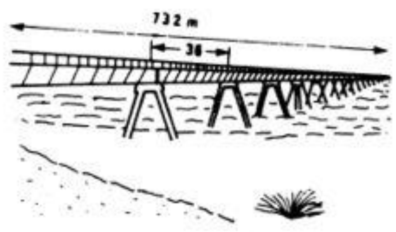
HCMR buoy



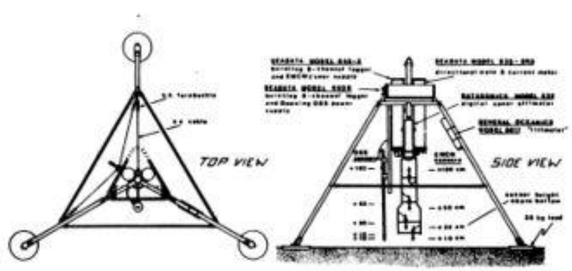
Near shore



Monopiles



Tripod



Offshore Structures...

Conclusions

All marine science has an important practical side in relation to overcoming the problems of working in the often harsh environment of the sea. Sea worthiness requires robust systems that work well in harsh physical conditions. Relaying data to users also requires a robust supply chain. Added to these demands are the extra ones associated with working with shipping companies and their commercial constraints and on ships that were not designed as scientific laboratories.

"Ship design and scientific platforms– PART II"

