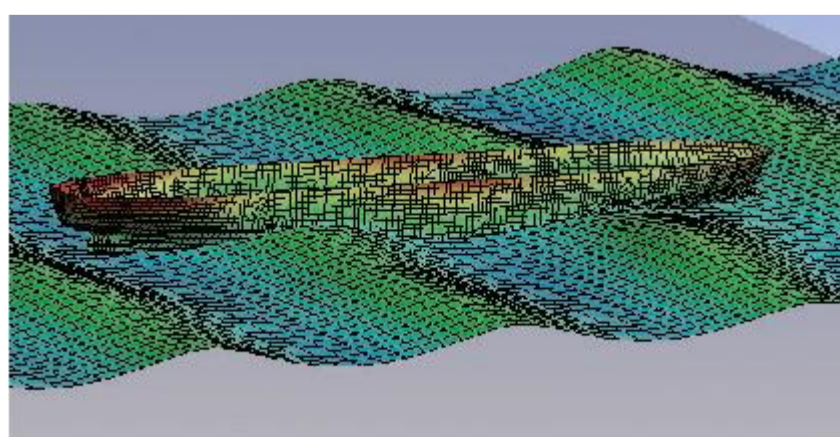
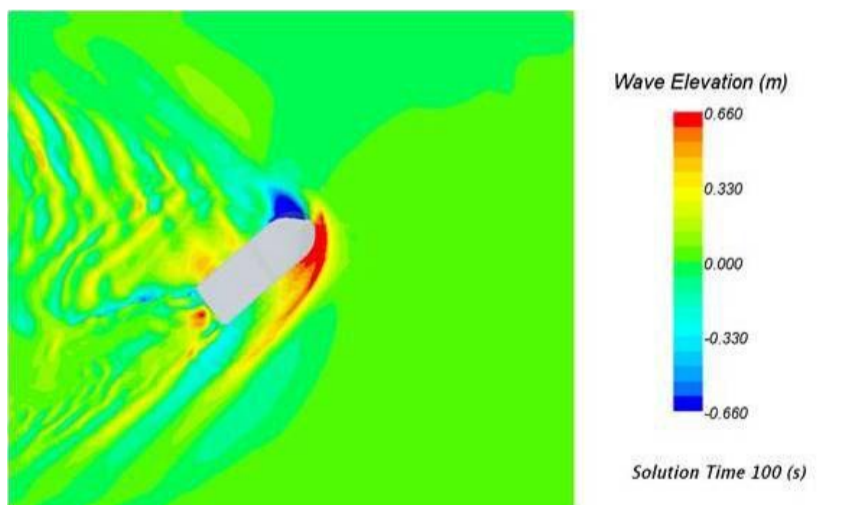
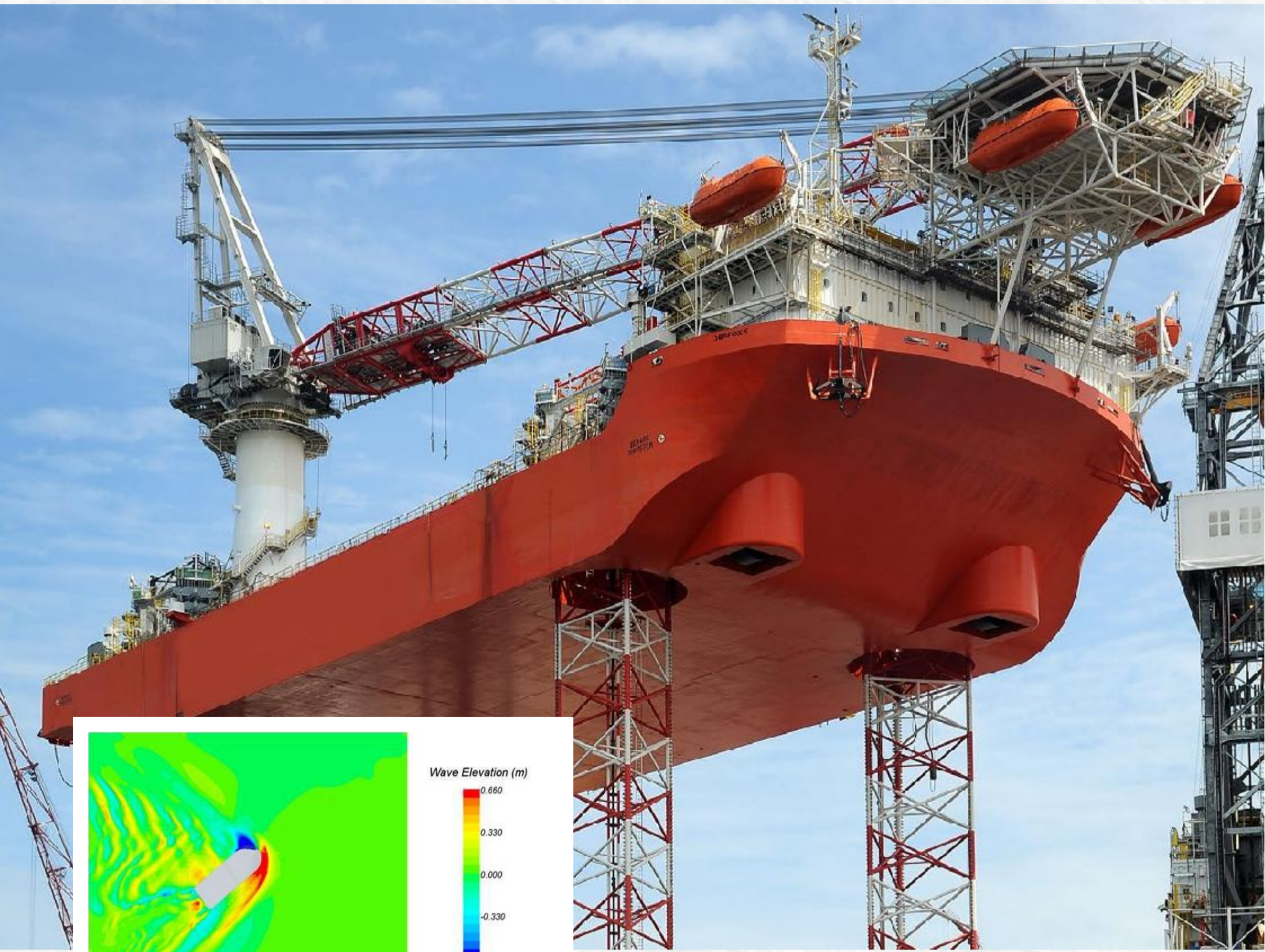


