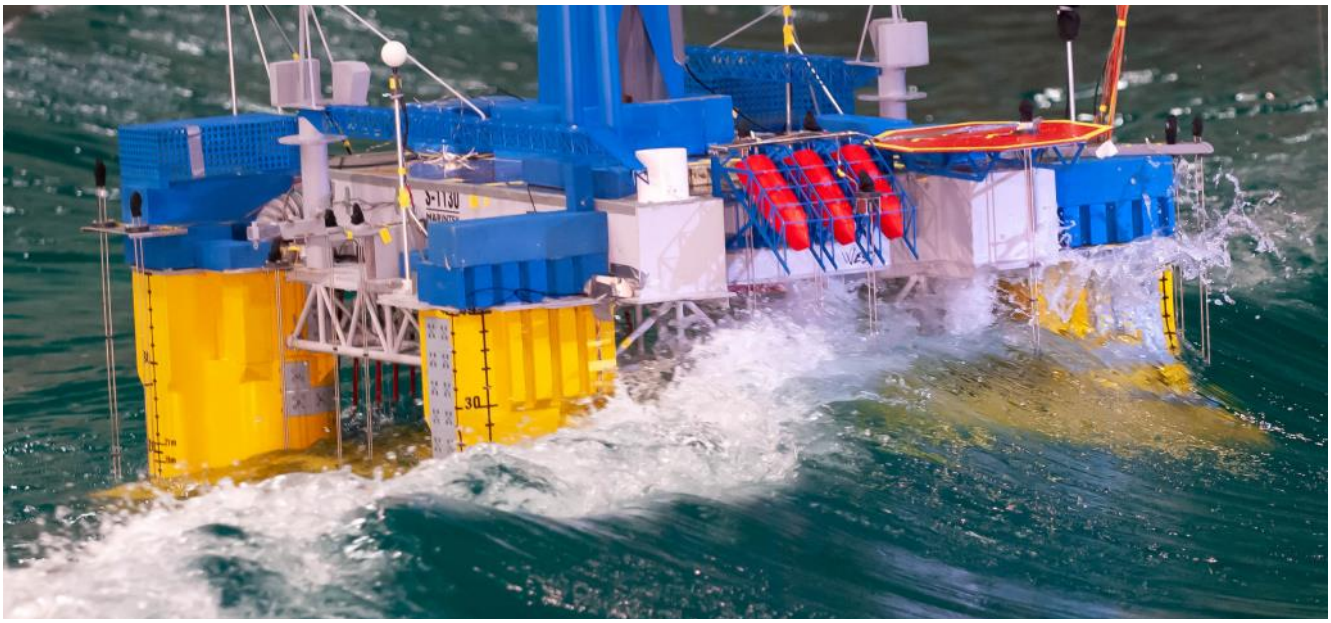
ENERGY SERVICES IN SINTEF OCEAN

SINTEF Ocean helps ensure a more efficient and sustainable utilisation of ocean resources through technology development and research. We offer services to ocean related markets, such as oil and gas, renewable ocean energy, aquaculture technology, marine pollution, fishery technology, new marine resources, maritime transport, biomarine processing.



Technology development and innovation are becoming more important than ever to reduce the cost level and improve the competitiveness of the offshore energy industry, in Norway as well as internationally.

SINTEF Ocean operates world class laboratories, focusing on technology development for the oil and gas sector. We combine our laboratory experience and our professional expertise in the development of numerical methods and software. Several of these are used in the global operator and supplier industries on a regular basis. We also assist the industry with analyses and calculations, where professional expertise, experimental data and long experience from the oil and gas industry are crucial to succeed.

SINTEF Ocean takes an active part in the development of offshore wind power via its research, software development, model testing and new operating strategies. We also participate in long-term research on tidal and wave power, and work with other partners in SINTEF to develop bioenergy based on marine raw materials.

SERVICES

Our services range from specialist analysis and model testing of offshore structures and SURF applications to detailed analyses of hydrodynamic loads and response. Our services comprise:

- Specialist analysis for Station keeping, Marine operations, SURF, Offshore renewables, and Arctic applications and accidental response.
- World class laboratories: Ocean basin, Towing tank, Structural labs, Riser and cable tests rigs.
- High end software development for SURF, Station keeping, Marine operations, Hydrodynamics.