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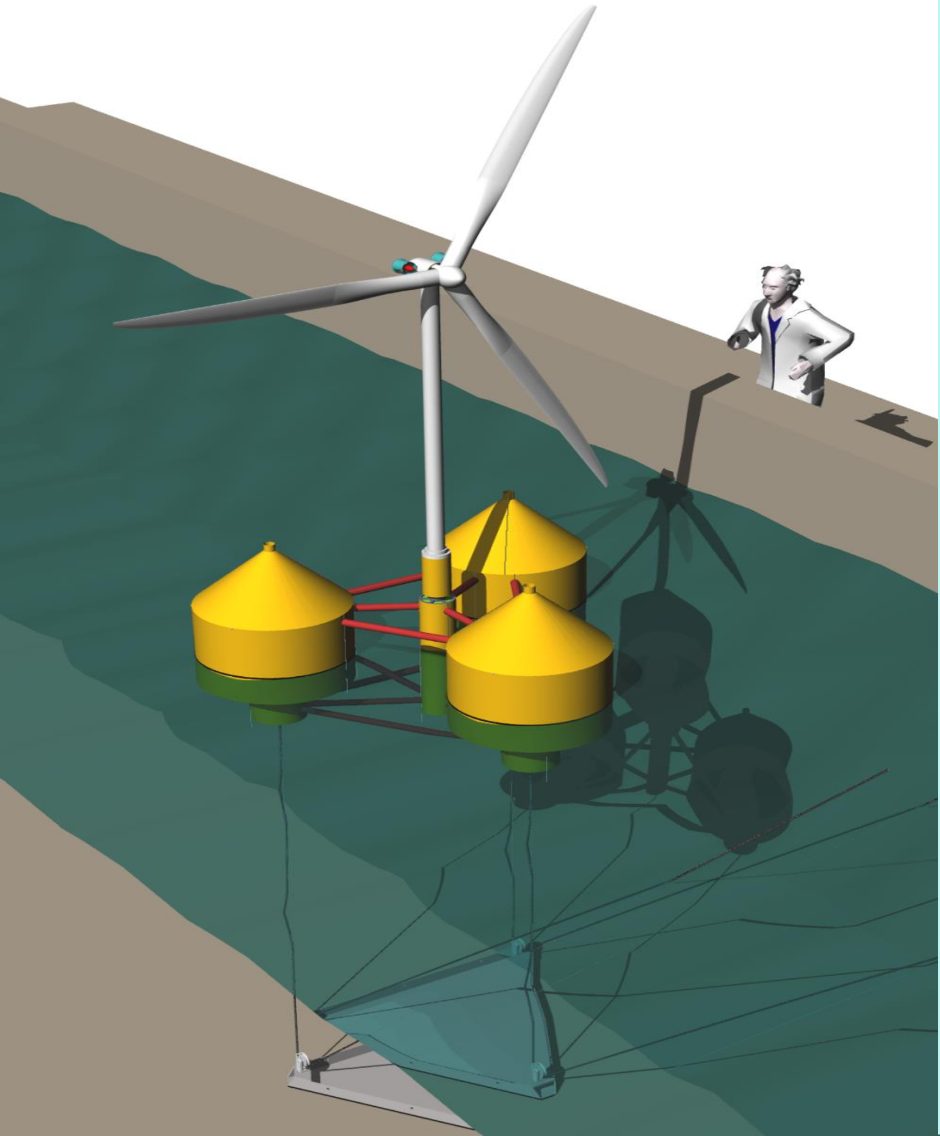
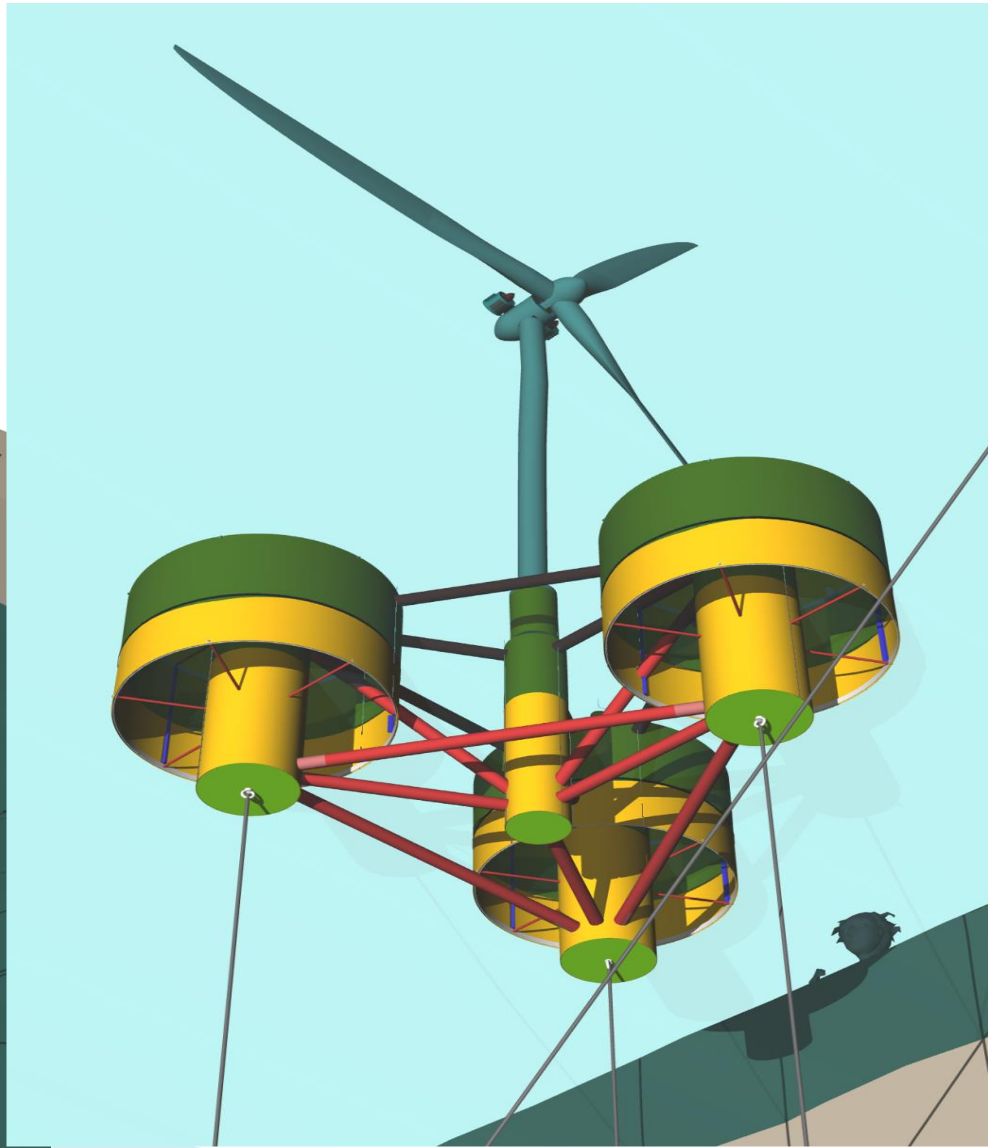
7th FerryBox Workshop,7-8 April Heraklion Crete, Greece