# OFFSHORE DESIGN & ENGINEERING

TECHNICAL SERVICES



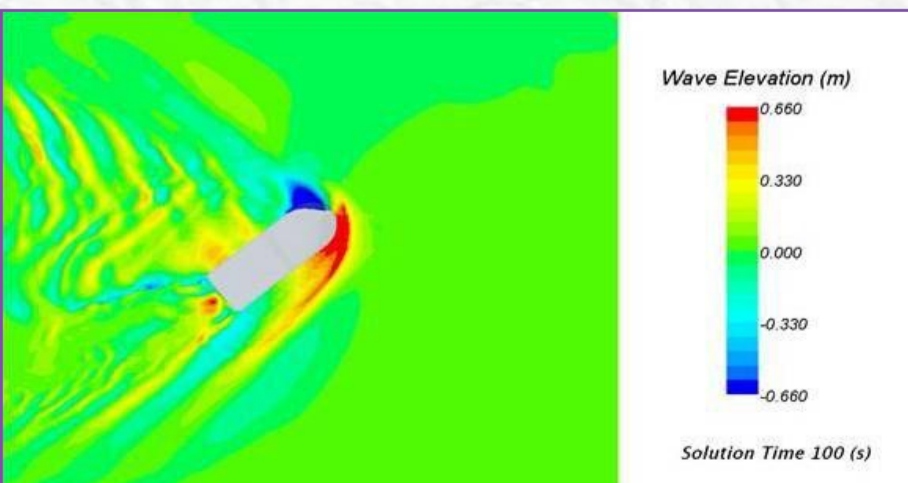
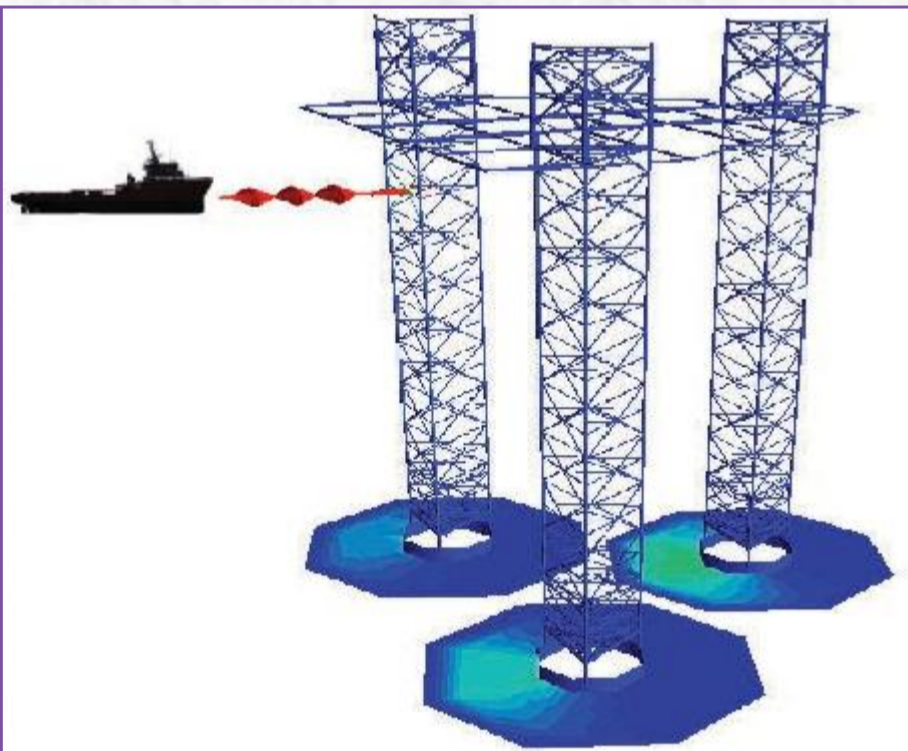
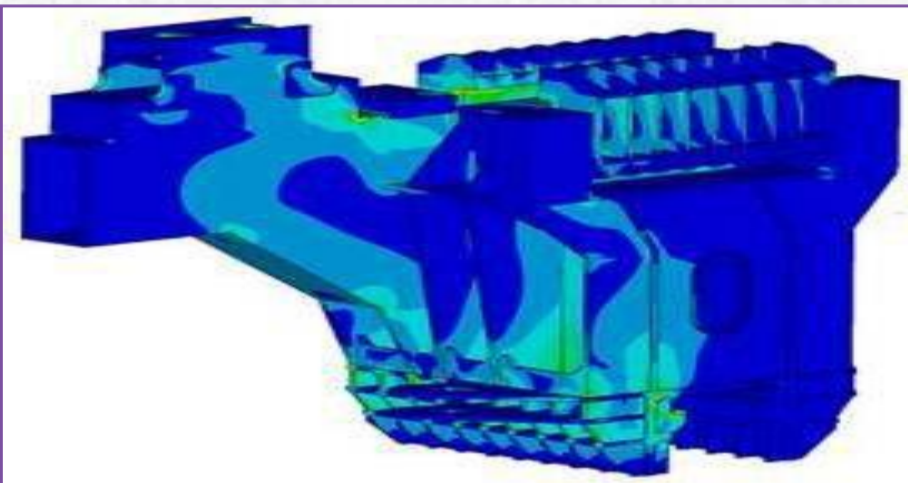
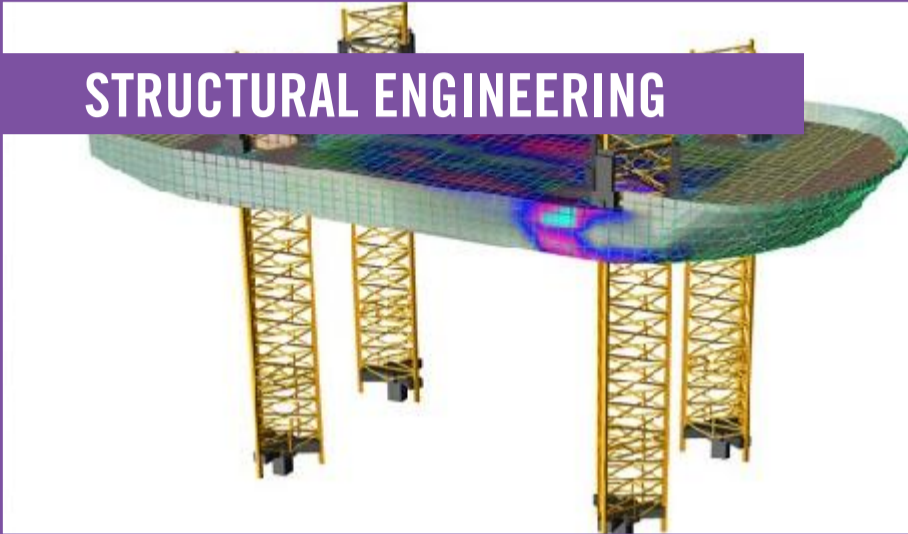
**Keppel**

