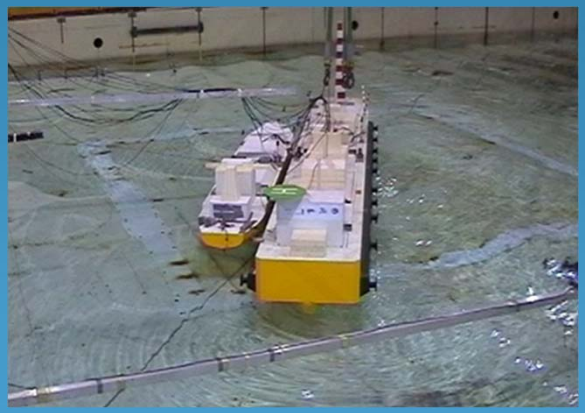
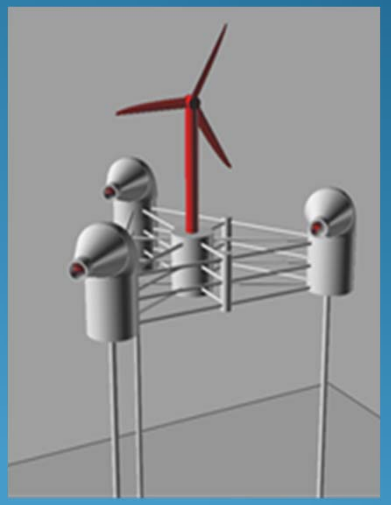
NATIONAL TECHNICAL UNIVERSITY OF ATHENS (NTUA)
School of Naval Architecture and Marine Engineering
Laboratory for Floating Structures and Mooring Systems (LFSMS)





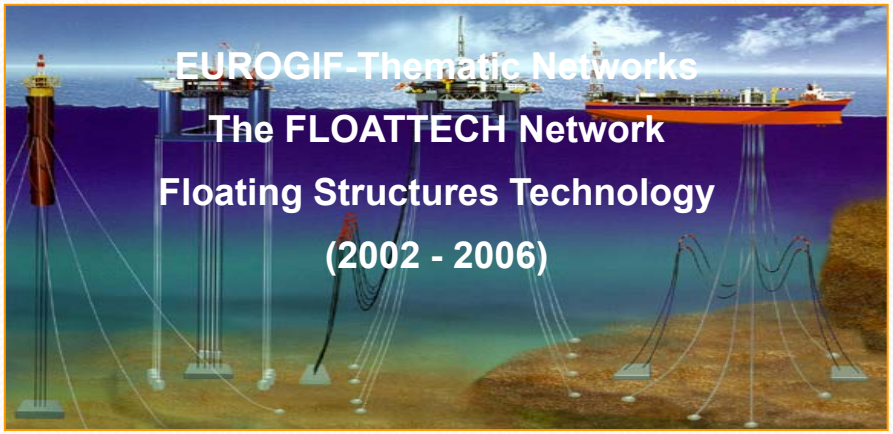
School of Naval Architecture and Marine Engineering, Laboratory for Floating Structures and Mooring Systems (LFSMS)

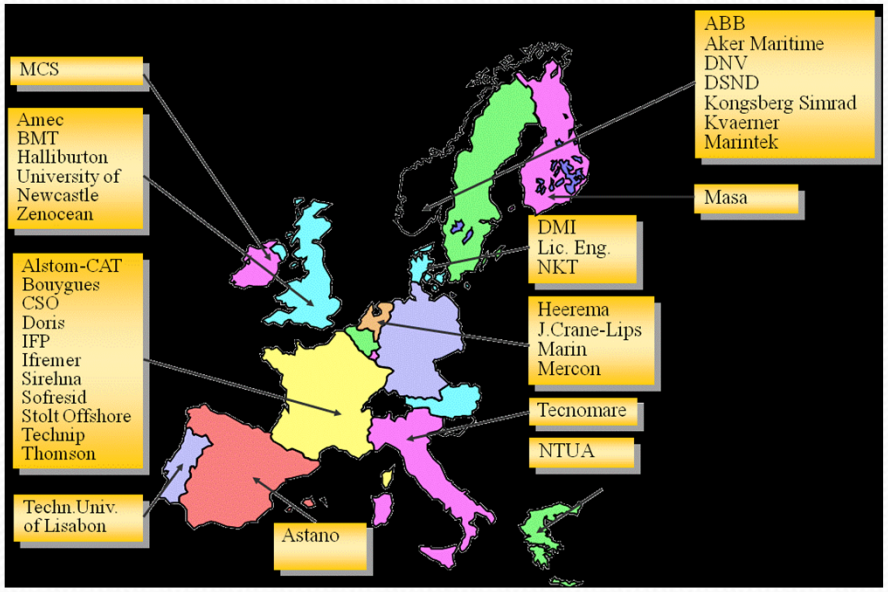
- **Legal status**: Ministerial Decree (Governmental Newspaper Nr. 1968B'/10-9-2009)
- **Scope**: To cover educational and research activities of the School of Naval Architecture and Marine Engineering, NTUA, in the fields of analysis and design of marine structures, among with analysis and optimal design of mooring systems and slender marine structures with applications to:
  - (a) **Offshore structures for the exploration, production and storage** of hydrocarbons in the marine environment (Semi-submersibles, TLP's, Articulated Towers, Interconnected structures, Spar Buoys, etc.)
  - (b) **Mooring Systems for offshore applications**
  - (c) **Slender Marine Structures and flow lines** for the transportation of oil and gas
  - (d) **Marine structures for the environmental protection** (e.g. floating or submerged wave breakers, floating booms for the oil spill protection, etc.)
  - (e) Marine structures for **sustainable energy development**, along with industrial, fishing (**fishing cages for the open sea**), touristic (e.g. **floating marinas**, etc.) and associated infrastructures near- and offshore
  - (f) **Systems for the offshore wind and wave exploitation** (wave energy converters: design and efficiency assessment; floating wind turbines and wind parks)

Research and Consultancy Areas

- Linear and Non-Linear Hydrodynamic Analysis of Offshore Structures (Diffraction, Radiation, Exciting Loads and Motions)
- Static and dynamic analysis and design of mooring systems
- Hydomechanic analysis of single or interconnected moored structures in frequency and time domain
- Linear and Non – linear dynamics of marine risers and slender marine structures
- Wave Energy Converters' analysis and efficiency evaluation (heaving devices, OWC's concepts).
- Floating Structures Applications (Floating Wind Turbine analysis and design, Fishing Farms)
- Analysis and design of oceanographic surface buoys and underwater gliders
- Wave propagation in harbors and motions of moored ships in harbors

Participation in Thematic Networks and International Bodies





- FLOATTECH: Floating Structures Technology, DG Research, 2002-2006 (μοναδικός Ελληνικός φορέας)

- Coordinated Action on Ocean Energy (2003-2007)

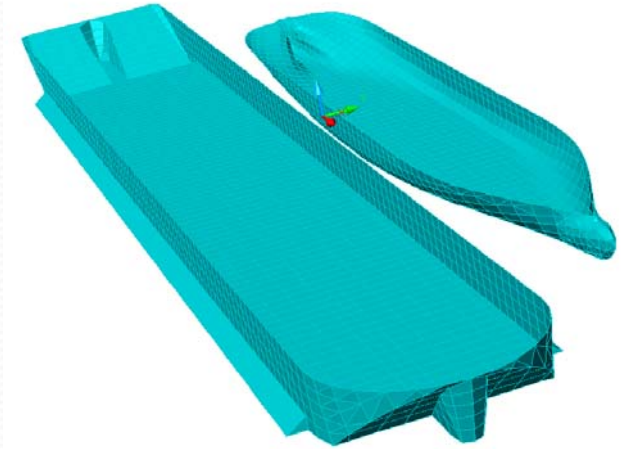
- Founding member European Association of Ocean Energy (2007 -)

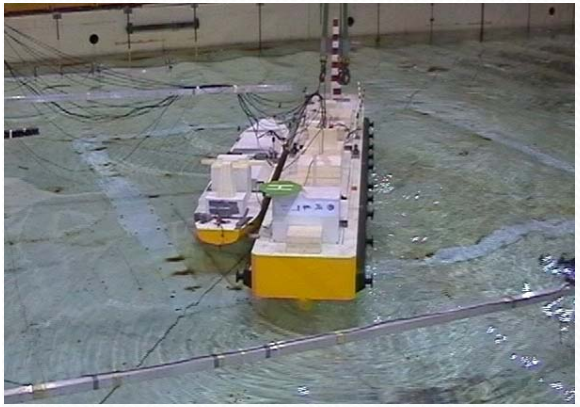
- International Ship and Offshore Structures Congress (ISSC, 1988 -)

Representative Research achievements
(Hydrodynamic analysis of large offshore structures)

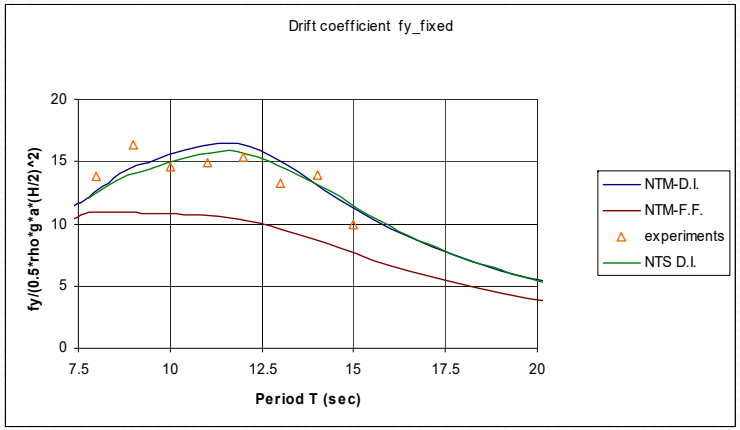
- Hydrodynamic analysis of gas import floating terminals (*)

Sketch of the Assembly (left) and panel discretization for the hydrodynamic analysis (right)





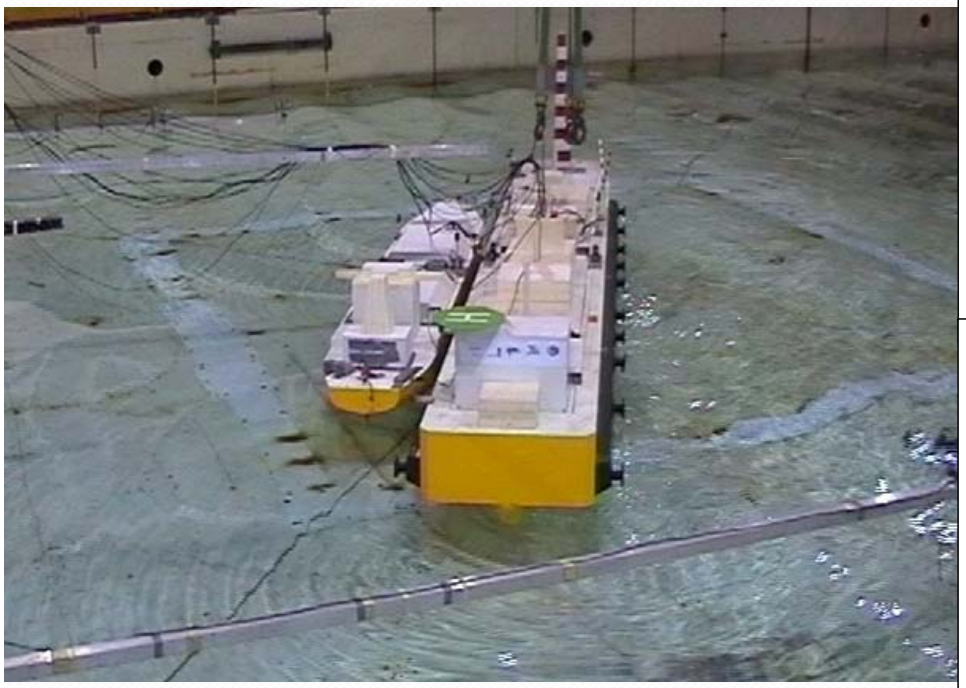
Physical Model Tests (left) and comparisons between numerical and experimental results for the mean drift forces (right). Experiments in BGO First, Toulon, France



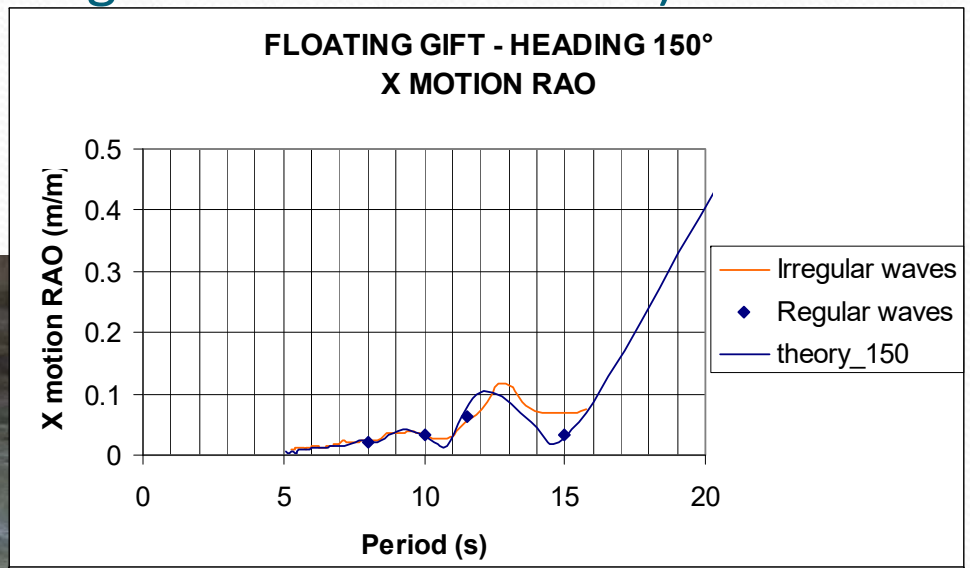
(*) EU two years (1.2.2005-31.1.2007) project, Gas Import Floating Terminal (GIFT), General Directorate for Transport, Project No: 012404, collaboration with DORIS Engineering (France), LMC (UK), DnV (Norway), CAT(France)