“Multi – Purpose Floating Structure for Offshore Wind and Wave Energy Sources Exploitation”





Basic design parameters and Environmental Conditions

Selection of installation positions: Water Depths 60, 120 and 200m
(ARISTEIA1, ARISTEIA2 , ARISTEIA 3, **ARISTEIA 4**, ARISTEIA 5, **ARISTEIA 6**)

Aristeia4: N35.43°, E26.80° (200m)
Rocky - semi-rocky soil formations

Aristeia6: N40.05°, E25.20° (120m)
No rock formations soil

Environmental Conditions– HCMR

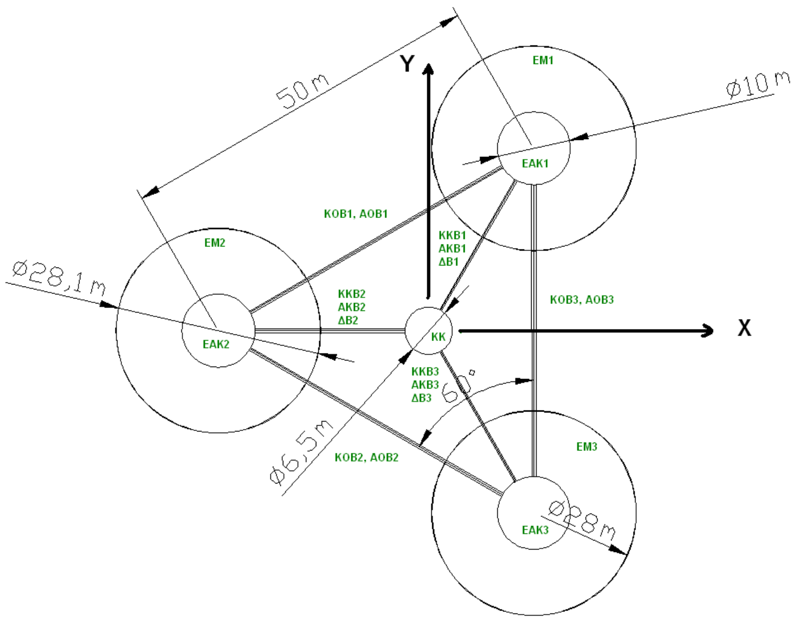
	N	m	min	max	s	CV	Sk	Ku
H_S (m)	29218	1.0147	0.0900	7.140	0.6176	60.8678	1.7833	5.7311
T_P (s)	29218	5.3824	1.6800	13.660	1.5200	28.2398	1.0460	1.5926
U_W (m/s)	29218	6.4672	0.1100	20.570	3.3328	51.5339	0.3513	-0.3352

Basic statistical characteristics of the time series of wind and wave
Aristeia 4 (200m)