**Offshore Technology  
Development**

## DESIGN & ENGINEERING

Equipped with a wealth of experience in an array of fields and accomplished use of extensive analytical tools and software, Offshore Technological Development (OTD) offers a broad line-up of detailed engineering and technical services, ranging from structural (global and specific), offshore installation, geotechnical, naval architecture and hydrodynamics.

### STRUCTURAL ENGINEERING



- GLOBAL ANALYSIS AND DESIGN
- DETAILED FEA FOR KEY COMPONENTS
- EXPLOSION ASSESSMENT
- DROPPED OBJECT ANALYSIS
- FATIGUE ANALYSIS
- BOAT IMPACT ANALYSIS
- PUSHOVER ASSESSMENT
- CFD ANALYSIS

With strong team of engineering, we are able to offer various global finite element analyses (FEA) and designs, by using industry common recognised software, such as ANSYS, SACS, SESAM, etc. The analyses can be performed for various load scenarios, together with environment (e.g. wind, wave, current) or motion effects to determine the structure performance, including yielding and buckling strength. Our structure design and analysis capability had been proven by quantities of projects that we have delivered.

Our experienced engineers understand the importance of proper integration of structure basis and mechanical components, through close cooperation with our own mechanical team, we are able to provide seamless design for various structure foundations, yokes, pins, studs, as well as other local structures such as jackcase, cantilever, drillfloor, leg footings, etc. We can design in compliance with all major industry standards and class regulations.

With the state-of-the-art advanced analysis technology and expertise, our team is capable of tackling the costly issue of assessing the reserved strength of offshore platforms subjected to the accidental damages caused by explosion, fire, dropped objects, ship collision, dynamic and fatigue effects, and the extreme environment events. By utilising the inherent redundancy found in the offshore structures, we are able to help owners to manage the safety and operation of offshore structures, and hence protect the health, safety and the environment, which are paramount for the operators of offshore platforms.