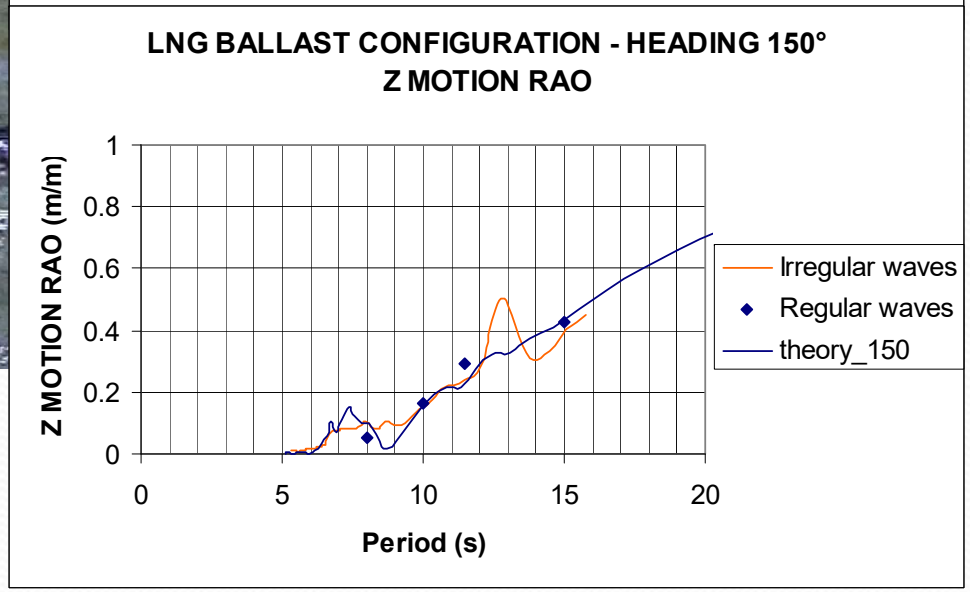
Representative Research achievements
(Hydrodynamic analysis of large offshore structures)

Hydrodynamic analysis of gas import floating terminals(*)



(*) EU two years (1.2.2005-31.1.2007) project, Gas Import Floating Terminal (GIFT), General Directorate for Transport, Project No: 012404, collaboration with DORIS Engineering (France), LMC (UK), DnV (Norway), CAT(France)

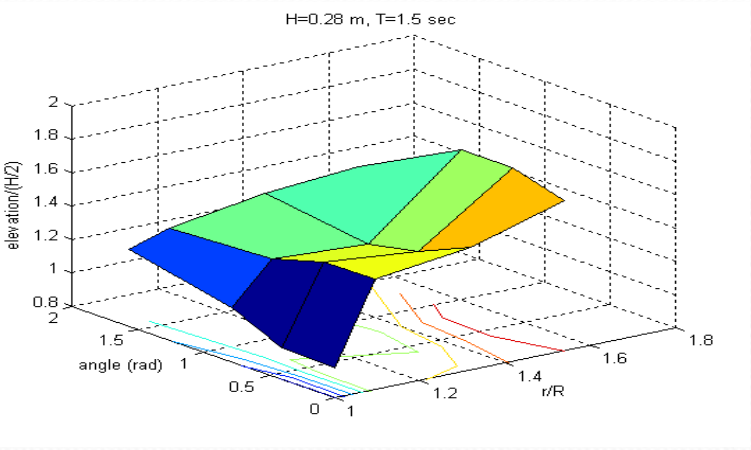




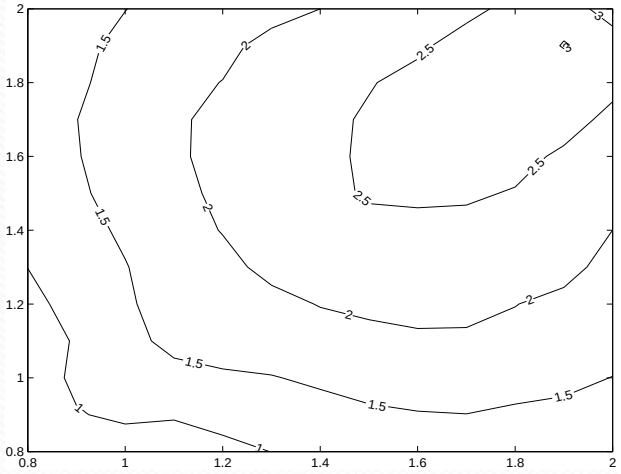
Representative Research achievements
(Numerical and experimental investigation of the hydrodynamic behavior of large offshore structures)

- Hydrodynamic analysis of a TLP platform(*)

Troll Olie Platform (left); Scale down model for the experiments conducted in EL PRADO Model basin, Madrid, Spain (right)



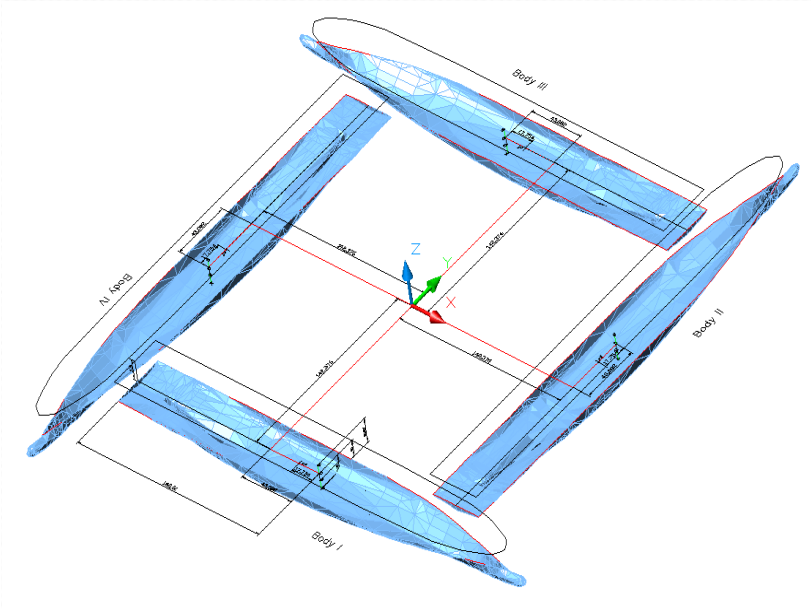
Wave elevation around structural components (left); contours of the second-order surge forces in bi-chromatic waves (right)

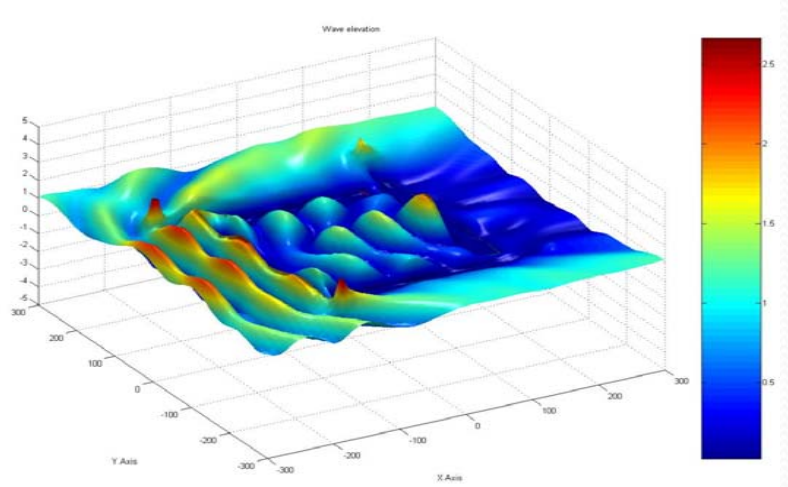


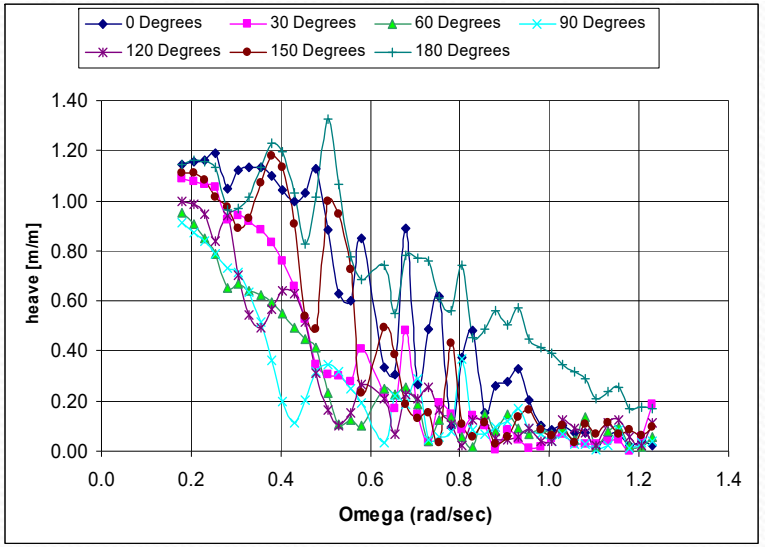
(*) EU project within the "Transnational Access to Research Infrastructures", carried out in the wave basin EL PRADO Model basin, Madrid, Spain, 2005.

Representative Research achievements
(Hydrodynamic analysis of large floating infrastructures)

- Hydrodynamic Analysis of a four-ship cruisers' assembly (*)





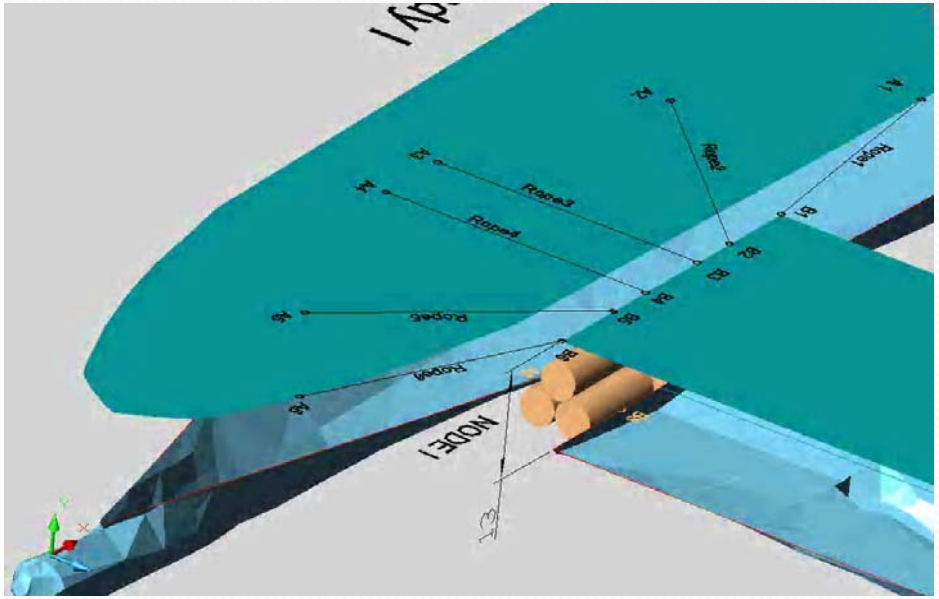


- Panel discretization (above)
- Wave elevation in the internal basin (upper right)
- Response amplitude operation (RAO) of the first ship in heave motion (down left)

(*) EU project VISIONS, 2007, on "the cruise of tomorrow" : Developing of autonomous cruising concepts by creating cruisers' hubs at remote destinations

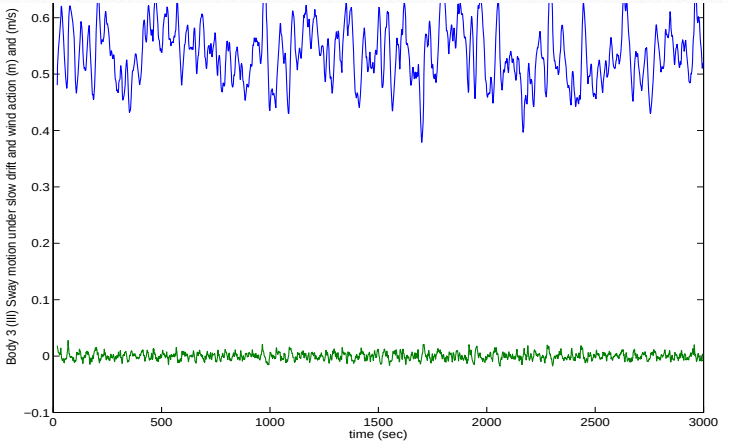
Representative Research achievements
(Hydrodynamic analysis of large floating infrastructures)

Analysis of the slowly-varying motions of a four cruisers assembly (*)

