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FSRU seakeeping model calibration

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“We think the FSRU moves less than predicted”. With this incipit, OLT Offshore LNG Toscana (and its operator ECOS) asked Oceanira to calibrate the Toscana FSRU seakeeping numerical model with on-site measurements. For a naval architect this is one of the most interesting (a good chance to see if what one does all day is actually meaningful) but also challenging undertakings as it involves a number of competencies, the most important of which are:

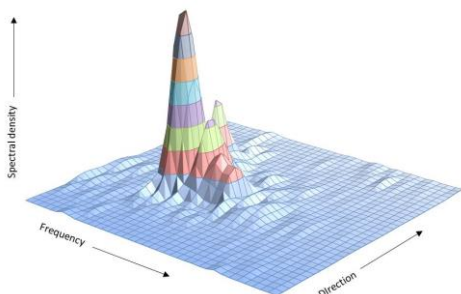
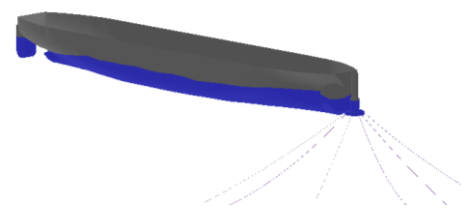
1. a deep understanding of the ship dynamics theoretical background, of the numerical model used and of the numerical parameters with the greatest uncertainties;
2. knowledge of environmental actions modelling and effects & consequences of numerical simplifications and idealizations;

3. full comprehension of the equipment and methods used for the measurement of floater motions and environmental actions, together with their inherent limitations.

The data measured by the FSRU on-board wave radar and accelerometers was collected between October and January and the following strategy was put in place:

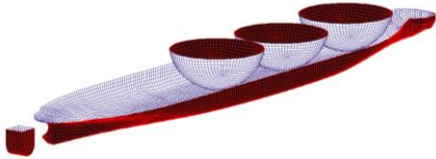
- statistical processing of motions measured onboard;
- analysis of time histories statistics parameters and identification of days for which motions have sufficient amplitude for calibration;
- extraction of wind and waves metocean conditions and vessel heading for the identified days;

- qualitative checks of waves, wind and motions data, based on consistency analyses;
- identification of time slots when metocean conditions, vessel heading and motions are characterized by an stationary response;
- numerical modelling and simulation of the identified steady state environmental conditions;
- comparison of the motions predicted by the numerical model and the measured data.

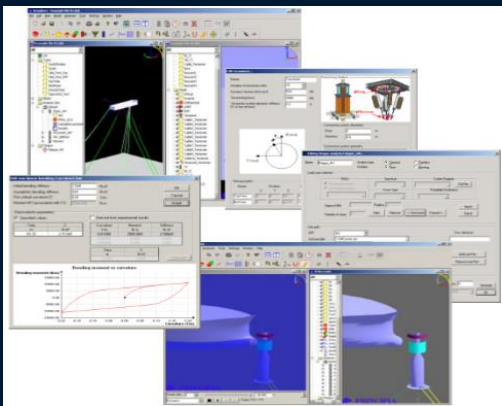


| OUR LATEST PROJECTS | |
|---|------------------------|
| Project | Client |
| Toscana FSRU seakeeping/dynamic model calibration with on-site measurements | OLT/ECOS |
| Norman Atlantic quayside mooring | Visemar di Navigazione |
| Assistance for FSRU feasibility/operability study | Principia (Engie) |
| FSRU Toscana side by side mooring analysis of a 180,000m ³ LNG carrier | OLT/ECOS |
| Laybarge RAOs in shallow waters | Maris (GSP) |

In order to model the actual offshore conditions as accurately as possible, the effects of LNG in tanks (“sloshing”) was accounted for in the hydrodynamic analysis (HydroStar) and user-defined multi-directional spectra were used in the time domain simulations (DeepLines™), with a total of approx. 1400 wave frequencies over a directional range of 360deg. As expected, some model parameters with the highest uncertainties had to be adjusted to match the measured motions but the biggest challenge has been to acquire a complete understanding of the environmental data measuring equipment, in order to identify any spurious record, the possible influence of diffracted/radiated waves from the FSRU on the wave pattern and impact of Doppler effects.