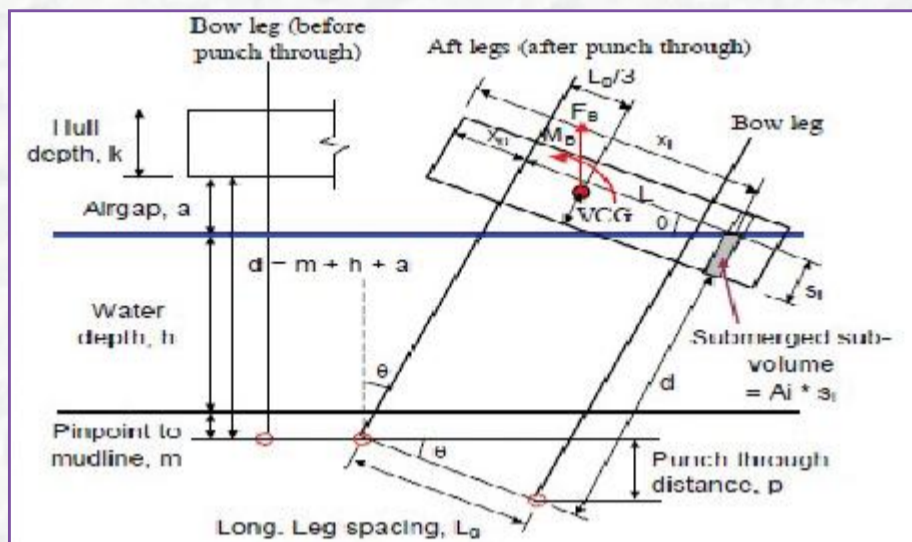
Our years of successful CFD applications and researches in the offshore, marine, oil & gas, and renewable energy industries have enabled us to achieve reliable and viable design solutions with excellent accuracy and cost effectiveness for numerous complex simulation scenarios, including but not limited to the prediction of environmental loads, resistance & propulsion, seakeeping & maneuvering, and industrial multiphase flows.

## OFFSHORE INSTALLATION ENGINEERING



- JACK-UP SITE SPECIFIC ASSESSMENT
- LEG PUNCH THROUGH CAPABILITY ASSESSMENT
- GOING ON/OFF LOCATION ANALYSIS
- RPD TRAINING

Our team is able to perform jack-up site specific assessment to determine the suitability of the jack-up rig to operate in a particular site. The assessment can be done in accordance to SNAME 5-5A, ISO 19905-1 and/or any specific requirement from Customer. The objective is to assess the suitability of the jack-up in terms of structural and foundation capacities based on the environmental condition, the elevated configuration and the geotechnical condition for a particular site.



For leg punch through capability assessment, the objective is to assess the leg strength and the holding system under a simulated punch through condition for a given leg penetration, water depth, air gap/ draft and specific loading condition. This assessment allows the rig owners or operators to clearly understand and assess the potential risks and plan for mitigation in advance when necessary.

Punch through incidents are normally occur during preloading operation. If not planned and executed properly, preloading in a punch through potential site may result in damage to the leg structure of the jack-up. Our team is able to recommend a specific preloading procedure specially designed to mitigate the risk of punch through.



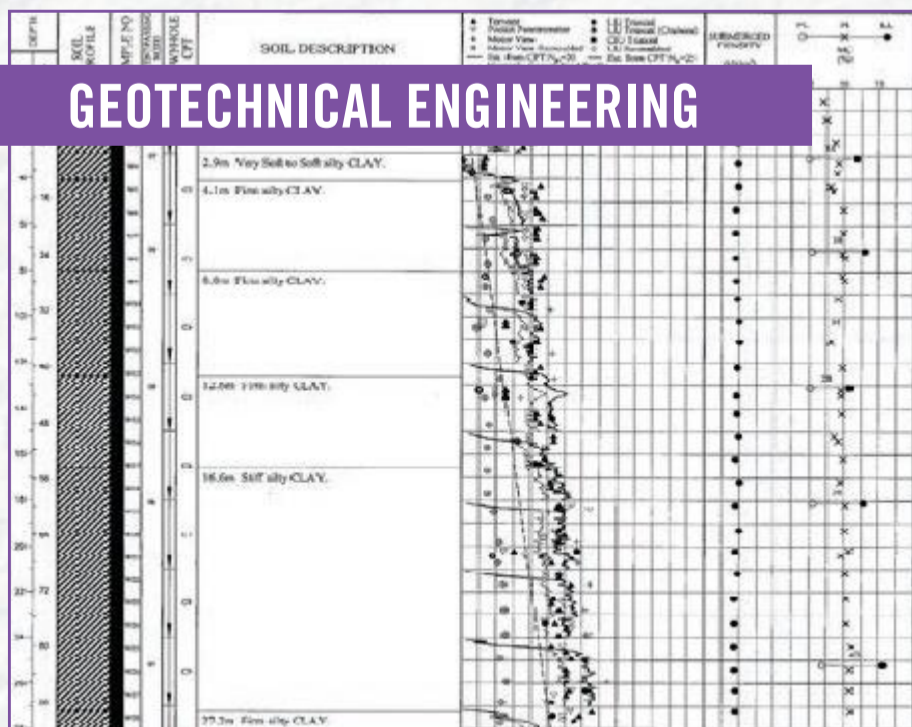
For going on location study, our team is able to perform a leg touch-down analysis to determine the allowable motion curve in terms of roll and pitch versus the period. The analysis will be performed under a given sea state or environmental condition, seabed condition, water depth and specific loading condition.