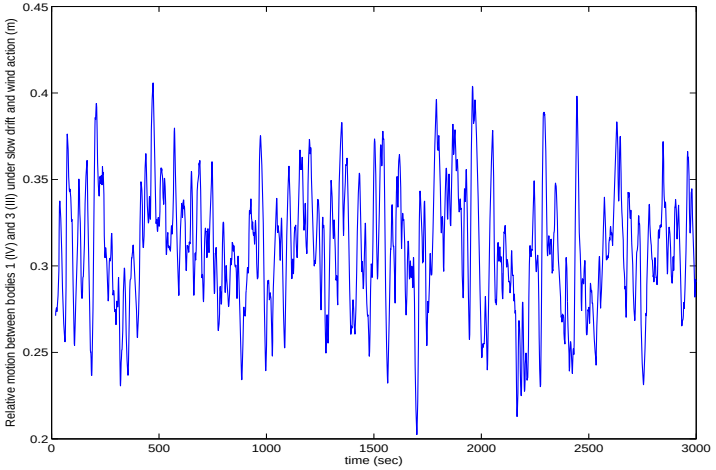


Berthing of adjacent cruisers

(*) EU project VISIONS, 2007 "the cruise of tomorrow" : Developing of autonomous cruising concepts by creating cruisers' hubs at remote destinations

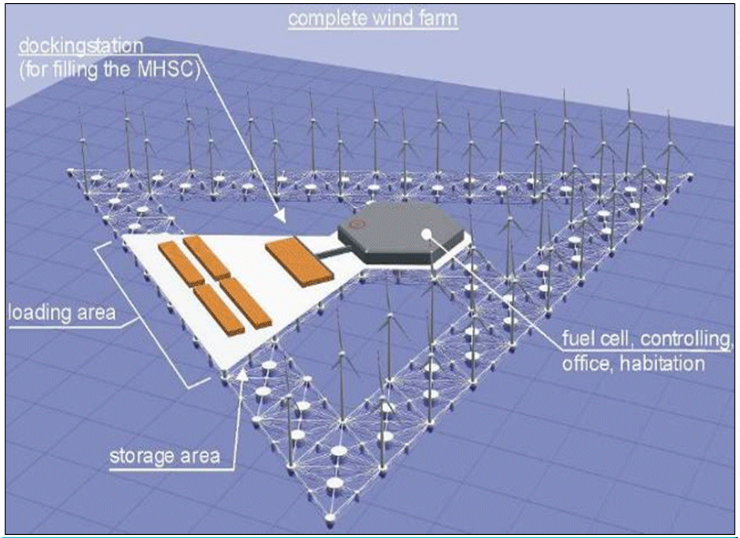


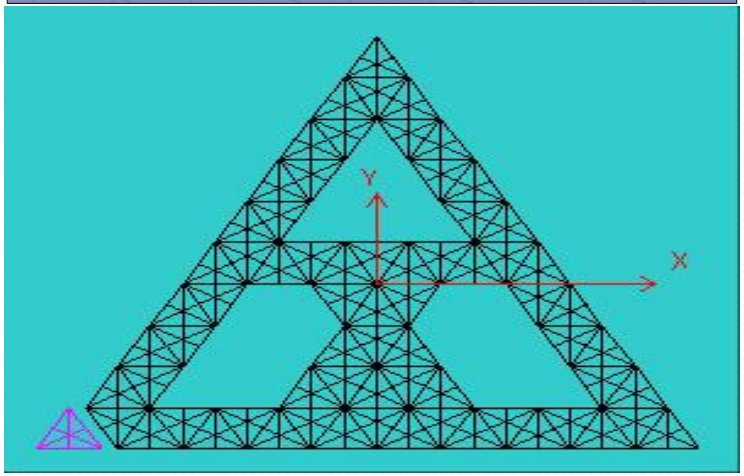
Absolute (above) and relative (down) transverse motions and velocities under the combined action of wind and wave. Ships Nrs. III and II

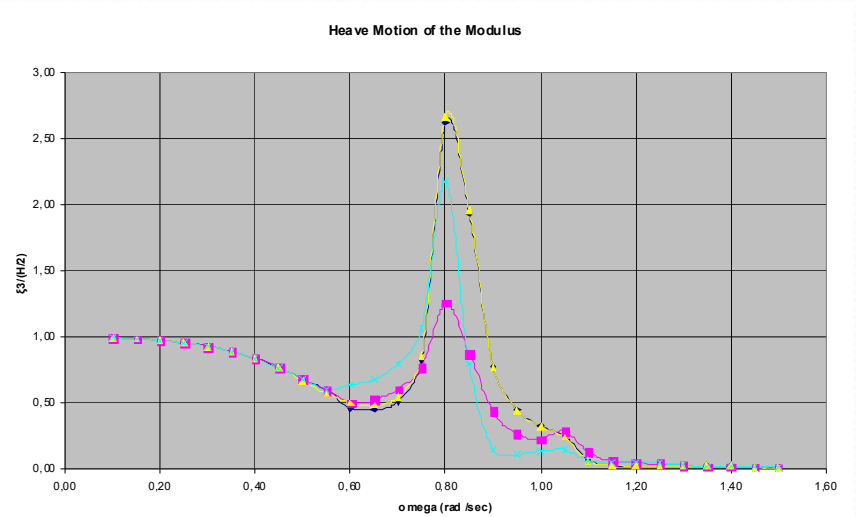


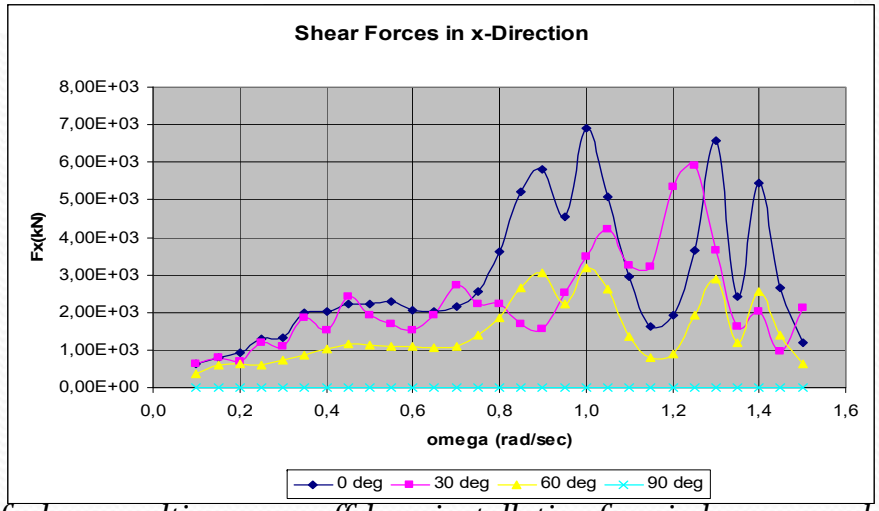
Representative Research achievements
(Analysis of multi-purpose offshore installations for the wind energy sources exploitation and storage)

Hydrodynamic Analysis of an offshore wind farm (*)







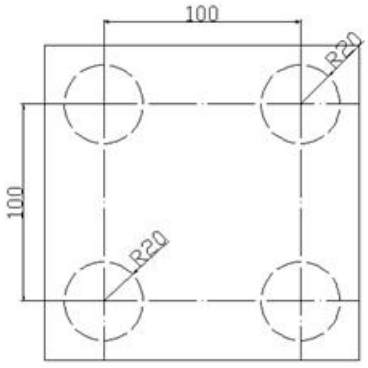


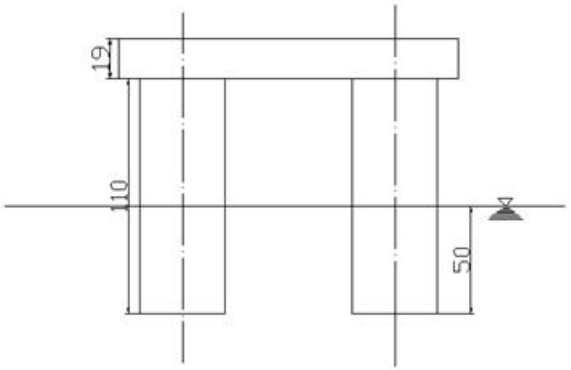
(*) *EU project VISIONS, 2006, on "mobile power" : Analyzing of a large multi-purpose offshore installation for wind energy exploitation and storage*

Representative Research achievements

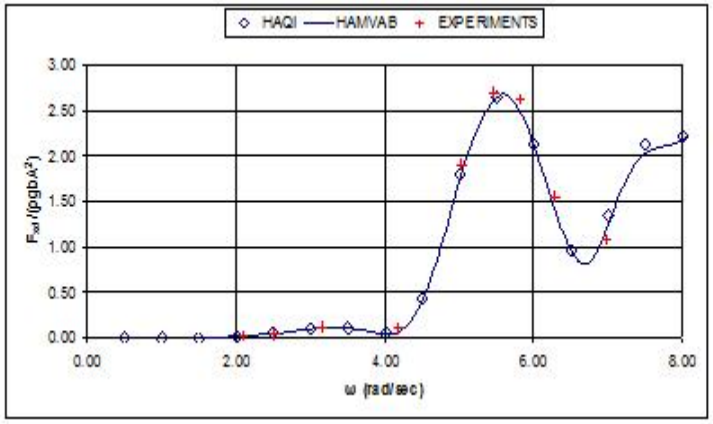
(Hydrodynamic analysis of offshore structures at low forward speed)

- Wave –Current interactions on multiple vertical cylinders (*)

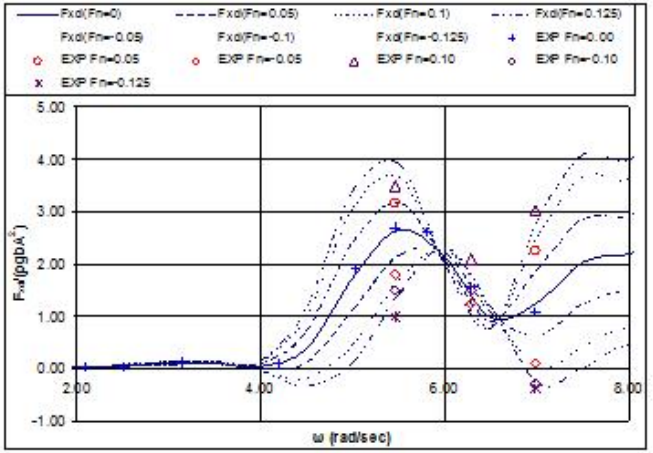




Physical model and dimensions of a four cylinder configuration



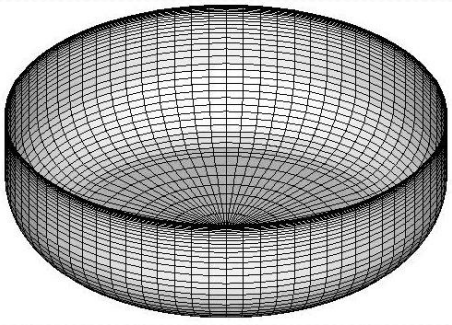
Mean drift forces on the restrained (left) and the Moving configuration (right). Comparisons between numerical and experimental results. Experiments in IFREMER, Brest, France.



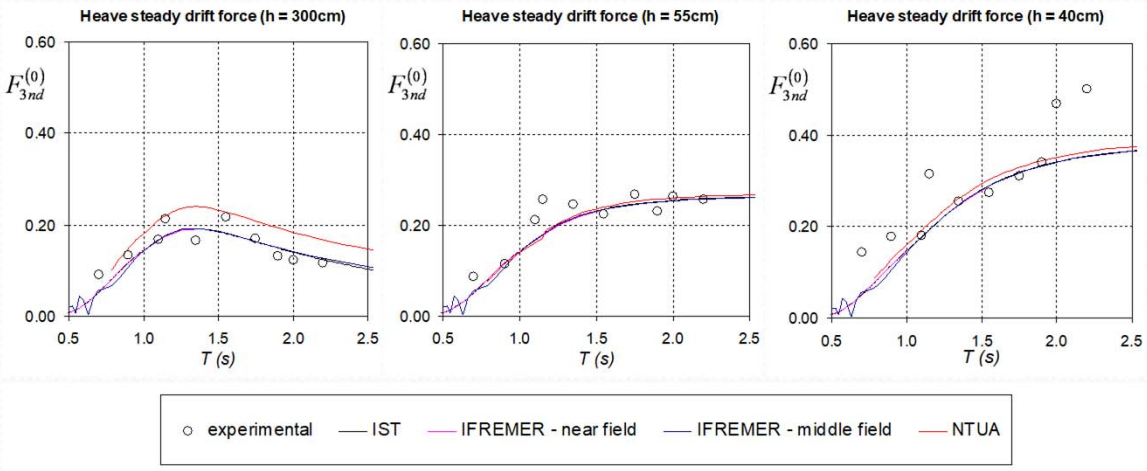
(*) *EU project within the "Transnational Access to Research Infrastructures", METRI -2, carried out in the wave basin IFREMER, Brest, France, 2009 .*

Representative Research achievements
(Hydrodynamic analysis of vertical cylinders)

- Experiments for the drift forces on a floating body of simple geometry (*)



Cylinder in the wave tank during experiments (left), discretization for the numerical evaluation (middle), scaled-down physical model (right)



