Project Title: Hydroelastic response of large floating structures and arbitrarily shaped bodies in an environment of varying 3D bathymetry.
Acronym: HydELFS
Duration: 33 months
Primary Field of Study: 11.5.23 COASTAL, PORT AND OFFSHORE ENGINEERING
Secondary Field of Study: 11.20.4 SHIP BUILDING
Starting Date: 03-01-2011

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He received his Diploma in Mechanical Engineering (1989), and his Ph.D. in Engineering (Fluid Mechanics, 1998), both from the University of Patras (UoP). From 1999 to 2002 he worked as a technology transfer consultant at the TT/liaison office of FORTH and then he joined FORTH Photonics (a VC funded FORTH spin-off) as a project manager (mediated the investment and managed a total portfolio 3,3M€). In parallel, he was a post doctoral research collaborator at FORTH (part time). He has 29 publications in international scientific journals and conferences. His research interests include fluid mechanics and in particular physics & modelling of two-phase flow in porous media (Ph.D.), homogenization techniques, continuum mechanics, wave propagation and mechanics of composite materials (post graduate research). He is also active in exploitation of research results and technology transfer. He has ample teaching experience in Hydraulics, Irrigation Mechanics, Construction Equipment Management, Technology Transfer (at TEI Athens) and Technical Project Management (post graduate level, Hellenic Open University) and he supervises the CIE Hydraulics Laboratory.

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CV available from: **http://users.teiath.gr/fkokkinos/Archimedes/CV_Katsardi_V.pdf**

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Outline the institute and its research interests (150 words max), including 5 recent (within the last 5 years) publications with active links

The present proposal is submitted by the Dept. of Civil and Infrastructure Engineering in collaboration with the Dept. of Naval Architecture of TEI of Athens. The former aims to equip students with knowledge for solving various civil engineering problems with emphasis on infrastructures, while the mission of the latter is to promote the curriculum development in shipbuilding science and technology.

The facilities of the Departments include Computer Lab rooms for support of Computer Programming, CAD and CASD and a small-scale tank, equipped with a wavemaker capable of controlling the depth of the water (from deep to shallow water) for hydrostatic and hydrodynamic model tests of ships and offshore structures. Research in the Departments is supported by a DELL computer cluster, with 1+8 (front end + computer) nodes, each with 2 Xeon CPUs @ 12Gb memory, connected through 10GBit network, with storage capacity 4Tb.

Civil: **http://www.teiath.gr/stef/civil/**

Naval: **http://www.na.teiath.gr/english.html**

Publications with active links

Belibassakis, K.A., Athanassoulis, G.A., 2005, A coupled-mode model for the hydroelastic analysis of large floating bodies over variable bathymetry regions, *Journal of Fluid Mechanics*, Vol. 531, pp. 221-249.

Active link: **http://users.teiath.gr/fkokkinos/Archimedes/2005_JFM_hydroel.pdf**

Belibassakis, K.A., Athanassoulis, G.A., 2006, A coupled-mode technique for weakly non-linear wave interaction with large floating structures lying over variable bathymetry regions, *Applied Ocean Research*, Vol.28, pp. 59-76.

Active link: **http://users.teiath.gr/fkokkinos/Archimedes/2006_AOR2006_hydroel.pdf**

Gerostathis, T., Belibassakis, K.A., Athanassoulis, G.A., 2008, A coupled-mode model for the transformation of wave spectrum over steep 3D topography. A Parallel-Architecture Implementation, *Journal of Offshore Mechanics and Arctic Engineering, JOMAE*, Vol.130

Active link: **http://users.teiath.gr/fkokkinos/Archimedes/2008_JOMAE_wave3D.pdf**

Kokkinos, F.T., 2010, A layer-wise Analog Equation modelling of thick plates, *Recent Developments in Boundary Element Methods*, ed. E.J. Sapountzakis, WITPress, Computational Mechanics Publications, Southampton, pp. 103–118.

Active link:

http://users.teiath.gr/fkokkinos/Archimedes/2010_ChapterBEM_Layer-wise_AEM_Thick_Plates.pdf

Athanassoulis, G.A., Belibassakis, K.A., 2009, A novel coupled-mode theory with application to hydroelastic analysis of thick, non-uniform floating bodies over general bathymetry, *Journal of Engineering for the Maritime Environment,* Vol.223, pp. 419-437.