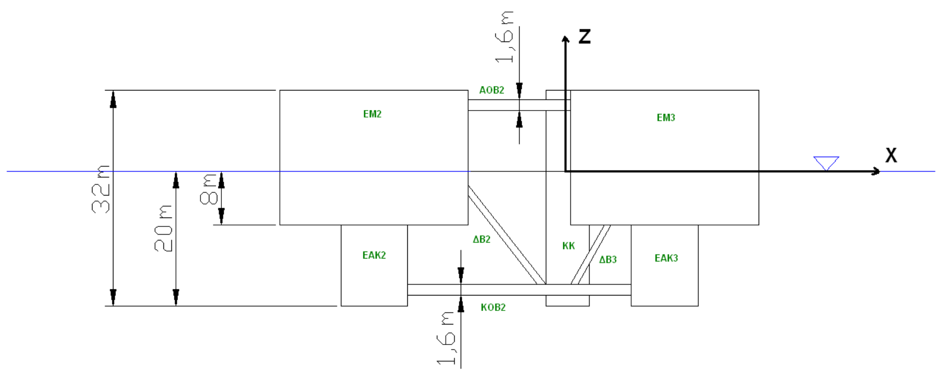
	N	m	min	max	s	CV	Sk	Ku
H_S (m)	29218	0.4074	0.000	4.500	0.402	98.699	2.7925	12.0299
T_P (s)	29218	3.2296	1.260	7.710	0.945	29.2723	1.0385	1.7451
U_W (m/s)	29218	4.1412	0.060	20.680	2.924	70.605	1.2027	1.5689

Basic statistical characteristics of the time series of wind and wave
Aristeia 6(120m)

Floating System Properties



Top view of floating structure and basic characteristics of its parts.



Side view of floating structure and basic characteristics of its parts.

Floating Platform Geometry

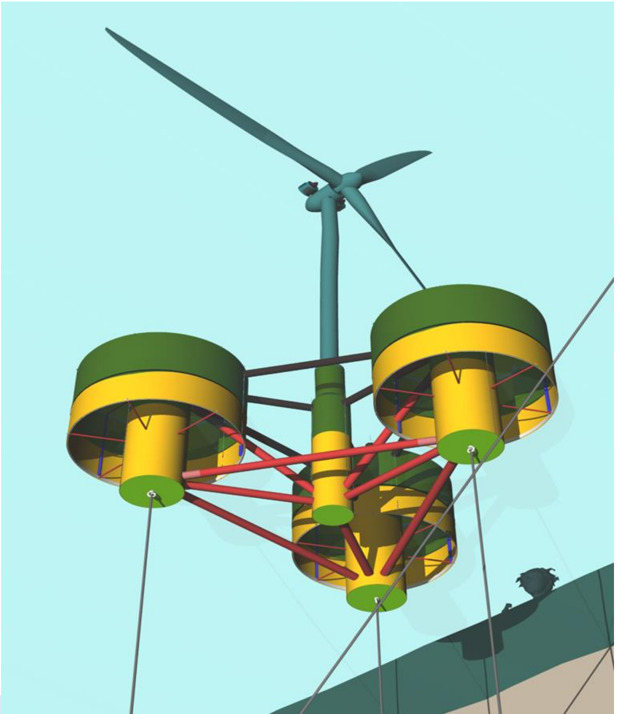
Geometrical Dimensions of each OWC device	
Radius of inner concentric cylindrical body	5m
Draft of inner concentric cylindrical body	20m
Outer & inner radius of the oscillating chamber in each device	14-14.5m
Oscillating chamber's draft	8m
Spacing between offset columns	50m
Length of Main column (tower base)	20m
Diameter of pontoons and cross braces	1.6m
Draft	20m
Elevation of main column (tower base above SWL)	10m

Mass Characteristics

Platform Mass (including ballast)	2.1836×10^6kg
Displacement	6086.3t
KG (below SWL)	4.05m
Platform roll inertia	1.5×10^9kgm^2
Platform pitch inertia	1.5×10^9kgm^2
Platform yaw inertia	2.7×10^9kgm^2

Floating Platform Geometry
Mooring System

Number of mooring lines	3
Mooring line diameter	130mm
Mooring line Mass per unit length	104kg/m
Mooring line mass in water	888.6N/m
Young's modulus of elasticity (E)	200GPa
Equivalent mooring line extensional stiffness (EA)	2646MN
Total Restoring coefficient Kxx (depth 200m)	180KN/m
Total Restoring coefficient Kzz (depth 200m)	44.1MN/m
Pretension	32.4MN