For going off location study, our team is able to perform a hull in water analysis to determine the safe over draft limit in attempt to pull the jack-up leg. The analysis will be performed under a given sea state or environmental condition, leg penetration, geotechnical condition, water depth, and specific loading condition.



Some locations may have certain geotechnical conditions such as sloping or uneven seabed. This will cause some eccentric loading to the spudcan which will induce bending moment to the leg/ hull interface. If not managed properly, this will cause the leg to bend and will results in the Rack Phase Difference (RPD) in the leg to increase, which may cause some damage in the leg members. Hence it is important during jacking operation, to monitor and manage the RPD properly. Our team is capable to assist in managing RPD in such challenging geotechnical conditions for a safe jack-up installation. We can also provide RPD training for the rig crew to be equipped with RPD management skills to handle such situation during rig moves.

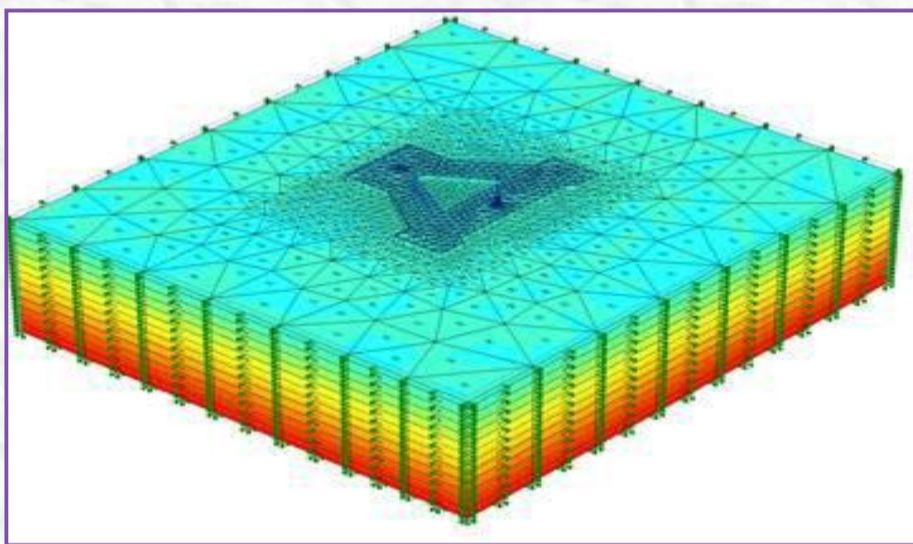
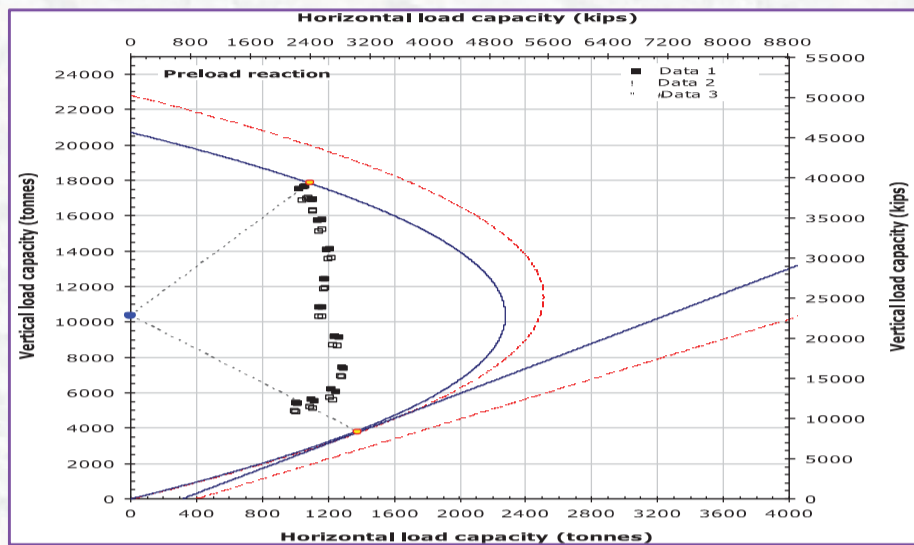
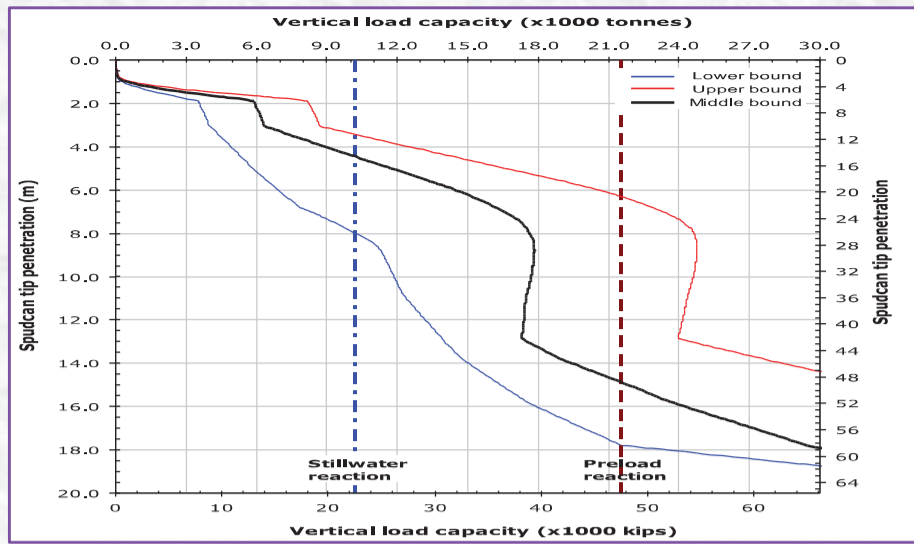
## GEOTECHNICAL ENGINEERING