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Belibassakis, K.A., 2008, A boundary element method for the hydrodynamic analysis of floating bodies in general bathymetry regions, *Engineering Analysis with Boundary Elements,* 32 (2008), pp. 796-810.

Active link:
http://users.teiath.gr/fkokkinos/Archimedes/2008_EABE_wav_structure.pdf

Katsardi,V., Swan, C., 2010, On the Description of Large Shallow Water Waves. Part I: Uni-Directional Seas, *Royal Society, Series A*.

Active link:
http://users.teiath.gr/fkokkinos/Archimedes/2010_RSPA_nonlin_waveUD.pdf

Abstract *(To be organized as: Background, aim, workpackages, expected results)* (300 words max)

Background: The interaction between sea waves and very large floating elastic structures and bodies is an interesting problem, finding important applications in designing large offshore floating structures (production/extraction and storage/offload stations) and in the coastal zone (as floating airports, floating facilities for accommodation/entertainment, floating bridges, marinas, breakwaters etc.). In the same category belongs the interaction of waves with thin sheets of sea ice, a problem having very important environmental impact in polar areas. Describing such problems becomes more complicated in fields of general 3D bathymetry (near-shore areas), where wave diffraction, refraction, shoaling phenomena take place along with non-linearity and dispersion effects.

Aim: The main object of this project is the development of innovative design tools by introducing new nonlinear hydroelastic-hydrodynamic mathematical models for the calculation of the wave-structure and wave-ice interaction, in general bathymetry regions.

Workpackages:

1. Development/optimisation of models and numerical techniques for wave propagation over coastal and marine areas of varying 3D bathymetry.

2. Hydroelastic analysis of large floating bodies in a general ocean/coastal fields, modelled within the context of the thin-elastic-plate theory.

3. Development of an improved theory for plates of finite thickness in vacuo, including shear stress effects, variable thickness and multiple layers.

4. Development of a novel coupled-mode model for the hydroelastic responses using the improved plate theory. Applications in floating and submerged, long bodies, under the impact of the local wavefield.

5. Application of the finite element method for the examination of local phenomena. Global-local model conjugation including coupled-mode types.

6. Evaluation and assessment of results – publicity actions.

Expected results: Key objective of the proposed project is the development and improvement of computational tools that permit the resolution

of technical problems by the simulation/prediction of the interactions of waves with large floating structures, as well as with sea-ice contributing to global environmental risk assessment.

Project concept and objective(s) ***(Describe the state of the art, methodology, research plan, work packages and research milestones.)*** **(2000 words max)**

The interaction of free-surface gravity waves with floating deformable bodies is a very interesting problem which finds significant applications in very large floating structures (VLFS, megafloats), operating offshore (**power stations/mining** and storage/transfer) and in coastal areas (**floating airports**, residence/entertainment facilities, **floating bridges**, **marinas**, breakwaters etc.). For all the above problems, hydroelastic effects are significant and should be properly taken into account. Extended surveys have been presented by Kashiwagi (2000), Watanabe et al. (2004). In addition, the effect of water waves on floating deformable bodies is related to environmental issues finding important applications. A specific example concerns the interaction of waves with thin sheets of sea ice, which is particularly important in the Marginal Ice Zone (MIZ) in the Antarctic, a region consisting of loose or packed ice floes situated between the ocean and the shore sea ice. As the ice sheets support flexural–gravity waves, the energy carried by the ocean waves is capable of propagating far into the MIZ, contributing to breaking and melting of ice glaciers (Squire 2007, 2008) and accelerating global warming effects and rise in sea water level.

The rapid growth of population in urban development areas with tight housing space available, as well as in countries with a large number of islands (or with vast coastline), town planners and engineers use the reclamation of land from the sea, in order to relieve congested cities. Creating areas of land in the sea by filling is applicable only when the water is shallow (less than 20 meters), otherwise it is too expensive both economically and environmentally. Faced with these physical limitations and environmental effects, very large floating structures offer an alternative to creating a solid ground for operation.

The term mega-float or Very Large Floating Structures is used to describe a system that includes a floating structure, the docking and the access system. Unlike vessels, VLFS having very large surfaces are not likely to tumble and they are developed by linking a number of floating construction units. Therefore, in the case of mega-floats, excessive horizontal dimensions, compared to the typical field wavelengths, lead to the elastic displacement across the body, thus the potential of modeling the structure as a thin floating elastic plate. The structure's dynamic deflection is characterised primarily by the vertical elastic displacement, caused by the surface waves, which also propagate from one structure edge to the other, and influences loads and motions which should be taken into account in the design and construction of the mega-float in order to ensure its proper functioning. It also provides basic information for further local dynamic analysis, study of the floating structure's strength and material fatigue, so that long term use of mega-floats will be guaranteed.