Wind Turbine Geometry

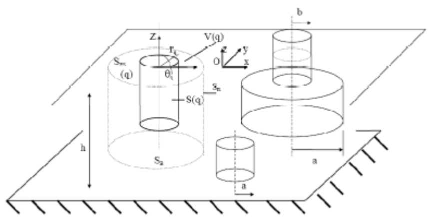
Wind Turbine Geometry

WT components	Mass [t]	Zcg [m]	Length [m]
Tower	250	43.3	77.6 (+10)
Nacelle	240	89.45	-
Hub	50	90	-
Blade x 3	17.74	~90	61.5 (+1.5)

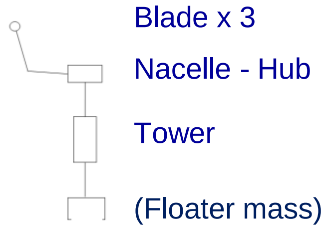
WT masses and center of mass

Formulation of the problem

❖ **Analytical Method (Computer Code: HAMVAB- S. A. Mavrakos, 1995)**



❖ **Reduce Order Model of the WT (Mavrakos, 2015, Mazarakos, 2015)**



❖ **Coupled Analysis- RAO's (Computer Code: HYDRAEROFLOAT- T. P. Mazarakos, 2015)**

$$\left[M_{ij}+A_{ij}(\omega)+M^{WT}\right]\ddot{x}+\left[B_{ij}(\omega)+B_{ij}^{WT}\right]\dot{x}+$$

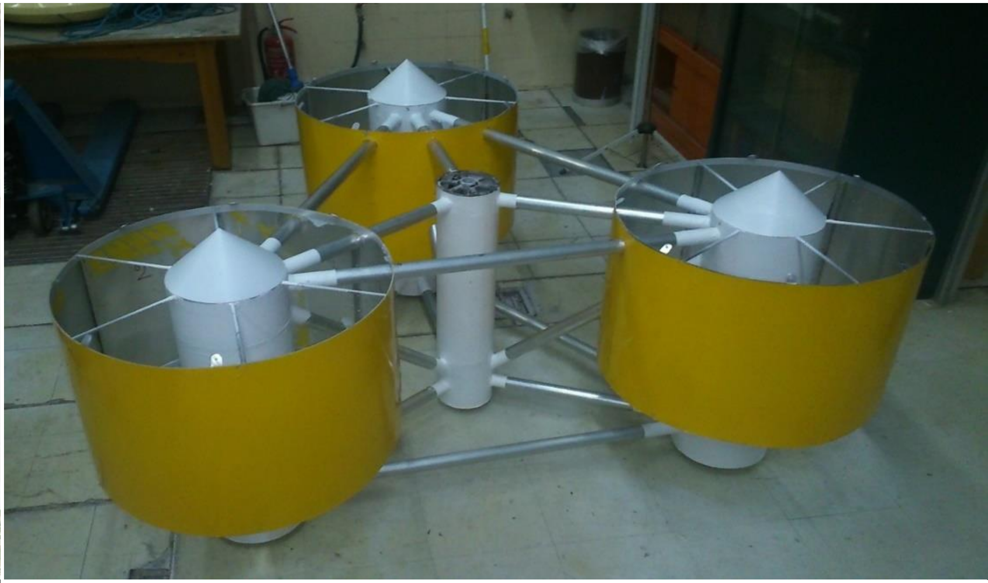
$$\left[C_{ij}+C_{moorings}+C_{ij}^{WT}\right]x=F(\omega)e^{i\omega t}$$