Thanks to this exceptionally interesting work, we have been able to deepen and confirm Oceanira know-how and knowledge of floaters modelling in connection to on-site data acquisition, creating an internal database that only few companies have the advantage and privilege of owning. Among the lessons learnt we feel one is worthwhile mentioning: it is crucial to have more than one source of environmental data acquisition to be able to cross check measurements.

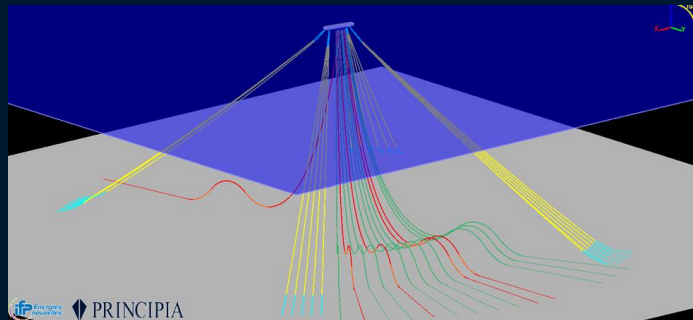


DEEPLINES™ IN ITALY

We are extremely proud and happy to announce that from the 1st of January Oceanira is the official distributor of DeepLines™ in Italy, on behalf of Principia SAS.

We have been using DeepLines in some of our latest projects, including the FSRU calibration, and have used it extensively during our past work experiences. Our commitment is not the consequence of a commercial agreement but comes from the strong belief that this is a reliable, flexible and state of the art software.

DeepLines™ is part of the marine software solutions developed by Principia and IFP Energies nouvelles.



It is based on the finite elements method and forms an integrated software solution to perform in-place and installation analyses of a wide range of offshore structures including flexible and steel risers, umbilical risers, pipelines, floating hoses and mooring lines.

The software package combines a powerful finite elements engine featuring advanced modeling capabilities with an intuitive user interface offering optimum productivity through multi-threading.

APPLICATIONS

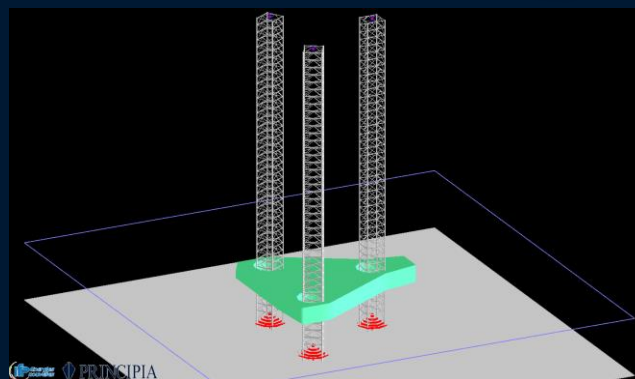
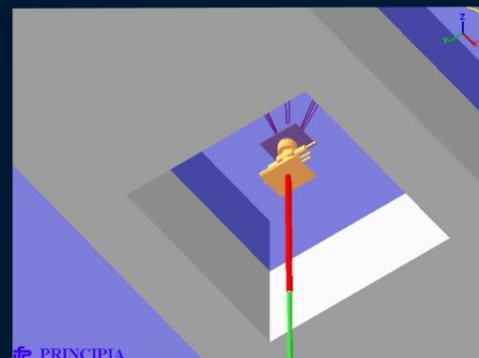
- Flexible risers, umbilical and loading hoses
- Production and drilling rigid risers
- Hybrid riser systems such as riser towers
- Mooring lines and multi-body offshore systems
- Subsea equipment installation
- Towed systems analysis
- Pipeline S-lay, J-lay and on-bottom stability analysis
- Design of pipelines and spools submitted to thermal loads