In the near-shore area, **elastic wave-structure interactions** are also affected by the seabed. Indeed, surface gravity waves that propagate in relatively shallow regions feel the bed and are subject to shoaling, refraction and diffraction phenomena, whose description becomes more difficult as the bottom topography becomes more complex. These wave transformations have immediate effect to the wave-structure interaction. In addition, there are side-effects associated with the development and/or transformation of local currents in the coastal zone around the structure which change the distribution of oxygen in the water column; the latter sometimes affecting significantly the marine biology of the region having serious environmental effects. All of the above make the specific hydroelastic problems of **wave-bed-structure interaction** even more complex, and strengthen the interest in the development of methodologies for better prediction of their effects.

The examined hydroelastic problem, after linearization, is effectively treated in the frequency domain and many methods have been developed for its solution (e.g., the review in Belibassakis & Athanassoulis, 2005). In the case of an ice sheet of varying thickness, floating on water of varying depth, Porter & Porter (2004) derived a simplified model using a variational principle and invoking the mild-slope approximation with respect of the ice thickness and water depth variations. Numerical methods for predicting the linearized hydroelastic responses of VLFS in variable bathymetry regions have been also developed, based on BEM (Utsunomiya *et al.* 2001, Wang & Meylan 2002), on FEM (Kyoung et al. 2005), on eigenfunction expansions in conjunction with step-like bottom approximation (Murai et al. 2003). In the case of the hydroelastic behaviour of large floating bodies over general bathymetry, modelled as thin homogeneous plates, a coupled-mode system has been derived and examined by the authors (Belibassakis & Athanassoulis 2005, 2006). This method is based on a local vertical expansion of the wave potential in terms of hydroelastic eigenmodes, extending previous similar approach for the propagation of water waves in variable bathymetry regions (Athanassoulis & Belibassakis 1999, Belibassakis *et al.* 2001). A similar approach based on multi-mode expansion has been presented by Bennets et al. (2007), with application to wave scattering by ice sheets of varying thickness.

The key objective of the proposed project is the development and improvement of computational tools permitting the simulation of the hydrodynamic-hydroelastic interaction of sea waves with large floating structures with general characteristics in areas of general 3D bathymetry, in order to assist both in the further development of such floating structures (as explained in more detail below), and in the prediction of ice detachment processes and the boundary between sea and ice.

WORKPACKAGES AND METHODOLOGY

WP1. Development and optimisation of specific models and numerical techniques for the description of wave propagation over coastal and marine areas of varying 3D bathymetry.

Development/optimization of a reliable wave model, which satisfactorily describes surface water waves propagating from offshore to coastal areas; these include calculations throughout the wavefield from the bed up to the free surface, without the presence of structures. This will provide the basis for formulating and solving the hydroelastic problem including the effect of the VLFS.

Activities:

WP1.A1. Development/optimization of a coupled-mode model, capable of describing the entire wavefield in detail, without the presence of structures, over varying general 3D bathymetry.

WP1.A2. Numerical solution of the wave problem, based on the above model, for periodic waves, in various selected conditions and wavefields (wave frequencies, bathymetry).

WP1.A3. Comparisons with simpler models (Boussinesq type); model evaluation in variable bathymetry regions. Comparisons with field measurements, model calibration.

WP2. Hydroelastic analysis of VFLS in general ocean/coastal fields within the context of water-wave and thin-elastic-plate theory.

Development of a continuous, nonlinear, coupled-mode technique; application to the hydroelastic analysis of VFLS of shallow draft over a general bottom topography, based on the coupled-mode model developed by WP1, for waves propagating in variable bathymetry regions. Under the assumption of small deflections and neglecting the rotation of plate section, the shallow-draft platform will be modeled as a thin floating plate, using linear elastic plate theory. This model will be the basis for comparisons for more sophisticated models that are going to be developed in the following WPs.

Activities:

WP2.A1. Theoretical expression of the combined hydrodynamic-hydroelastic problem in general bathymetry wavefields, in the context of thin-elastic-plate theory with general characteristics of mass and stiffness.

WP2.A2. Development and numerical solution of the above problem with an extension of the coupled-mode model of WP1.