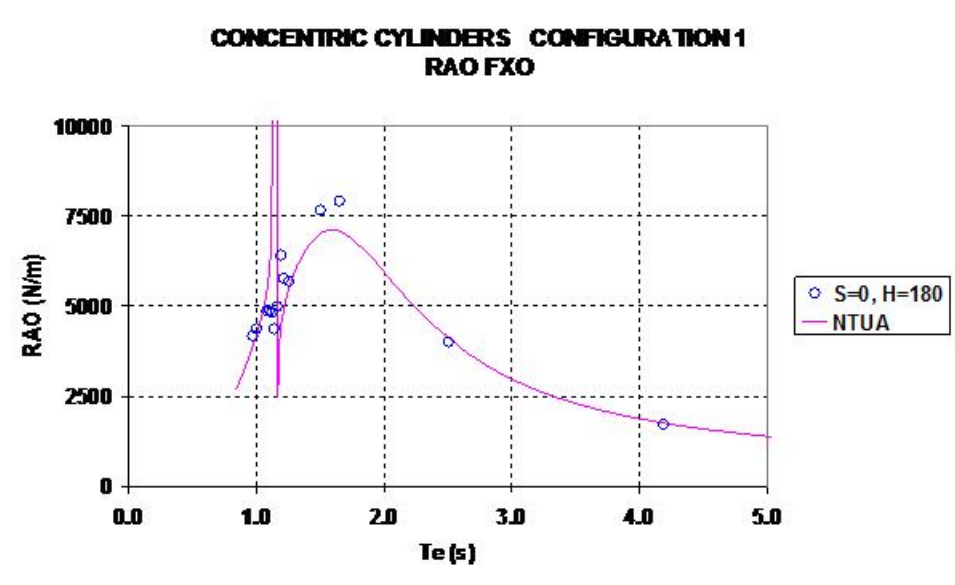
(*) *EU project within the "Transnational Access to Research Infrastructures", HYDRALAB III, carried out in the wave basin DHI, Copenhagen, Denmark , 2009.*

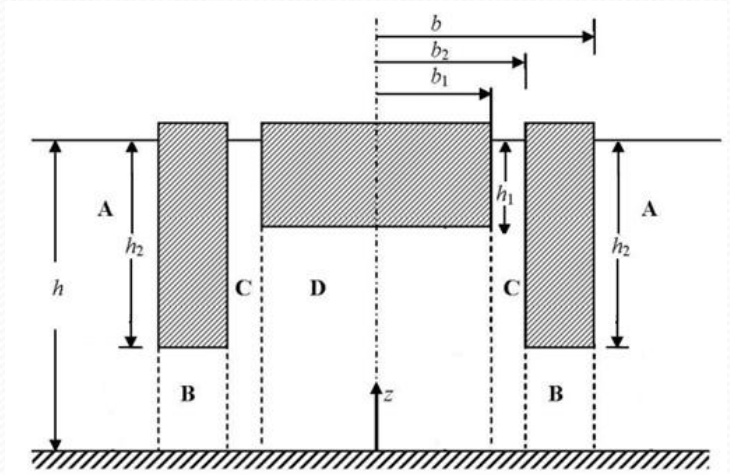
Representative Research achievements

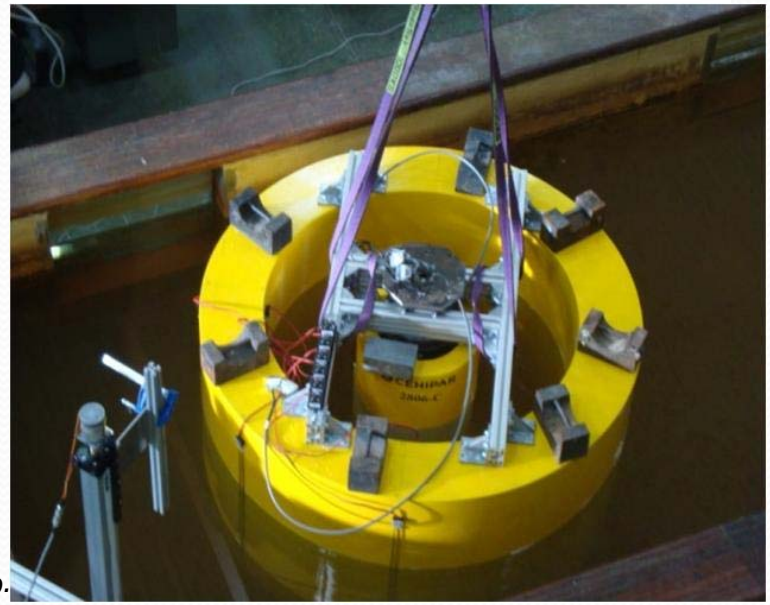
(Hydrodynamic analysis of vertical cylinders with moon pools: Application to oscillating water column wave energy converters)

Hydrodynamics of Concentric Cylinders(*)

System Sketch (upper right) and physical Model (down right)





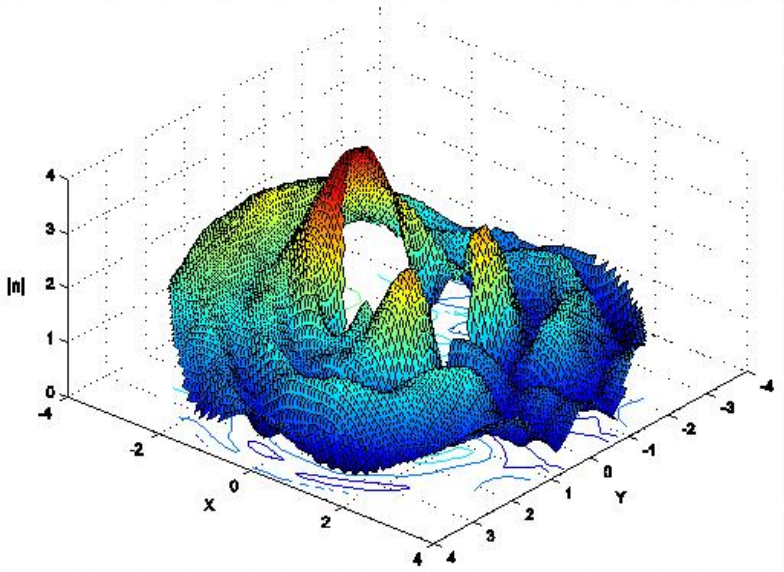


Horizontal exciting wave forces on the external torus. Numerical results versus experiments. Experiments were conducted at CEHIPAR, Spain.

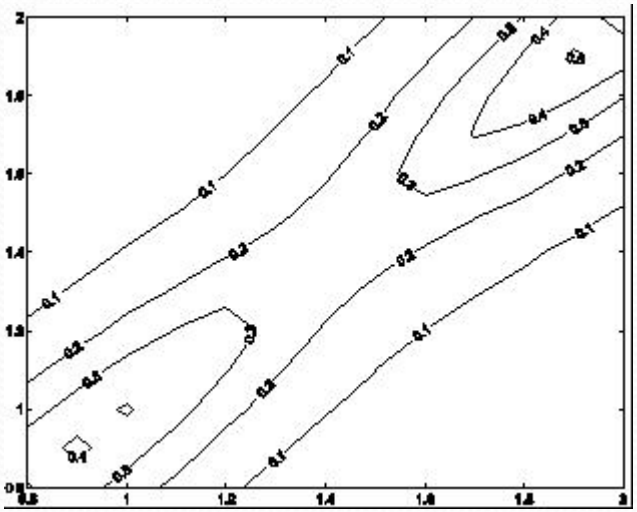
(*) *EU project within the "Transnational Access to Research Infrastructures", HYDRALAB III, carried out in the wave basin CEHIPAR, Madrid, Spain, 2009.*

Representative Research achievements
(Non-linear hydrodynamic analysis of vertical cylinders)

- Second-order interaction between vertical cylinders and incident surface waves in mono- and bi-chromatic excitation (*)



Second-order wave run up

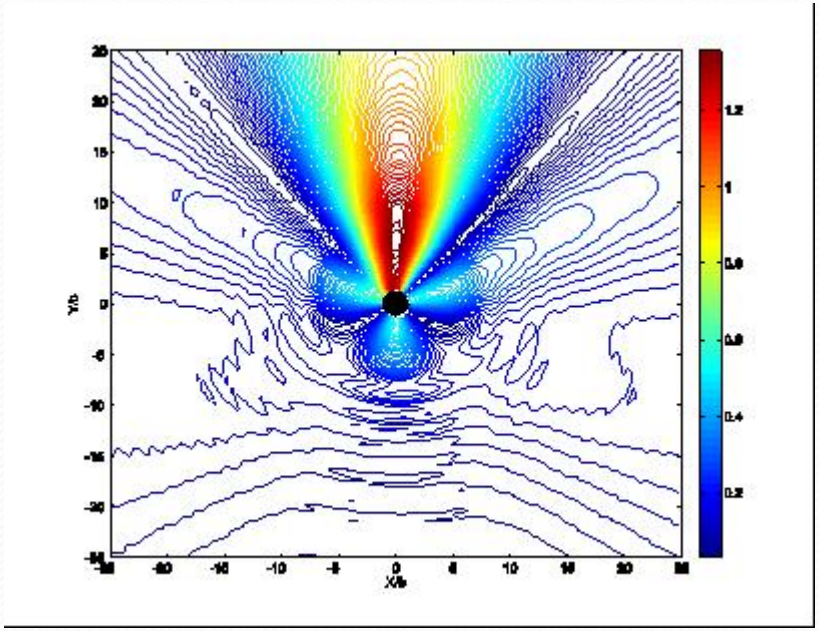


Vertical exciting second-order forces in bi-chromatic waves

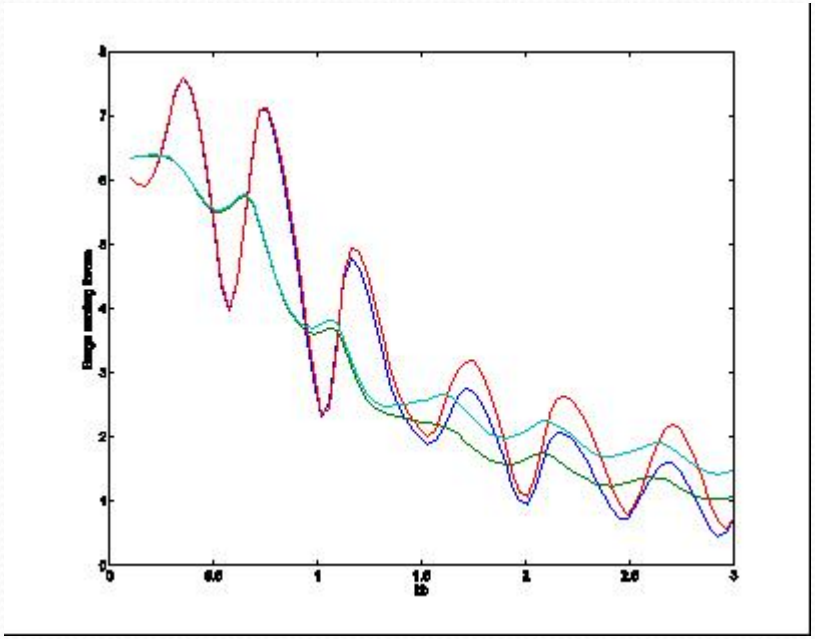
(*) Three-year research project (1.3.2004 – 28.2.2006), sponsored by the Greek Ministry for Education, Program PYTHAGORAS: "Hydrodynamic and Hydroelastic Analysis of moored floating or constrained vertical axisymmetric bodies for applications as wave energy converters"

Representative Research achievements
(Hydrodynamic analysis of vertical cylinders)

- Wave - Current Interaction on Multiple Cylinders in low Current Speeds (*)



V waves around a cylinder due to moderate current speeds

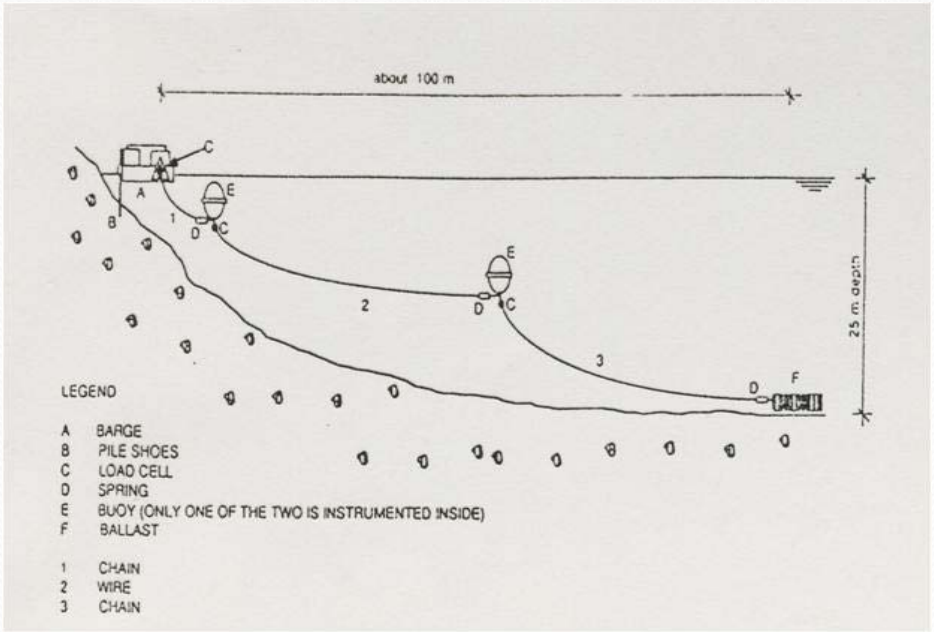


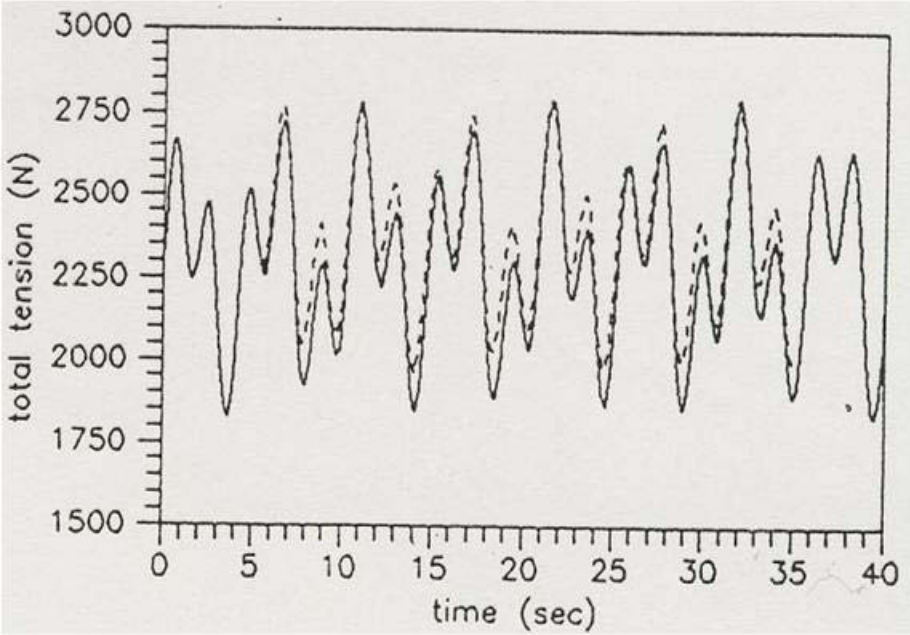
Change in exciting forces in a 3-cylinder configuration due to the interaction of waves with a current field