TYPE OF ANALYSES

- Static and quasi-static analysis
- Time-domain dynamic analysis
- Frequency domain dynamic analysis
- Design of drilling riser based on API RP 16Q
- Modal analysis of complete risers and mooring systems

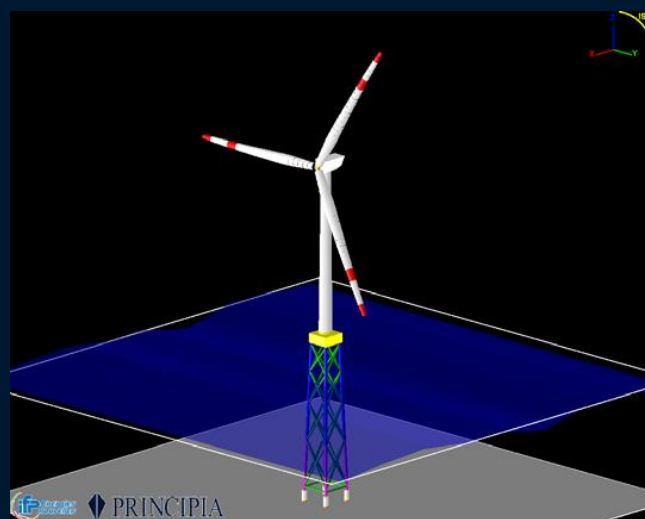
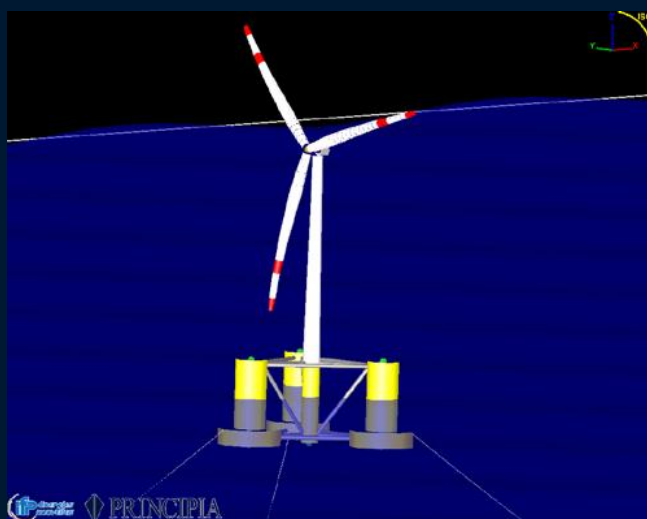


- Time-domain and frequency domain dynamic analyses can both be run from the same GUI
- Powerful and robust finite elements method including coupled bending/torsion effects
- Wide range of boundary conditions
- Non-isotropic 3D seabed friction and suction effect
- Wake models to assess drag loads on lines
- Modeling of sliding device including friction: J-tube, guides, keel-joint, PIP...
- External contact between lines for clashing analysis
- Contact with any user-defined surface, either fixed or moving (soil, moonpool, bellmouth, ...)
- Automated detection of contact zones based on proximity criteria
- Non-linear bending stiffness including hysteresis effect for modeling unbounded flexible pipes
- Includes the effect of thermal loads for any type of temperature profile
- Multi-linear stiffness for risers and specific elements to model synthetic ropes
- DNV-OS-F201 and DNV-OS-F101 unity checks are available straight from the user interface
- Assessment of in-line VIV response of pipeline span according to DNV-RP-F105



OFFSHORE RENEWABLES

A special DeepLines™ feature is the possibility of performing analyses with complete hydro-aero-servo-elastic coupling for wind turbines modeling. Considering the environmental challenges and the changes underway in the energy market, renewable energy offshore installations will be surely a part of our engineering future.



We provide commercial and technical assistance, including training and on-line & on-site support. For more information contact us at:

deeplines-contact@oceanira.com