WP2.A3. Comparisons with simpler models that correspond to simplified environments, such as constant water depth, and evaluation of the presented model in variable bathymetry regions.

WP3. Development of improved theory (in vacuo) of finite thickness plates, accounting for shear stress effects, variable thickness and multiple layers.

Development of a new model for shear deformable plates (or beams), derived by an enhanced representation of the elastic displacement field. The present model contains additional elastic vertical modes, permitting the shear strain and stress to vanish on both the upper and lower boundaries of the thick floating plate. This model will extend third-order plate theories by Reddy (1984) and Bickford (1982) (see Wang, Reddy & Lee 2000) to plates and beams of arbitrary shape and thickness (Kokkinos 1995, 2010).

Activities:

WP3.A1. Development of the above new model.

WP3.A2. Equivalent reformulation in the form of coupled system of differential equation with respect to the amplitude of the elastic modes.

WP3.A3. Numerical results. Examination of various test cases and comparison with simpler models based on thin elastic plate theory.

WP4. Development and application of a novel coupled-mode model for the VLFS responses using an improved plate theory. Applications to floating and submerged long bodies under the impact of the local wavefield.

Conjunction between the coupled-mode model of WP1 with the floating elastic body in a marine/coastal region (characterized by general bathymetry), modeled on the context of improved elastic-plate theory of finite thickness, arbitrary boundary, with internal discontinuities, multiple layers and general characteristics of mass and stiffness (per unit of surface area) produced in WP3.

Activities:

WP4.A1. Theoretical expression of the combined hydrodynamic-hydroelastic problem, in wavefields of general bathymetry, in the context of the improved theory of shear deformable elastic plates of finite thickness, with general characteristics of mass and stiffness.

WP4.A2. Development and numerical solution of the above problem by extending the coupled-mode model of WP2.

WP4.A3. Comparisons with the simpler model described in WP2 and evaluation of the presented model in variable bathymetry regions. Comparisons with experimental data and demonstration of the dominance of the novel model of this workpackage.

WP5. Application of hybrid finite-boundary element method for the examination of local phenomena. Global-local model conjugation including coupled-mode types.

Development and evaluation of new computational structural models for floating structures, based on FEM (e.g., Hughes 2000, Fung & Tong 2001) and BEM (Kokkinos, 2010). Simulation algorithms for the prediction of the sea-elastic plate and sea-ice local interaction phenomena.

Activities:

WP5.A1. Development of numerical techniques (hybrid BEM-FEM models) for the evaluation of the local dynamic behaviour and assessment of strength for critical structural components of VLFS.

WP5.A2. Numerical results for the local models (stresses, strains, stress intensity factors, etc.) and comparison to experimental results and data in the literature.

WP6. Evaluation and assessment of results – publicity actions.

Activities:

WP6.A1. Evaluation of results

The assessment of the proposed project will be carried out on a regular basis with the cooperation of all members of the research team and external partners. Core activity in the last WP is the viability study and the possibility of extending the cooperation beyond the end of the proposed project. Also, the coordinator of the project will prepare the progress report where annual reviews, as well as the data on output indicators, will be recorded. Two months prior to the formal completion of the project the Main Research Team (MRT) will produce an internal evaluation report, which will be targeted both on the positive results of the overall project and possible weaknesses and problems encountered during the implementation of the project.

WP6.A2. Publicity actions

Production of information material associated with the objects of the proposed research project. Development of a relevant webpage providing information on the progress and results of the project, relevant technical reports and published papers.

WP6.A3. Seminar organization

Two specialised seminars are proposed: The first meeting, which will last a week and the main speaker will be Professor J.N. Reddy, focuses on variational principles and the mathematical foundation of the finite element method, with applications to engineering, especially in terms of dynamic analysis of elastic/composite plates, in a general context, but also in relation to the objective of the proposed project. It should be noted that Prof. J.N. Reddy is a world famous expert in the above issues (over 400 journal papers and 10,000 citations), with wide research activity and a rich publication list (16 books) over the last forty years and his participation in this project is considered a great honor by our research group. The second one-week seminar, will have main speaker the Prof. G. Athanassoulis, who will focus on issues of maritime hydrodynamics and hydroelastic analysis of floating structures. Also, participation in the project of qualified researchers from NTUA and the Institute of Oceanography (part of the Hellenic Centre for Marine Research), will demonstrate the interest and applicability of the work in the production of marine technology and the protection of the coastal area.