(*) *Two-year research project (1.1.2005 – 31.12.2006), sponsored by the Greek Ministry for Education, PYTHAGORAS II"Wave – Current – Vertical Cylinder Array interaction*

Representative Research achievements
(Mooring analysis of single and multi – leg systems)

- Dynamic analysis of deep water moorings with attached submerged buoys (*), (**)





Large scale experiments in 25m water depth lake and comparisons with numerical predictions

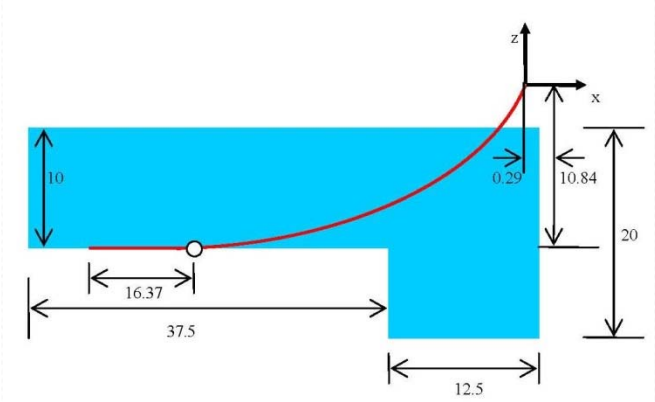
(*) *"Feasibility Study for Deep Water Anchoring Systems", Two years (1986-1988), Research project sponsored by the Hydrocarbon Division, Energy Directorate, EU.*

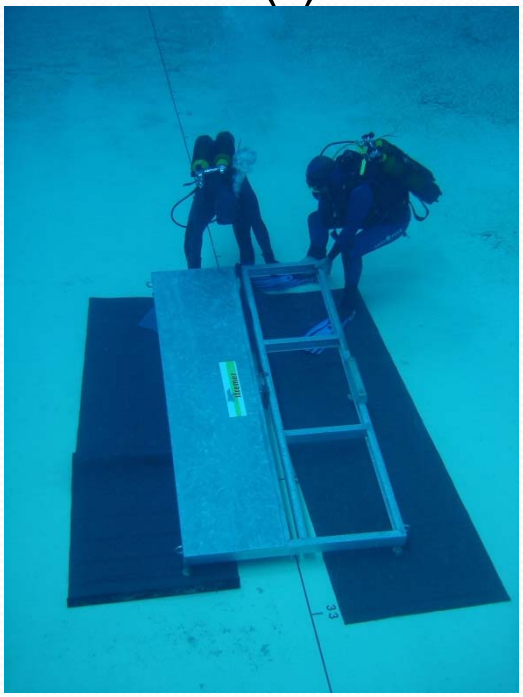
(**) "Use of Buoys to Reduce Static and Dynamic Tension in Deep Water Mooring Lines: A Pilot Study", Two –years project sponsored by the Hydrocarbon Division, Energy Directorate, EU, 1988-1990, in collaboration with Tecnomare SpA.

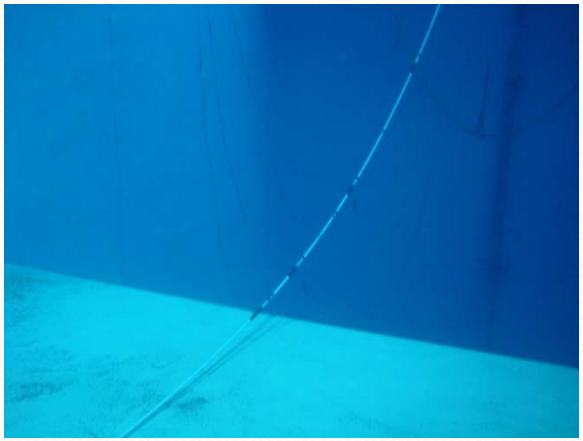
Representative Research achievements

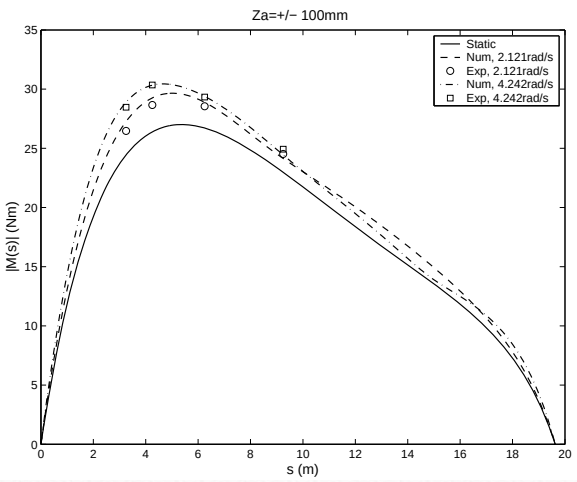
(Slender marine structures dynamic analysis – Risers' dynamics)

- Dynamic Response of Vertical and Catenary Shaped Riser-Type Slender marine structures (*)

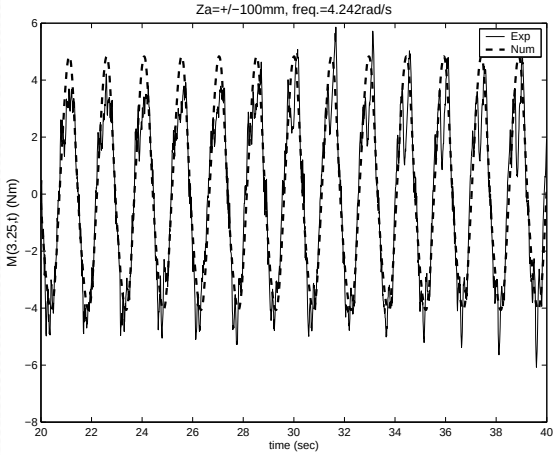








Numerical and Experimental results for:
(a) the variation of the bending moment along the riser (left)
(b) The top tensions (right)

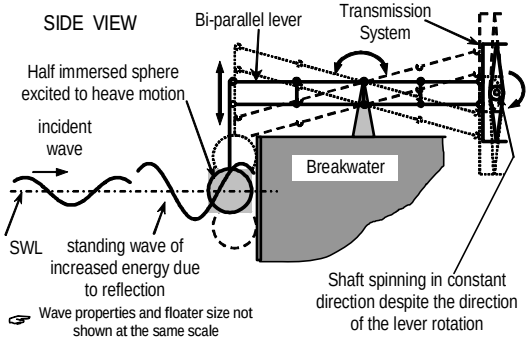


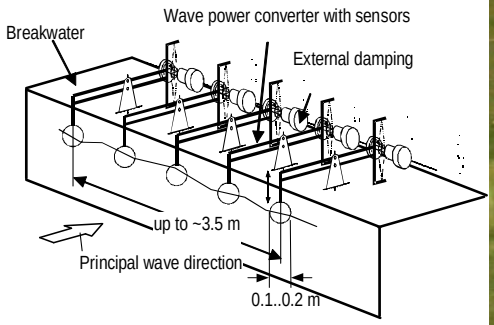
(*) EU project within the "Transnational Access to Research Infrastructures", METRI -2, carried out in the wave basin IFREMER, Brest, France, 2007 .

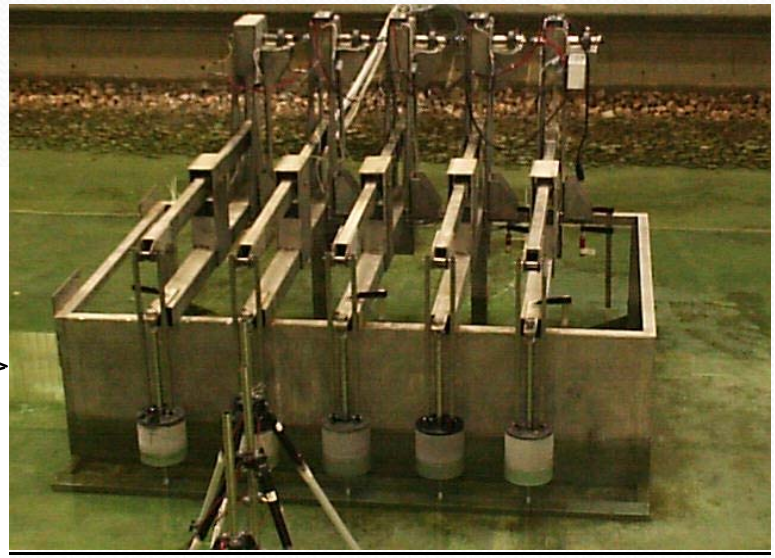
Representative Research achievements

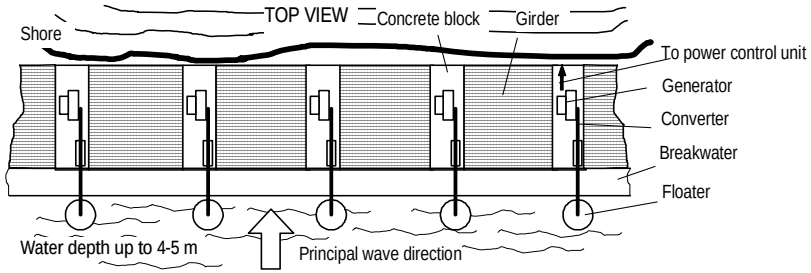
(Higher-order hydrodynamic analysis end efficiency evaluation of Wave Energy Converters – WEC's)

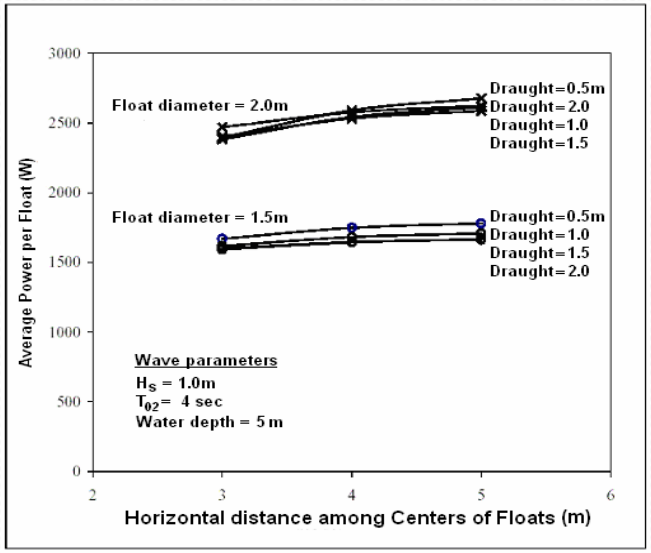
- Heaving Devices in Front of a Vertical Breakwater (*)











Experiments in the Laboratory for harbor works and numerical predictions

(*) LABBUOY: «Economically Efficient Floating Device for Wave Power Conversion into Electricity; Phase I: Mathematical and Physical Model Testing», Two-year (1/1/2002 – 31/12/2003), EU Project, sponsored by the Direction General for Energy

Representative Research achievements

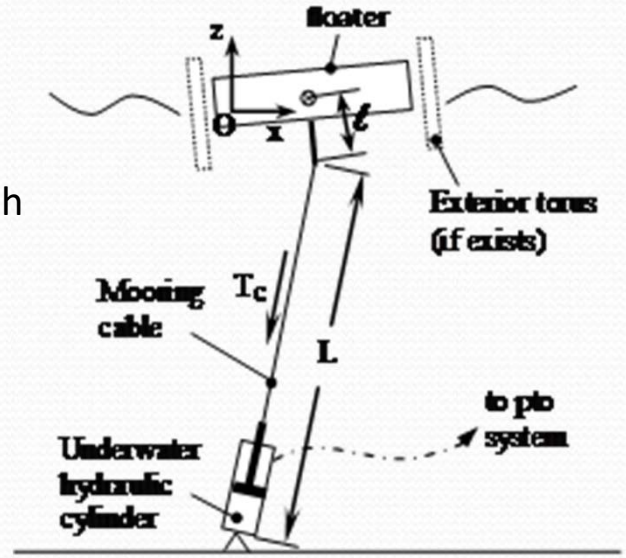
(Higher-order hydrodynamic analysis end efficiency evaluation of Wave Energy Converters – WEC's)