- GEOTECHNICAL SITE INVESTIGATION REVIEW
- LEG PENETRATION ANALYSIS
- FOUNDATION ASSESSMENT
- OTHER FOUNDATION TYPES DESIGN

Our geotechnical team is able to review the geotechnical soil investigation data provided by Customer. Based on the geotechnical site investigation data, soil parameters such as lower bound and upper bound friction angles and shear strength will be interpreted for subsequent leg penetration analysis and geotechnical assessment. The soil strength degradation subjected to cyclic storm loading could be considered for foundation assessment.

Our geotechnical team is also able to provide advice and recommendation for site improvement to reduce the potential hazards when necessary.



With the proper geotechnical site investigation data, our geotechnical team is able to perform a leg penetration analysis to derive the load versus leg penetration curve. With this information, the rig operator will know the estimated leg penetration behaviour especially during jack-up leg lowering and preloading operations. Based on the leg penetration curve, we could identify if there is any potential of geotechnical hazard such as punch through, scour, etc and provide mitigation recommendation. In addition, the leg extraction resistance can be predicted.

With the preloading and penetration depth, our geotechnical team is able to assess foundation bearing & sliding capacity as well as fixity stiffness, in accordance with SNAME/ISO/DNV criteria. The additional leg penetration corresponding extended foundation bearing capacity would be evaluated when necessary.

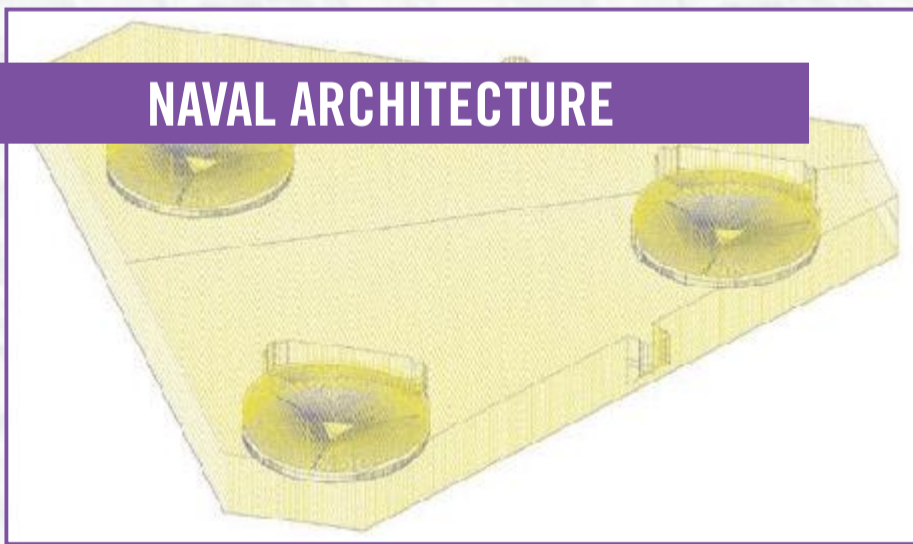
Furthermore, the interaction between spudcan and other structures (i.e. pile foundation, mud line cellar, previous footprint, etc.) can be assessed, and the long-term foundation settlement can be predicted.

Besides spudcan, our geotechnical team is able to design other types of foundation for different soil conditions, such as caisson, mat foundation, pile foundation, gravity base, hybrid foundation, etc.

Besides soil conditions, installation/retrieval requirement, draft requirement and performance would be considered to choose the foundation type.

Hybrid foundation combined of the merits of suction caisson and mat foundation is patented. It could be self-installed without external preloading, and provide the most economical performance for some challenging sites.

## NAVAL ARCHITECTURE



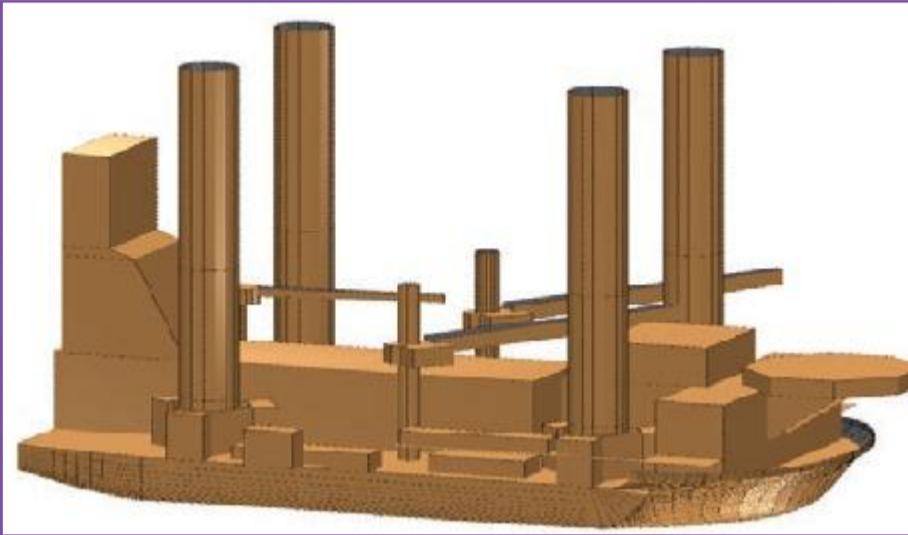
- HULL FORM AND STABILITY
- WIND HEELING MOMENT CALCULATIONS
- WATERTIGHT SUBDIVISION
- NA GENERAL SERVICES