Progress beyond the state of the art *(Describe the new findings in the area, that are anticipated after the successful completion of the study, not reported previously)* (350 words max)

As already mentioned, the main objective of the project is the development of innovative and powerful computational tools that simulate the hydrodynamic-hydroelastic wave-structure interactions for large floating elastic bodies on seas of general characteristics in offshore and near-shore areas. The described problem becomes even more complicated within environments of varying 3D topography. Indeed, in near shore areas phenomena as refraction, diffraction and shoaling make the wave-structure interaction problem considerably difficult. This project will deal with these issues by developing innovative nonlinear mathematical models to describe wave propagation over varying general bathymetry including the wave interaction with large floating structures; the latter not being dealt before. This will allow the development of new technological processes in the design and the production of such structures, including the study of the impact on the coastal zone, as well as the wave-ice interaction, which is a major environmental problem particularly in the polar regions with global implications.

The usual approach treats the presented hydroelastic problem in the context of thin plate theory for the deflection of the large floating body and calculation of induced motion and loads. The development of a new model for shear deformable plates (or beams) of finite and variable thickness consisting even of multiple layers, derived by an enhanced representation of the elastic displacement field, is an important result for beam/plate vibration in vacuo. The computational model will combine through energy variational principles the advantages of the finite and boundary element methods and it will incorporate a mesh reduction approach through the Analog Equation Method. Furthermore, the coupling of the above enhanced model with water wave hydrodynamics in general bathymetry regions will permit better simulation of the physics of a very complicated problem and will significantly extend its applicability.

Finally, the global model will be coupled with local 3D FEM-BEM models accounting for structural details of the floating body. These will permit the evaluation of the local dynamic behaviour and the assessment of the strength for critical structural components ensuring long term use of mega-floats and, in the case of wave-ice interaction, will support further studies concerning global environmental effects.

Management structure and procedures ***(Summarize the managerial structure of each workpackage (allocation of work per laboratory) and the procedures to achieve the deliverables)*** **(350 words max)**

WP1. Development and optimization of specific models and numerical techniques for the description of wave propagation over coastal/marine areas of varying 3D bathymetry.

WP1.A1. Development/optimization of a coupled-mode model.

WP1.A2. Numerical solution in various selected wavefields.

WP1.A3. Comparisons with simpler models, field measurements and evaluation.

Research team: Belibassakis, Kokkinos, Athanassoulis, Gerostathis, Valavanides, Sybetheros, Katsardi, Soukissian

Period: months 1-21

WP2. Hydroelastic analysis of VFLS in general ocean/coastal fields within the context of water-wave and thin-elastic-plate theory.

WP2.A1. Theoretical expression of the problem using thin-elastic-plate theory with general characteristics of mass and stiffness.

WP1.A4. Numerical solution in various selected wavefields.

WP2.A1. Comparisons with simpler models and evaluation.

Research team: Belibassakis, Kokkinos, Athanassoulis, Gerostathis, Valavanides, Katsardi, Georgiou

Period: months 4-21

WP3. Development of improved theory (in vacuo) of finite thickness plates, accounting for shear stress effects, variable thickness and multiple layers.

WP3.A1. New model for shear deformable plates of finite thickness.

WP3.A2. Derivation of coupled system of differential equation with respect to the amplitude of the elastic modes.

WP3.A3. Numerical results and comparison with models using thin-elastic-plate theory.

Research team: Kokkinos, Reddy, Belibassakis, Athanassoulis, Gerostahthis

Period: months 4-27

WP4. Development and application of a novel coupled-mode model for the VLFS responses using an improved plate theory. Application to floating and submerged, long bodies, under the impact of the local wavefield.

WP4.A1. Theoretical expression of the combined hydrodynamic-hydroelastic problem.

WP4.A2. Numerical solution of the above problem by extending the coupled-mode model of WP2.

WP4.A3. Comparisons with simpler models, field measurements and evaluation.

Research team: Belibassakis, Kokkinos, Athanassoulis, Gerostathis, Katsardi, Politis

Period: months 7-33

WP5. Application of hybrid finite-boundary element method for the examination of local phenomena. Global-local model conjugation including coupled-mode types.

WP5.A1. Development/application of hybrid FEM-BEM models for evaluation of local dynamic behaviour and strength assessment of critical structural components of VLFS.

WP5.A2. Comparison of numerical results with experimental data and validation.