If you have any questions please contact:

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- **Bård Wathne Tveiten**, Research Director, Ships and Ocean Structures
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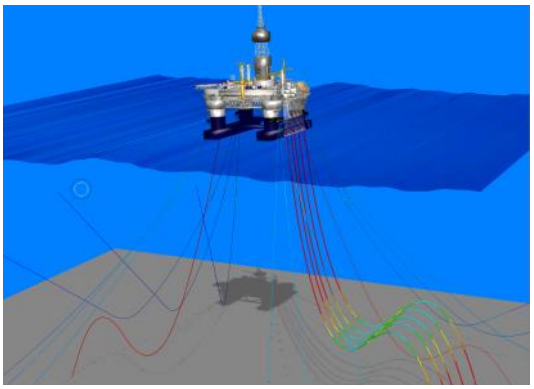
Station Keeping System



Mooring and dynamic positioning systems are crucial components in floating vessel concepts like FPSOs, Semis and SPARS. SINTEF Ocean has more than 40 years' experience in studying such systems. Analytical and numerical research, software development and hydrodynamic model testing represents various multi-discipline activities. A crucial benefit with this multi-discipline activities is that lesson learned from e.g. model test may be used to develop new theory that are implemented into the software such as SIMA/SIMO and MIMOSA.

If you have any questions or ideas, please contact nuno.fonseca@sintef.no or vegard.aksnes@sintef.no

Subsea pipelines, risers and umbilicals/cables

Structural response of pipelines, risers and umbilicals/cables under harsh environment, including stability, stress and fatigue asserts a great challenge for offshore industry. SINTEF Ocean has been for decades leading in developing advanced numerical tools to address new technical and engineering challenges for these slender structures. The application of these numerical tools can greatly reduce costs from fabrication to operation by removing uncertainty in predicting the structural response of such structures. Reliability and applicability of these tools are guaranteed by extensive small and full scale laboratory tests.

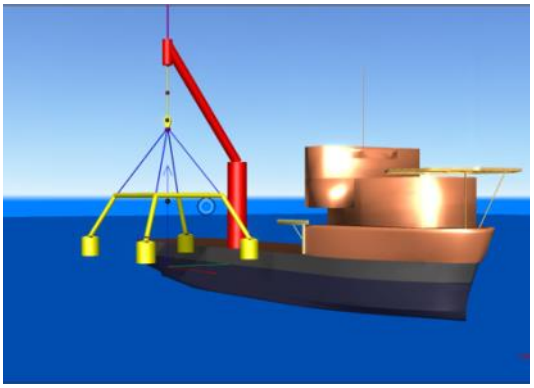
If you have any questions or ideas, please contact janne.gjosteen@sintef.no or nina.langhelle@sintef.no

Vortex Induced Vibrations

Slender marine structures such as deep-water marine risers, pipelines, umbilicals, and cables that are subjected to currents will normally get Vortex Induced Vibrations (VIV), which can cause fast accumulation of fatigue damage. SINTEF Ocean has more than 25 years experience on VIV research including model testing in model and full scale, advance analyses and development of theory and software. Semi-empirical tools are normally used by the industry to predict VIV induced fatigue on slender structures and we have developed a state-of-the-art prediction tool, VIVANA, which now has both a frequency domain and time domain model.

If you have any questions or ideas, please contact halvor.lie@sintef.no or jie.wu@sintef.no

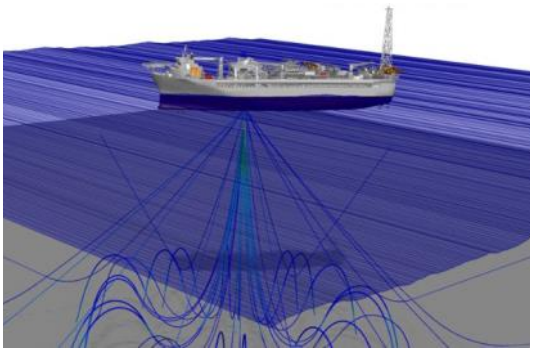
Marine Operations



The installation process and maintenance of the necessary offshore systems are demanding both for the technical solutions and for the human actions involved. SINTEF Ocean is developing knowledge, methods and computer tools for safe and efficient analysis of both the equipment and the installation process. The results are required in challenger fields such as in deep water and cold climate in order to document the enabling technologies to perform the marine operations.

If you have any questions or ideas, please contact orjan.selvik@sintef.no or froydin.solaa@sintef.no

Digitalisation



Improving safety and efficiency of assets through application of digital solutions have been centre of attention in recent years. At SINTEF Ocean we have combined our expertise in numerical modelling and simulation with advanced digital technologies to offer simulation-based asset integrity management and decision support systems to our clients. Development and version control of assets' digital-twin, onboard sensor data management, continuous integration, automatic analysis and reporting, for offshore oil and gas as well as renewable energy platforms are among examples of such services.

If you have any questions or ideas, please contact babak.ommani@sintef.no

Offshore Structures and Extreme Loads

Through our hands-on experience from model testing and involvement in offshore projects, we know the importance of viewing actions and action effects as an interaction. A prime example on this is violent loads from wave slamming where the actual load is a strongly connected to the response of the structural and vice versa. In our work on the topic we combine sophisticated hydrodynamic model tests with state of the art simplified and numerical analyses in order to assess critical load events and finally determine the consequence for the offshore structure. This is also the topic for the SLADE research project which is hosted by SINTEF Ocean.