Our Naval Architects have an established reputation leaders in the field of hull form development and combine our breadth and depth of experience in the jack-up, wind installation vessels and naval markets to deliver designs tailored for good sea-keeping ability, low resistance, and high propulsive efficiency. Our proven design successfully overcomes the challenge for numerous jack-ups to carry long legs in fully retracted position.

The team of OTD Naval architects has been trained and qualified to use NA software suite NAPA. This enable us to provide custom requested stability for SPS vessels and jack-ups, Probabilistic Damage stability, Stability of Offshore Units, Liftboats etc.

We are able to provide customised Wind heeling moment calculations for existing units, due to changes to the wind areas, or for the new built. With the specialised software NAPA the Wind heeling moment is also 3D illustrated and calculations are automated for desired Classification Criteria. The Wind Heeling Moment calculation is used in Stability analysis, Bollard Pull calculation, Mooring Calculations, Propulsion and Resistance calculations.



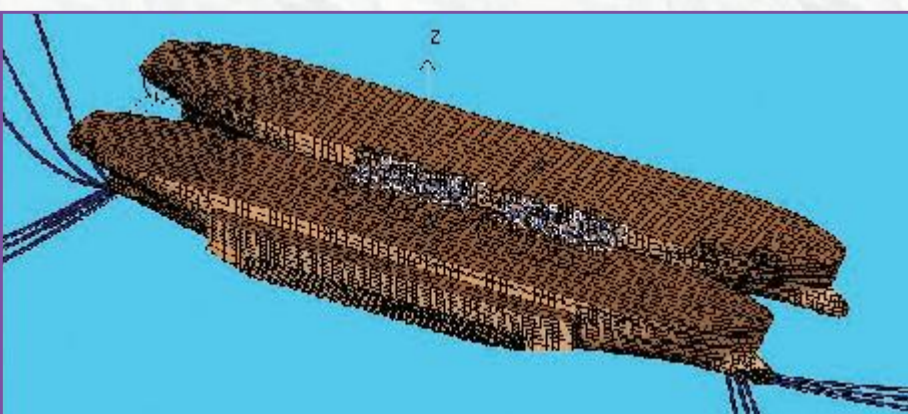
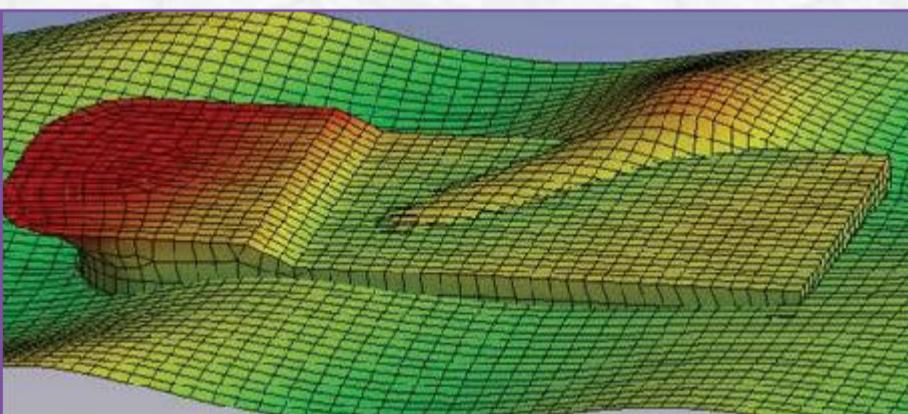
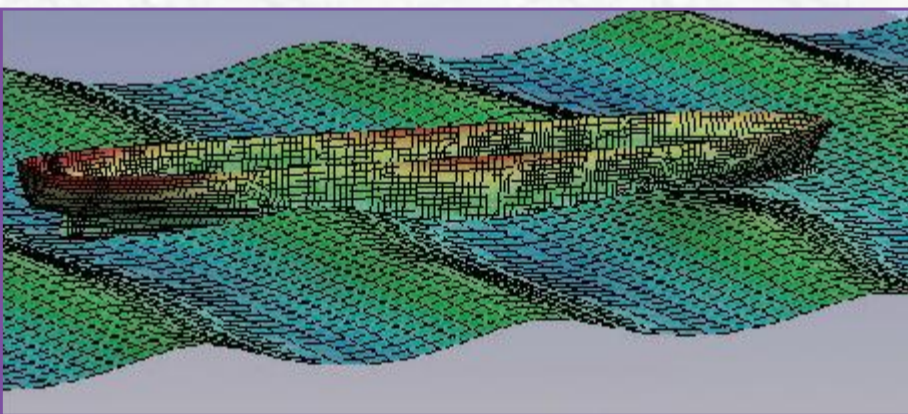
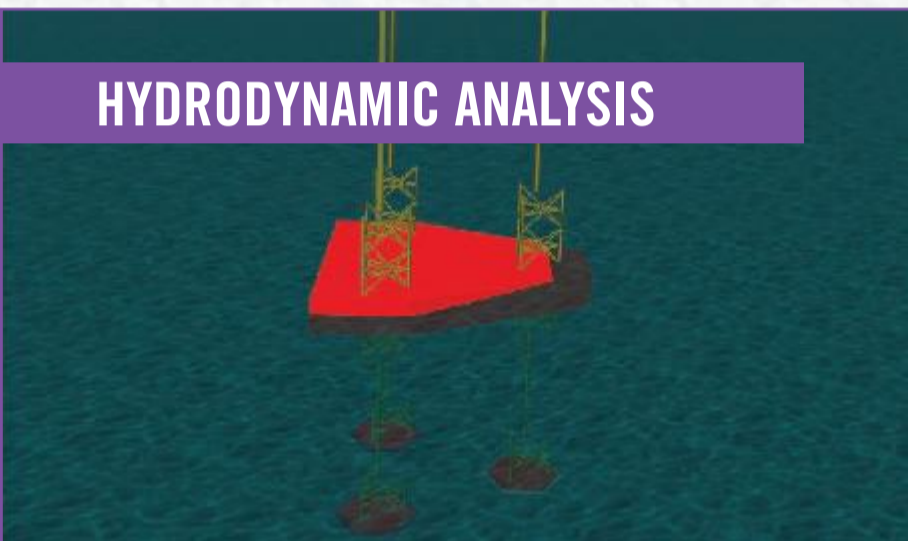