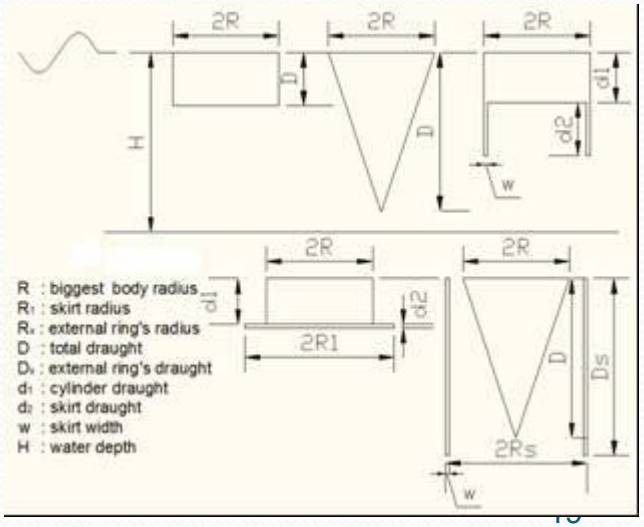
- Tightly Moored Point Absorbers

Table 1. Vertically moving floater, Linear PTO system Produced primary power [kW] – (efficiency %)		
2nd order forced not included	2nd order forced included	Increase [%]
10,6 (24%)	11,6 (26%)	9,4

Table 2. Freely moving floater, hydraulic PTO system Produced hydraulic power [kW] – (efficiency %)		
2nd order forced not included	2nd order forced included	Increase [%]
5,8 (13%)	6,4 (14%)	10,3

System Sketch (right) and floaters Geometries examined (down)





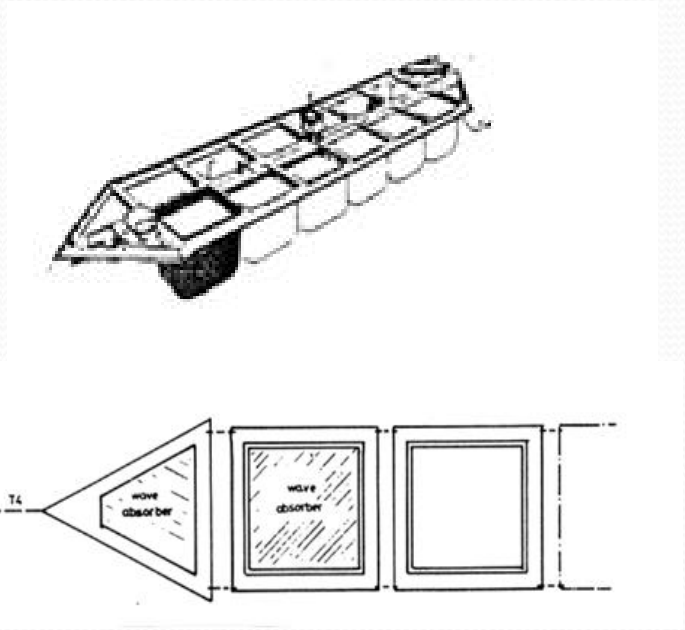
•REFERENCES

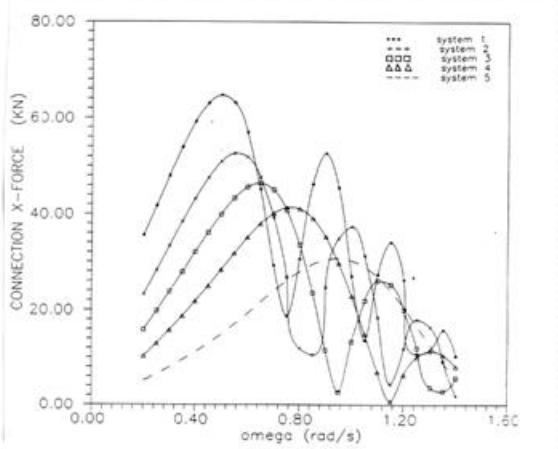
•Mavrakos, S.A., McIver, P. "Comparison of Methods for computing hydrodynamic characteristics of arrays of wave power devices", *Applied Ocean Research,* **19**, 1997, 283-291.

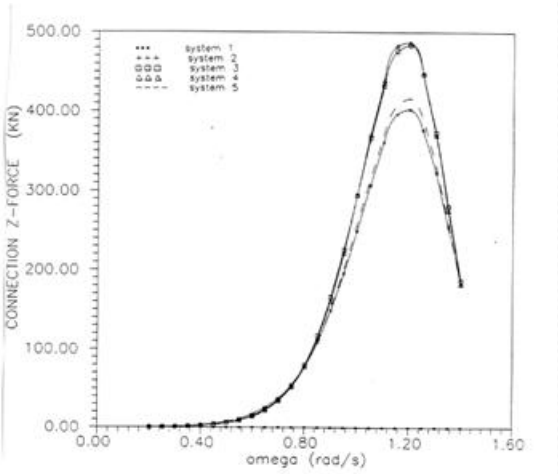
•Mavrakos, S.A., Katsaounis, G. "Parametric evaluation of the performance characteristics of tightly moored wave energy converters for several floaters' geometries", Proceedings, *8th European Wave and Tidal Energy Conference (EWTEC 2009)*, September 2009, Uppsala, Sweden.

Representative Research achievements
(Floating Structures Applications)

- Hydrodynamic analysis and design of fish farm cages for open sea applications (*)





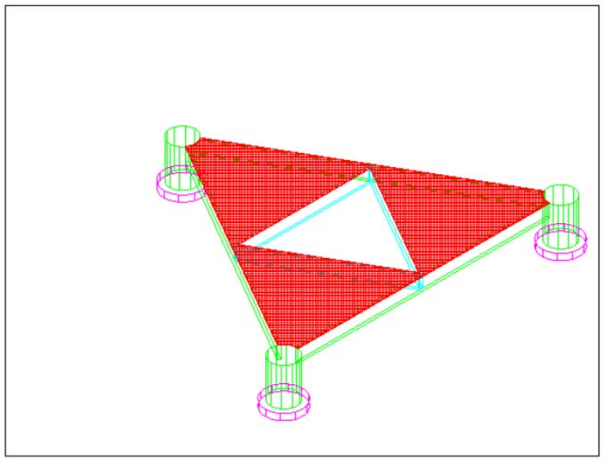


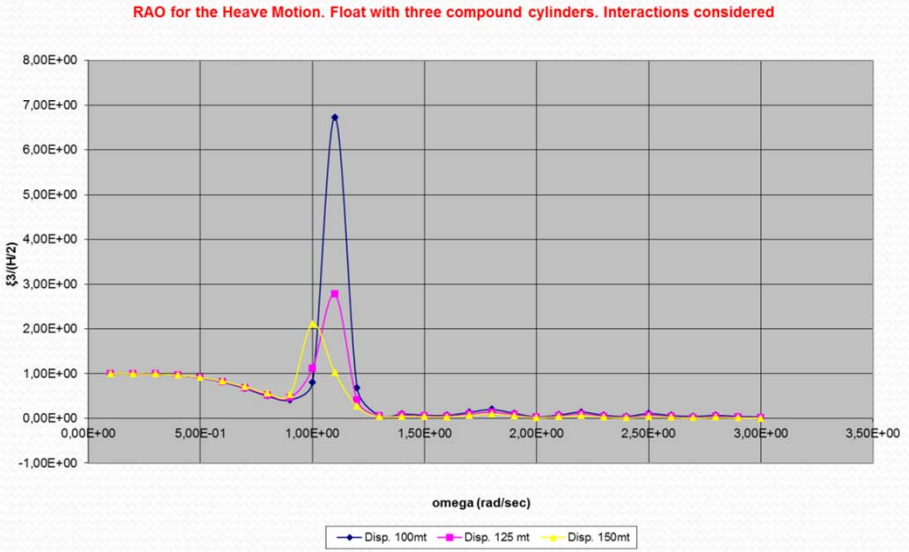
Sketch of the examined configuration (upper); Numerical results for the dynamic interconnection Loads in the horizontal and vertical directions (right upper and down, respectively)

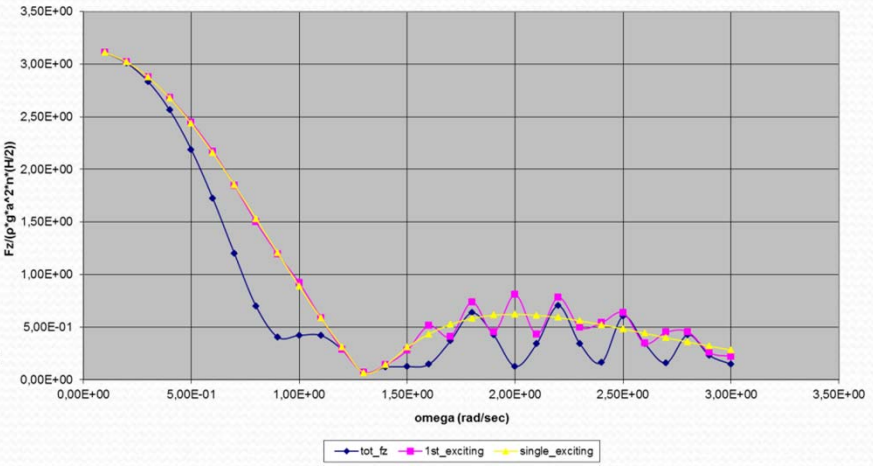
(*) Research Project sponsored by the Greek fishing farm company THALASSA S.A.

Representative Research achievements
(Floating Structures Applications)

- Hydrodynamic analysis and design of the NESTOR institute floating structure for Neutrino measurements (*)







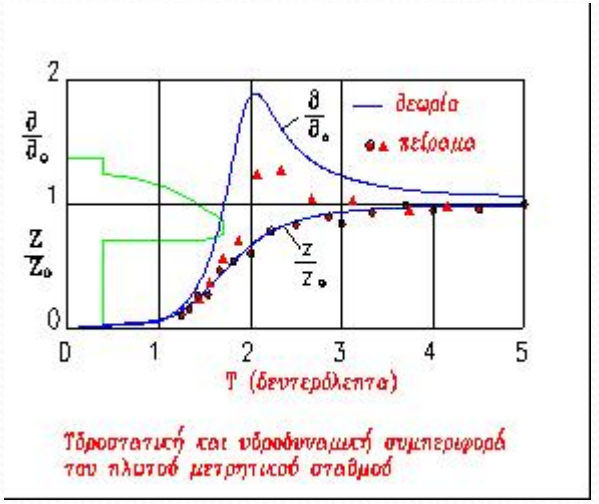
Sketch of the examined configuration (upper); Numerical results for the heave motion (right upper) and the heave exciting force (right down)

(*) Research Project sponsored by the NESTOR Institute, Greece

Representative Research achievements
(Analysis and design of oceanographic buoys)

- Analysis of the Oceanographic Buoy MEDOUSA

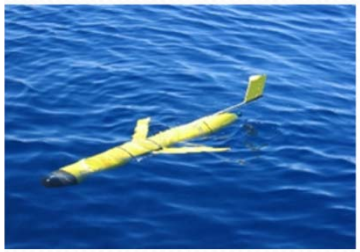
Experiments at the Laboratory of Naval and Marine Hydrodynamics (down); Physical model (upper right); Heave response (down right)

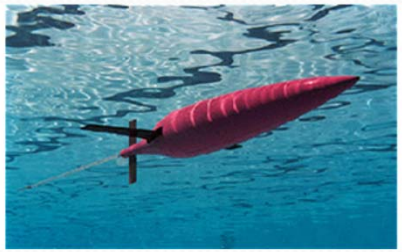


Τδροστατική και υδροδυναμική συμπεριφορά του πλωτού μετρητικού σταθμού

Representative research achievements

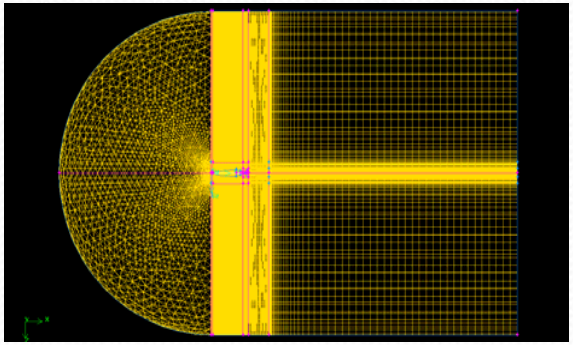
- Design of underwater oceanographic glider (*)