Research team: Kokkinos, Reddy, Filopoulos, Markolefas

Period: months 10-33

WP6. Evaluation and assessment of results – publicity actions.

WP6.A1. Evaluation of results

WP6.A2. Publicity actions

WP6.A3. Organization of Seminars

Research team: All

Period: months 1-33

Expected results ***(Summarize the deliverables anticipated following the successful completion of the study)*** **(150 words max)**

The deliverables of the proposed research are summarized below:

WP1. Computational wave models and documentation.

WP2. Computational hydroelastic models and documentation.

WP3. Computational models in vacuo and documentation.

WP4. Computational conjugated models (WP2 & WP3) and documentation.

Note: Preparation of related papers from WP1-WP4 for publication in international scientific journals/conferences by the members of the research team.

WP5. New computational hybrid FEM-BEM models to resolve technical problems relating to the construction and operation of large floating structures in the marine and coastal environment, simulation and prediction codes relating to the sea-ice interaction and contributing to global environmental risks assessment and documentation. Submission of technical papers to international scientific journals/conferences.

WP6. Publications in international scientific journals/conferences. Interim progress reports and final report of the proposed research program. Development and further improvement of the relevant webpage. Organisation of specialized seminars. Production of Seminar Notes (Lecture Notes). Internal evaluation of MRT Report.

Implementation possibilities ***(Highlight the utility(ies) of the deliverable(s) including translational capabilities and the target groups that might have interest for these deliverables)*** **(150 words max)**

The proposed research contributes to the technology for large floating structures, which can be used in Greece within the coastal zone for the economic development of islands in the Aegean and Ionian seas. Apart from that, VLFS is the main infrastructure for the development of maritime and offshore wind energy through **offshore wind farms**. EU Commission considers this the energy of the future, as it represents a source of clean, indigenous and renewable energy (its utilisation will be 40 times greater by 2020). Benefits: the production units at sea are larger than on land, winds are stronger and more stable at sea, wind farms protect certain marine ecosystems and provide new uses of the sea (offshore aquaculture benefiting from the VLFS).

It is necessary to have the appropriate technology and scientific resources to fully exploit VBLFS and, in this perspective, to develop synergies between clean energy production and maritime technology.

Expected benefits in local and international level *(Highlight possible benefits in Education and Academia, development of research environment and infrastructure, spreading of the results in the Society and putative financial interest in local or international level)* (200 words max)

The proposed work aims the creation and strengthen of a research team in TEI-Athens, in collaboration with the National Technical University of Athens, the Hellenic Center for Marine Research, the Dept. of Mechanical Engineering at Texas A&M University and others external associates, with mean activity in the development and optimization of large elastic floating structures technology that are located and operating in the near-shore and coastal environment. Also the proposed work, through the collaborations and the final deliverables serves as an integration of a long term research of the various members in various research directions.

Additionally, an important goal of the work is the optimization of experimental measurements using the small-scale towing tank of the Naval Architecture Dept. and the improvement of the prediction abilities of the experimental procedure through the assimilation of analytic models. For supporting the conduction of the measurements of hydrodynamic responses of elastic floating bodies to waves, the commission of special measurement devices is proposed (e.g. electronic accelerometers) and software for data acquisition is proposed. Thus the proposed work will complement the existing installed measurement equipment highlighting and extending its capabilities.

Timetable *(Create a table to describe the timetable of each workpackage, highlighting the overlapping periods between them as well as the interim and final reports of the project)*

Timetable

The *Timetable* of the project is provided in tabular form and PDF format at the following active link:

http://users.teiath.gr/fkokkinos/Archimedes/Timetable_Project_HYDELFS.pdf

Budget justification *(Create a table to show the total budget of the project. Following that, justify the requested budget per workpackage)*

The *Budget* of the project is provided in tabular form and PDF format at the following active link:

http://users.teiath.gr/fkokkinos/Archimedes/Budget_Project_HYDELFS.pdf

Please, provide the names, contact details and links to web pages of three researchers from abroad that can act as referees of your proposal (200 words max)

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http://www.eng.nus.edu.sg/esp/Prof%20Wang%20Chien%20Ming%20Web/Very%20Large%20Floating%20Structures%20(VLFS).htm

Additional notes ***(Add a note only if you feel that an important area of your project was not covered in the domains above) (350 words max)***

A list of basic references appearing in the various sections of this proposal is included here:

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Watanabe E., Utsunomiya T., Wang C.M. (2004), Engineering Structures, 26, pp. 245-256.