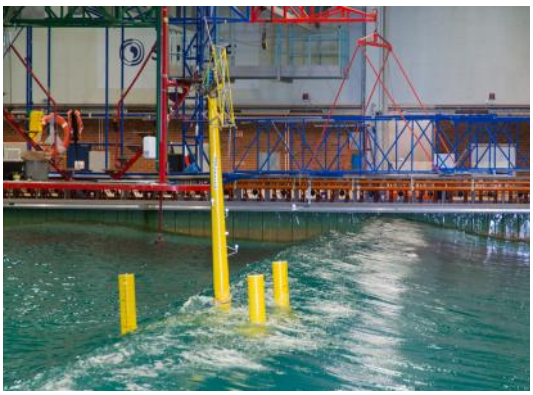
If you have any questions or ideas, please contact ole.d.okland@sintef.no or bjornchristian.abrahamsen@sintef.no

Arctic Environment and Loads

Operating in the high north is challenging due to factors such as remote locations, harsh environment and presence of ice. In order to serve the industry on this topic SINTEF ocean takes part in research on related topics such as safe arctic operations, vessel-ice interaction, arctic logistics, and arctic preparedness assessment.

If you have any questions or ideas, please contact kay.fjortoft@sintef.no or hagbart.alsos@sintef.no

Offshore Renewable Energy



Renewable energy, such as offshore wind and solar represents, a strategic area for SINTEF Ocean. Through our expertise in hydrodynamics, aerodynamics, structural response and decades of experience from offshore O&G, SINTEF Ocean has become a trusted partner for the industry. Our track record spans from wind park developments such as Dudgeon and Hywind, to international research programs hosted by SINTEF. Examples are NOWITECH research centre, EU H2020 LIFES50+, EU FP7 LEANWIND and KPN WINDMOOR, among others.

If you have any questions or ideas, please contact

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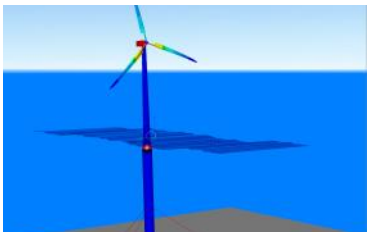
Specialist analysis in structure and hydrodynamics/ hydrodynamical and structural services

In hydrodynamical and structural services, theoretical, experimental and numerical approaches all have their strengths and limitations. A rational combination of those approaches has always been SINTEF Ocean's strategy in its research activities and commercial services. By giving special attention to each project's challenges, we mindfully select a tailormade combination of approaches that will best answer our customer's requests, resulting in a deeper understanding of the studied cases. This unique combination of fields of expertise has led to development of innovative testing techniques and software to answer the exact needs of our customers.

- Fundamental research vs. specialist analysis
- Feasibility studies, literature studies, advisory services
- Specialist analysis

Software Developments



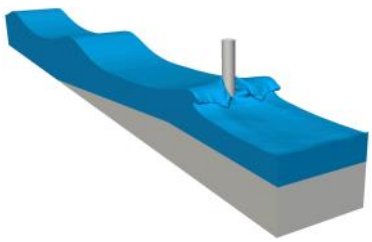
- SIMA/SIMO/RIFLEX—is a powerful SW package for hydrostatic, hydrodynamic and strength analysis of ships and floating offshore structures, such as FPSOs, Semis, offshore wind turbines. I is also used visually simulate, test and evaluate marine operations ahead of offshore operations and to analyse global behaviour of rigid and flexible riser systems, mooring lines and cables.
- VIVANA - a tool for calculation of vortex induced vibrations (VIV) of slender marine structures such as risers, free span pipelines and cables
- MULDIF - a 3D diffraction/radiation panel code for computing wave frequency and slow-drift forces of large volume structures from wave and current
- BFLEX/UFLEX - FEM software for stress and fatigue analysis of flexible risers, umbilicals and cables
- SIMLA - FEM software for simulation of pipelaying on 3D seabed terrain
- MIMOSA—Mooring software for static and dynamic analysis of moored vessels and mooring systems

Experimental Tests

SINTEF Ocean's laboratory facilities are internationally renowned. The key ones includes:

- Ocean Basin Laboratory - applicable tool for investigating offshore fixed and floating structure.
- Ship Model Towing Tanks - used for investigating hydrodynamic performance of ships
- Cavitation Tunnel - used to investigating hydrodynamic performance of prpellers, ship hulls and other hydrodynamic objects
- Marine Structural Laboratory - is mainly used for testing structures, structural components and materials
- Energy-/Machinery Laboratory - use for investigate various energy and machinery systems used on ships and offshore platforms

Specialist Analysis



SINTEF Ocean performs specialist analyses related to hydrodynamics and structural response for offshore applications. This builds on experience from engineering and research activities, model tests, and in-house and open source software developments. Our services spans from Computational fluid dynamics (CFD) for offshore hydrodynamic and arodynamic applications, numerical wave tanks (NWT), analyses based on potential methods, and Finite Element Analysis of offshore structures.