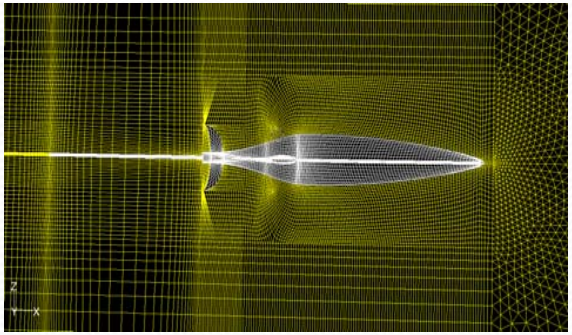


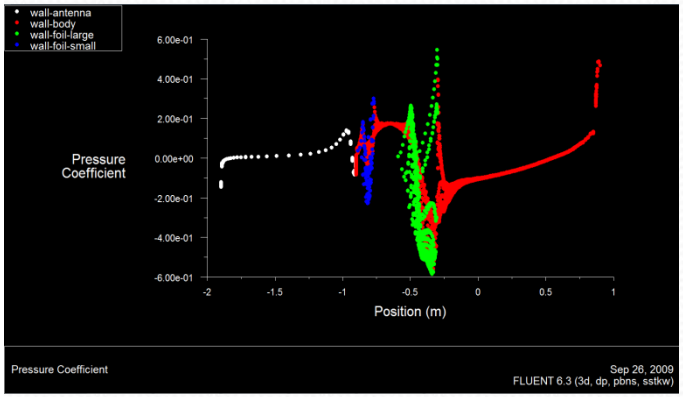
Slocum, Seaglider, Spray

(*) Design of autonomous underwater vehicle advancing though buoyancy control for oceanographic applications, Gen. Secretariat for Research and Technology, PENED 2003, Three-years doctorate program

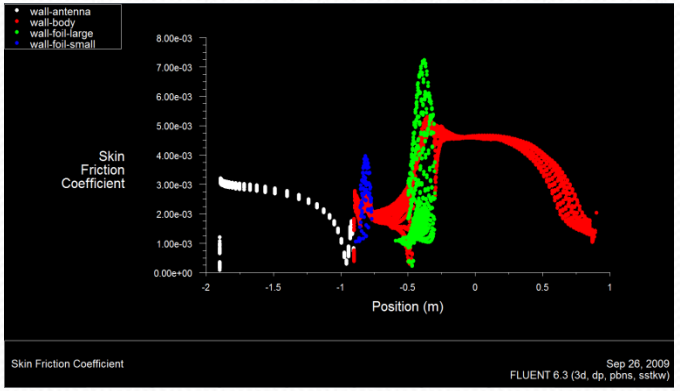


Discretization of the flow field



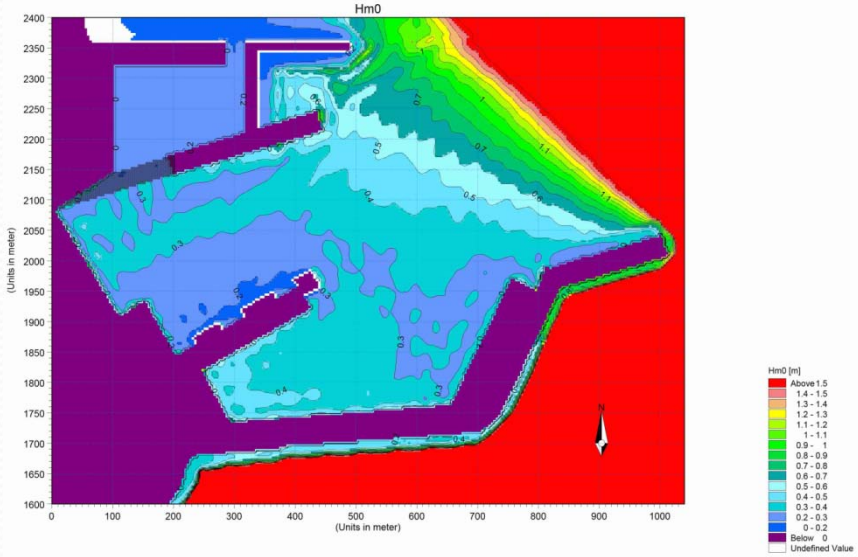


Drag and pressure drop resistance

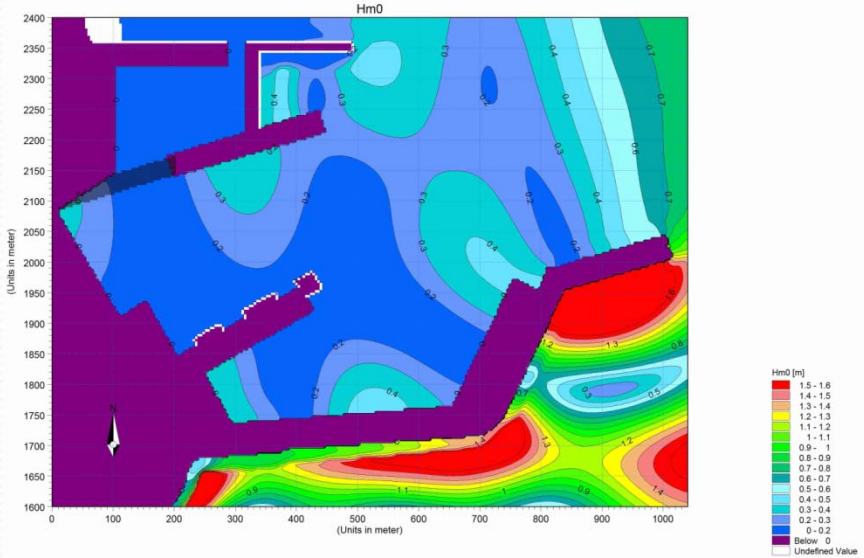


Representative Research achievements
(Wave Propagation in harbors) (*)

- Wave Propagation Analysis into the Katakolo Harbour, Prefecture of Ilia, Greece



South –east wave incidence. Hs=4m, Tp=8 sec. γ=3.1582



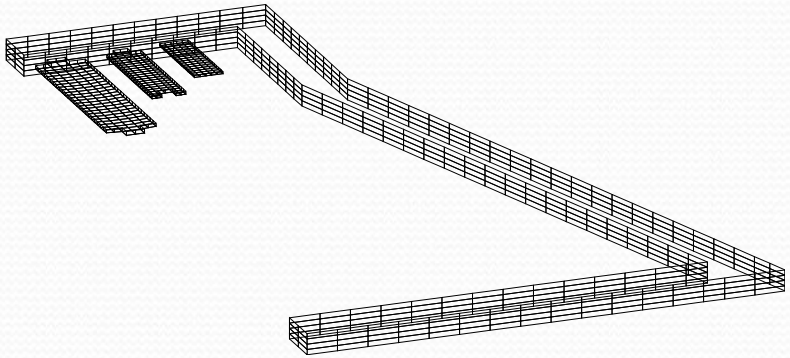
South wave incidence. Swell case. Monochromatic incidence waves, H=0.5m, T=55 sec.

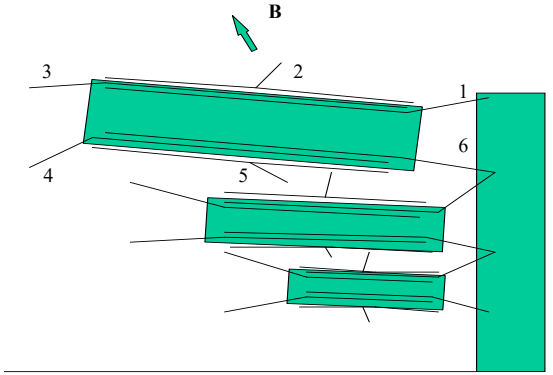
(*) «Wave propagation and motion response analysis of large Cruiser ships berthed in the new Katakolo Harbor, Project sponsored by the Prefecture of Ilia, Greece, June, 2007.

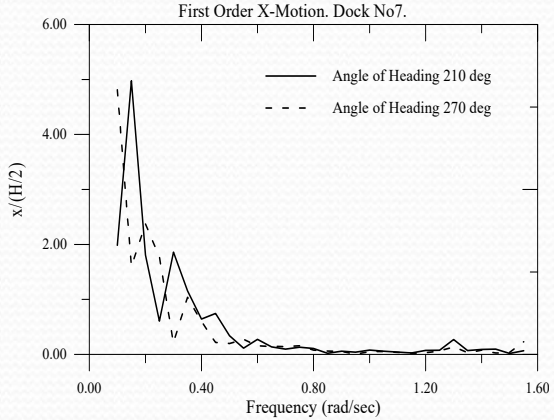
Representative Research achievements

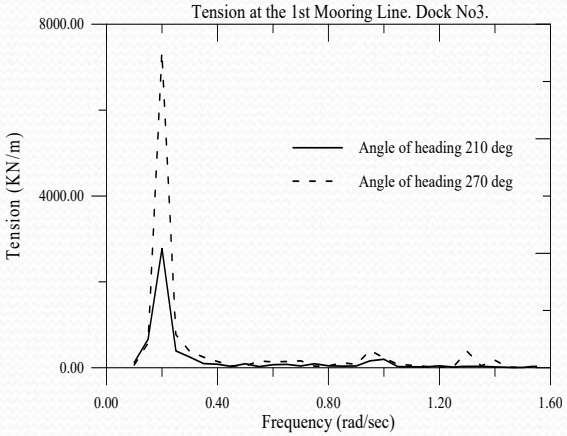
Motions of ships and floating structures in harbors)

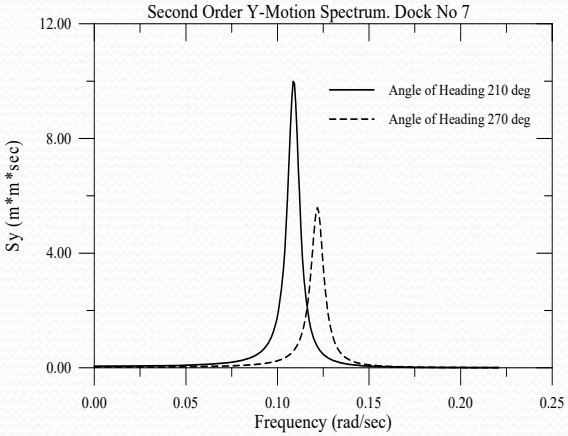
- Mooring and Motion Response Analysis of three Floating Docks for the Greek Navy in Souda Bay, Crete (*)







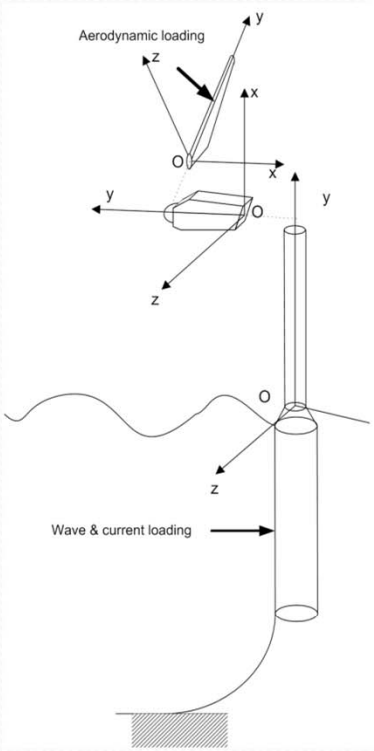


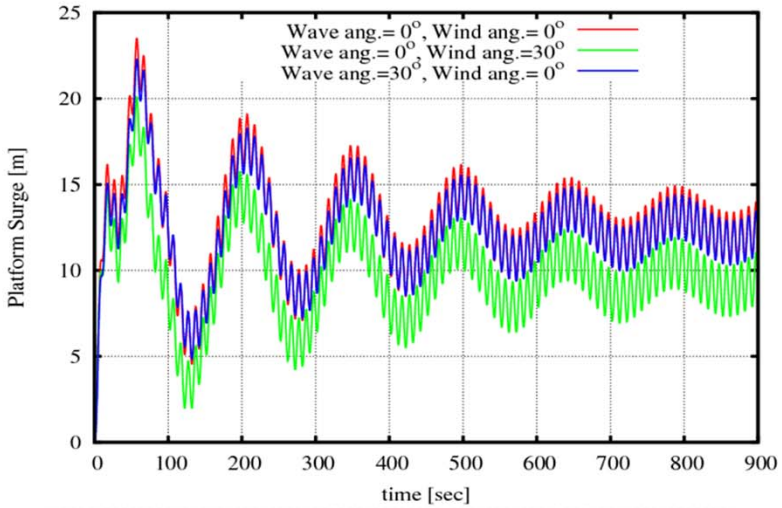


(*) Research Project sponsored by the Greek Navy, 1995

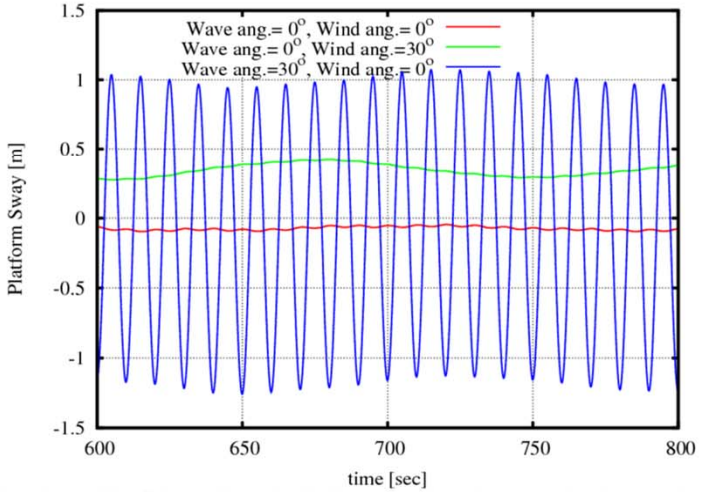
Representative Research Achievements

Validation of tools for the coupled analysis of floating Wind Turbines (W/T) (*)