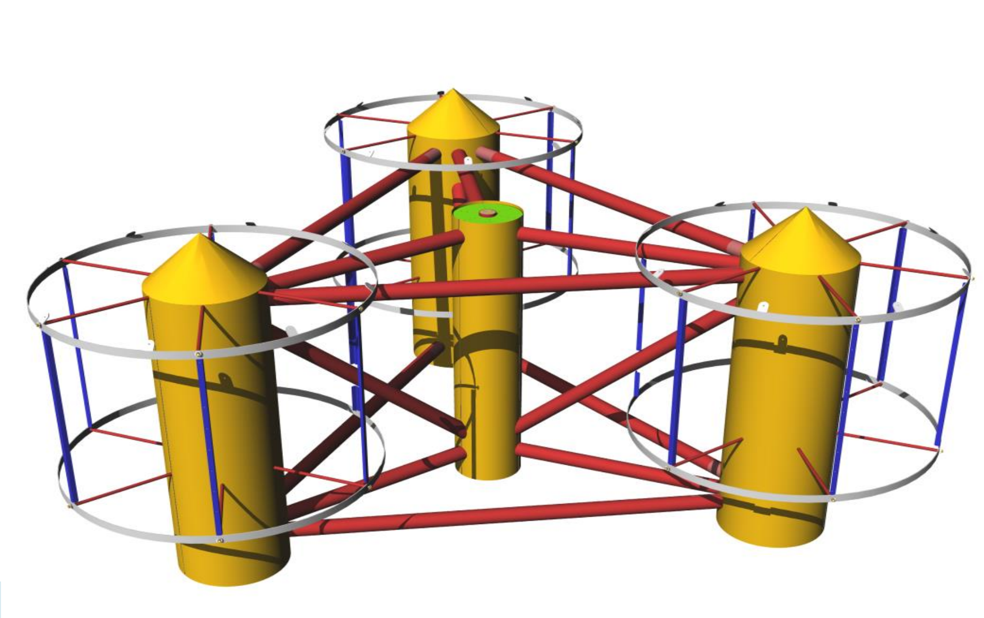
Hydrodynamic Studies and coupled hydro- aero-elastic analysis of the moored multi- purpose floating platform

Hydrodynamic Calculations for the Floating Platform POSEIDON (120m)

- ✓ Exciting Wave Forces
- ✓ Motions
- ✓ Air Pressure
- ✓ Volume Flow
- ✓ Drift Forces
- ✓ Added Mass/ Damping
- ✓ Wave Drift Damping
- ✓ Shear Forces