Literature: ADVANCED HYDRO-AERO-ELASTIC MODELING OF FLOATING WIND TURBINES
Dimitrios Manolas[1], Giorgos Katsaounis,
Vasilis Riziotis, Spyros Mavrakos, Spyros Voutsinas

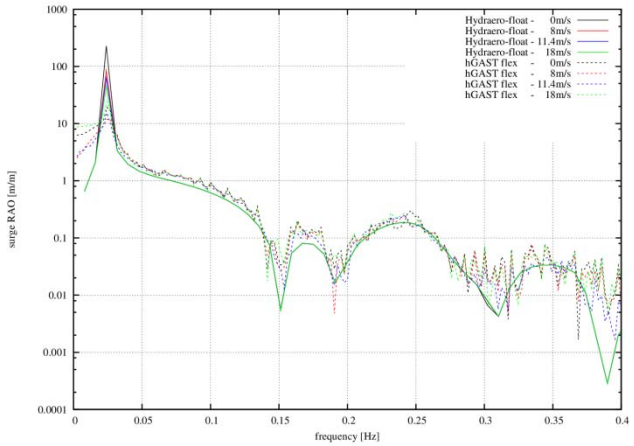


(*) *"Dynamic response of floating offshore wind turbines under random waves and wind action", Completed EU program within the 7th FP: "Integrated Infrastructure Initiative HYDRALAB IV: Assess to major experimental facilities", Experimental campaign in DHI Wave Basin, Copenhagen, Denmark, 1 - 31 October 2012.*

Research in Offshore Wind Energy

"Setting-up of a National Program for the exploitation of the offshore wind energy sources in the Aegean Sea for an up to 5Mw Wind Turbine", *Three – year program (2011- 2014), Supported by the Greek General Secretariat for Research and Technology, SYNERGASIA 2009*

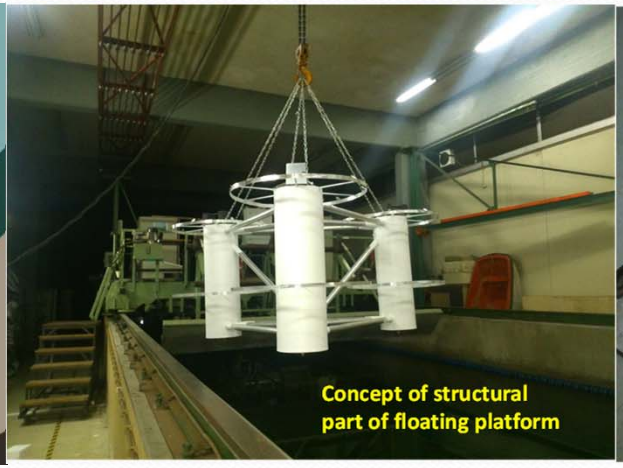
Partners: Center for Renewable Energy Sources (CRES), National Technical University of Athens, National Center for Marine Research (NCMR), ELICA A., ΕΝΤΕΚΑ ΑΕ, EXERGIA AE, Χ. ΡΟΚΑΣ ΑΒΕΕ, TERNA ΕΝΕΡΓΕΙΑΚΗ ΑΒΕΤΕ, JASPER ΑΙΟΛΙΚΗ ΕΛΛΑΔΟΣ ΑΕ,

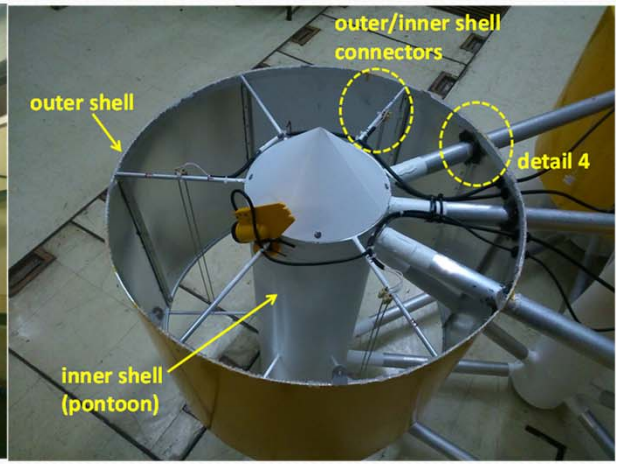


Surge motion for wave heading 30 degrees.

Research in Offshore Wind and Wave Energy combined exploitation

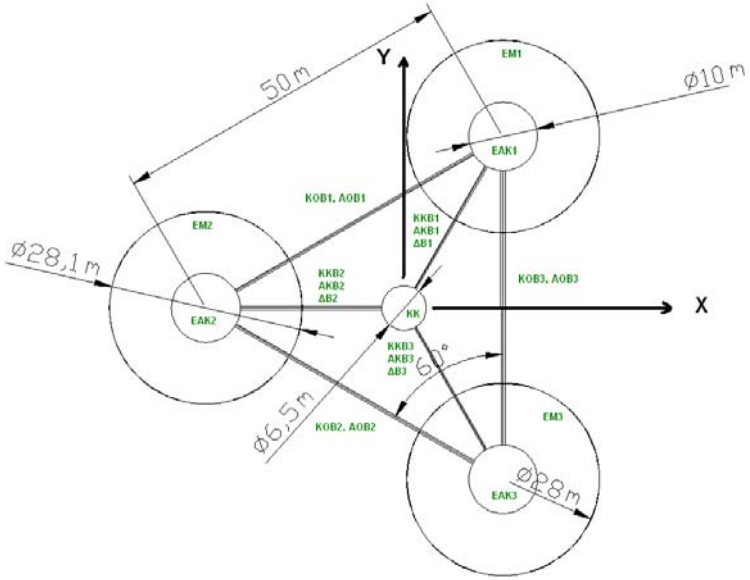
"POSEIDON: Multi-purpose floating structures for offshore wind and wave energy sources exploitation for an up to 5 MW W/T", *Three – years Program (2013- 2015), Sponsored by the Greek General Secretariat for research and Technology, Program: ARISTEIA 2011*



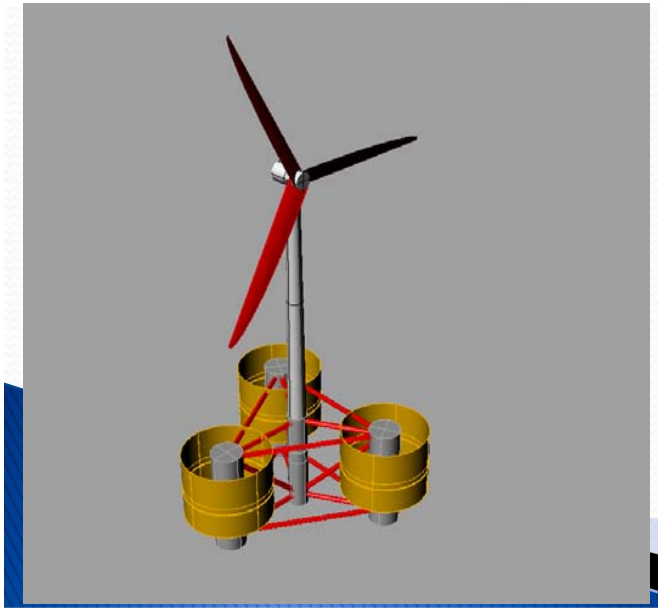


Research in Offshore Wind and Wave Energy

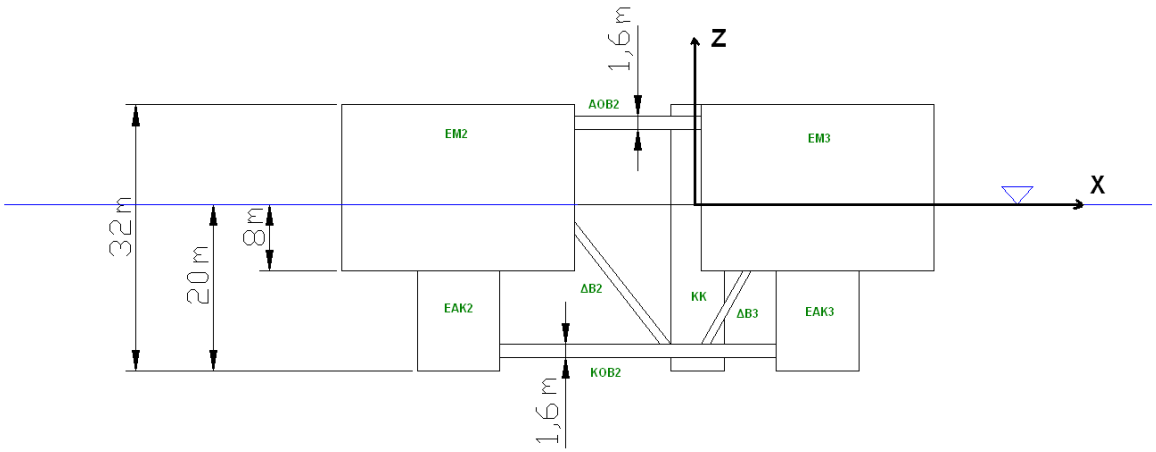
Top view of floating structure



Platform Mass (including ballast)	2.1836x10^{6}kg
Displacement	6086.3t
KG (below SWL)	4.05m
Platform roll inertia	1.5x10^{9}kgm^2
Platform pitch inertia	1.5x10^{9}kgm^2
Platform yaw inertia	2.7x10^{9}kgm^2



Side view of floating structure



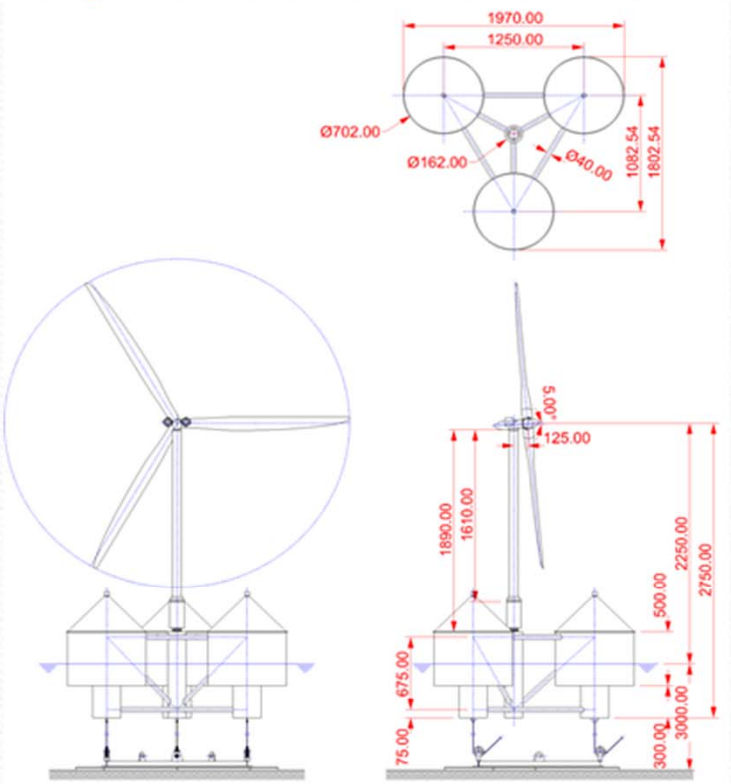
Research in Offshore Wind and Wave Energy combined exploitation

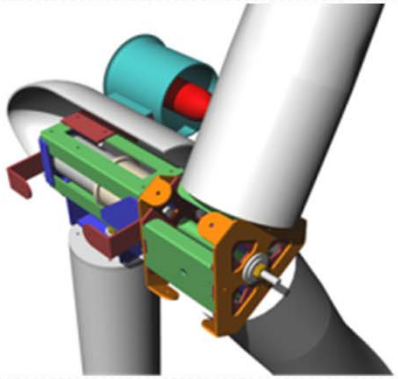
"REFOS: Life – Cycle Assessment of a Renewable Energy Multi – Purpose Floating Offshore System for an up to 10 MW Wind Turbine", Research Fund for Coal and Steel Call: RFCS-2015, EU Fund.

Partners:

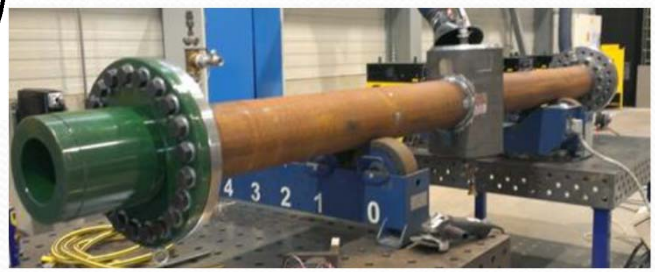
- NTUA – LFSMS, Leader, Greece (NTUA LABS: LA, LSMH, LHYT, FEL)
- Univesrity of Thessaly, Greece
- CSM, Italy
- EUROPIPE, Germany
- IDESA, Spain
- ELTECH-ANEMOS, Greece

Duration: 01/07/2016 – 31/12/2019





Research in Offshore Wind Energy



- "JABACO: Development of Modular Steel Jacket for Offshore Windfarms", Research Fund for Coal and Steel, Call: RFCS-2014, EU Fund.

- Partners:
- CSM, Italy, Leader
- NTUA (LFSMS, LA), Greece
- Univesrity of Thessaly, Greece
- IDESA, Spain
- RAMBOLL, Germany
- OCAS, Belgium
- Duration: 01/07/2015 – 31/12/2018