Experimental Campaign



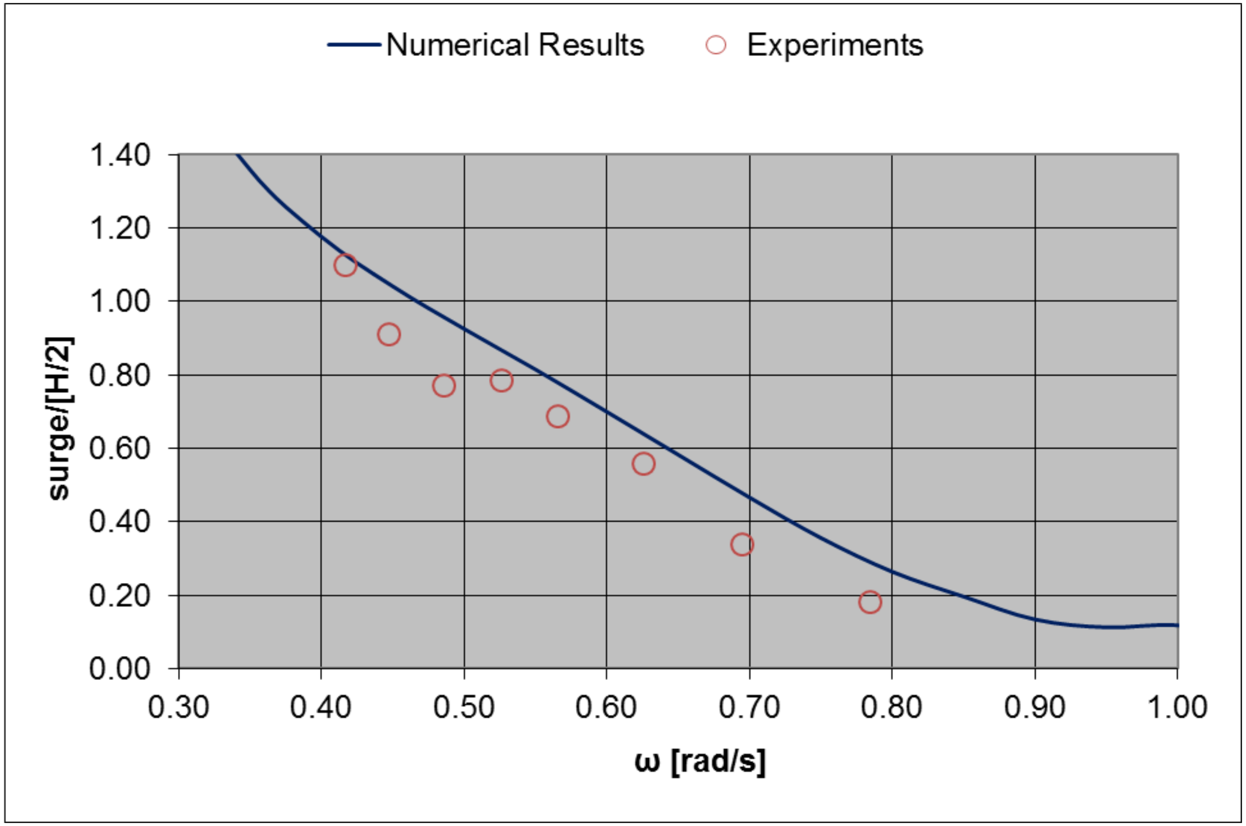


Experimental Campaign

Experimental Campaign

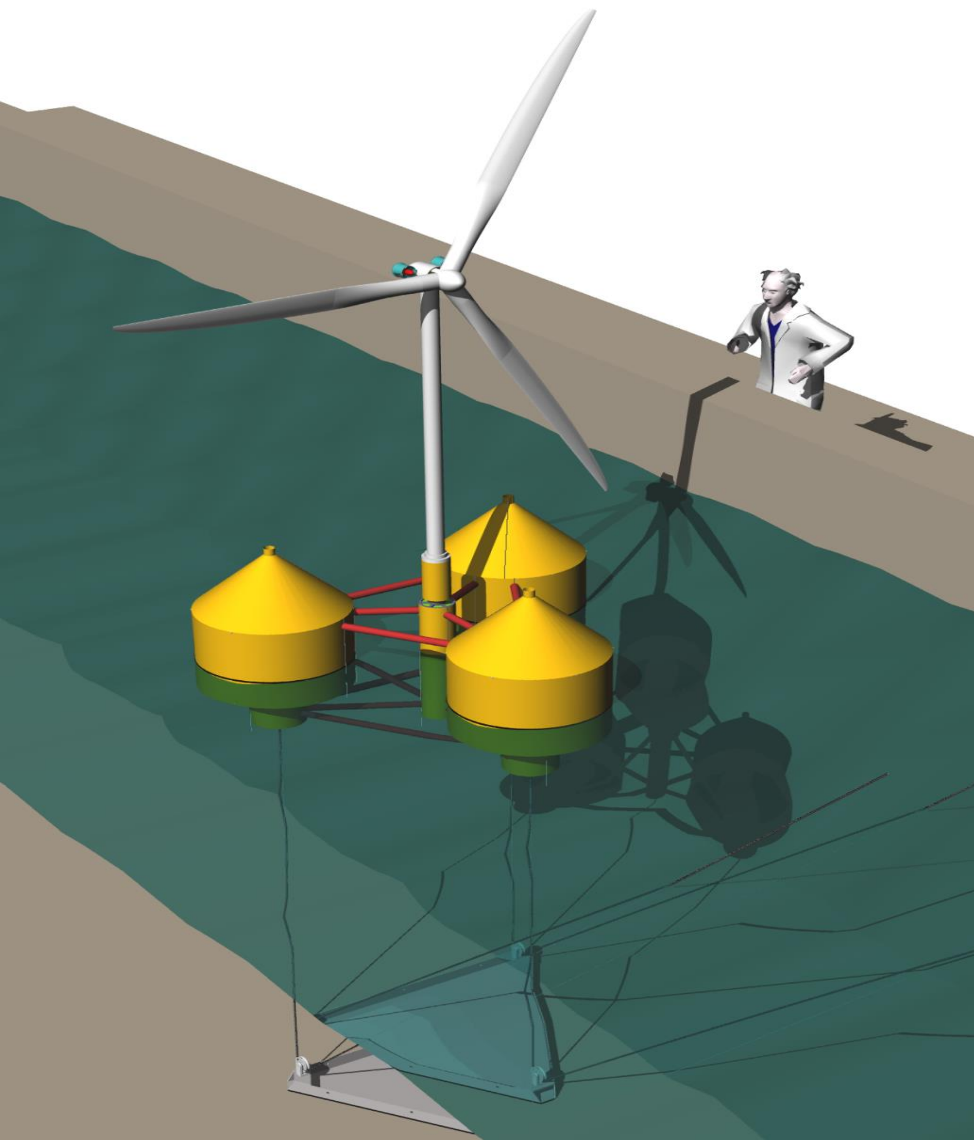
Video

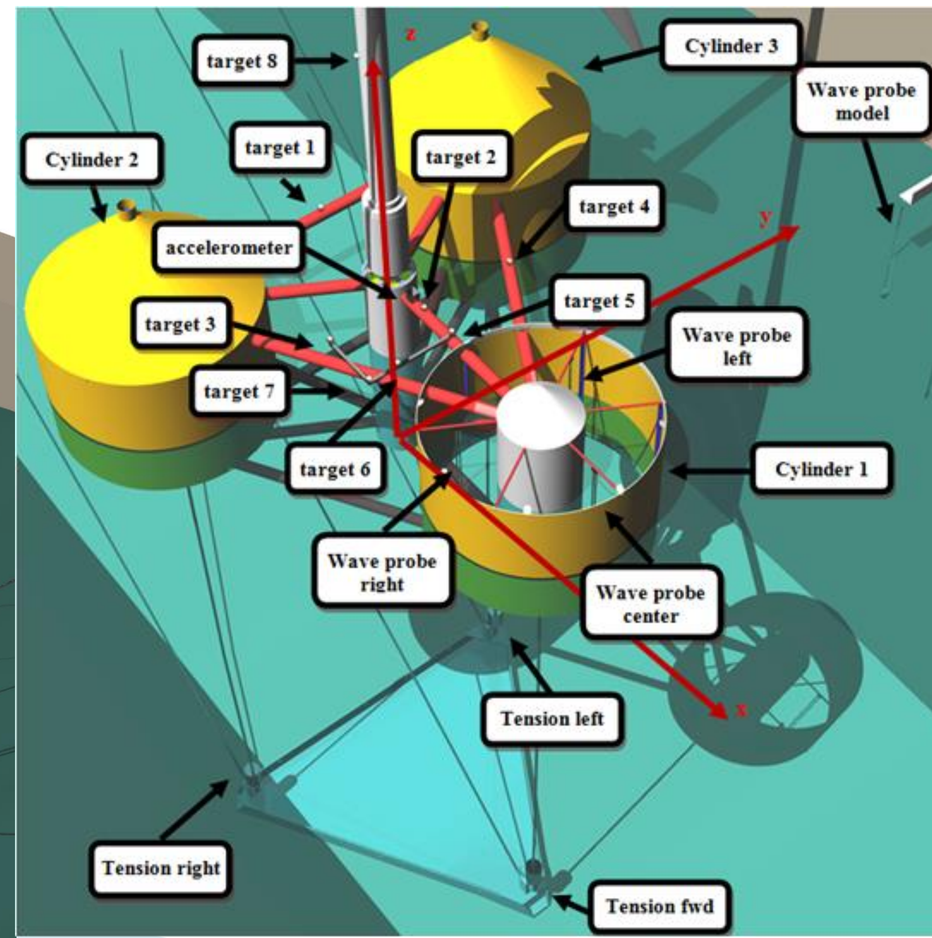
Experimental Campaign



Surge motion of the TLP combined floating platform, 3 OWC's and wind turbine system. Wave heading 0 degrees.

Multi – Purpose Floating Structure for Offshore Wind and Wave Energy Sources Exploitation – Sensors





Multi - Purpose Floating Structure for Offshore Wind and Wave Energy Sources Exploitation- Sensors