Watertight subdivision of hull is an art to meet Damage and Residual Stability requirements, while accommodating preferred layouts and segregation of spaces desired from Owners. We are specialised to ensure best watertight subdivision with minimum watertight compartments.

Our Naval Architects are able to provide NA services for special projects such as Arctic Jack-ups, self-propelled Wind Installation Jack-ups, Liftboats etc. This includes specific Hull form creation, resistance and propulsion calculation, stability in Ice, deck cargo plans for multipurpose vessels etc.

We are providing calculations for Jack-up moving, mooring calculations for Jack-up installation, Selection of Equipment and Arrangement Drawings for Mooring and Towing. Our Naval architects are providing calculations for Sea-fastening for wet Transit and Dry tow. We are specialised to produce all naval architecture drawings, such as Lines plan, Tank capacity, General Arrangement, Watertight integrity drawing, Escape routes arrangement, Ballast water management drawing, Deck loading plans etc.

## HYDRODYNAMIC ANALYSIS



- **WAVE EXCITATION FORCE COMPUTATION**
- **MOTION ANALYSIS**
- **GREEN WATER ANALYSIS**
- **OFFLOADING MOORING ANALYSIS**

With a strong track record covering a range of vessel types, our hydrodynamic team is well equipped to determine loads experienced on both fixed and floating bodies to meet customer needs.

Utilising well proven 3D potential flow theory, a variety of wave force components including mean drift force, second order difference-frequency and sum-frequency wave forces can be quickly and reliably established, providing confidence in the ability to operate in the required metocean conditions.

The potential flow calculations can also be backed up by state-of-the-art CFD analysis for unusual or particularly challenging conditions.

Backed by a large database of model tests and on-board measurements, our team is able to confidently predict the motion performance of new vessel designs, allowing meaningful hull shape assessment at an early design stage.

Our team offers complete solutions, consisting of metocean data assessment; added mass & damping calculation; unit motion, velocity and acceleration response amplitude operators (RAOs) calculation; short term / long term extreme response prediction based on spectrum analysis.

Building on our extensive motion capabilities, assessment of the potential for green water during transit can be performed to determine the minimum free-board between upper deck and extreme wave surface to assess the possibility of waves encroaching onto deck that can cause extensive damage to equipment and superstructure.

Coupled with a full suite of design services available, such analysis enables more effective design resulting in safer operations.

Recent moves towards offshore LNG production has driven a need for understanding vessel motions and complex mooring arrangements. Our strong background in motion analysis, allows our hydrodynamic team to evaluate the motion characteristics of the spread-moored FLNG/LNG with a vessel tied side by side; providing assessment of the mooring system for the FLNG/LNG and verify the mooring/hawsers performance.

Participation in Marin's on-going JIP project "Offloading capability" allows us to benchmark analysis results software with model test measurement, allowing calibration and improved predictions.

# LIST OF ENGINEERING SERVICES

## Structure Engineering

- Global hull strength analysis
- Longitudinal hull girder strength analysis
- Ice belt reinforcement for polar class vessels
- Finite element assessment of steel plate structures
- Equipment foundation design
- Jacking foundation structure and bracing design
- Cantilever structure design
- Cantilever supports structure design

## Offshore Installation Engineering

- Site Specific Assessment (SSA)
- Elevated operating rating study
- Leg strength for towage/Critical motion curve
- Leg punch through survival capability assessment
- Going on/off Location Analysis
- Jack-up preloading procedure
- Technical assistance/manpower support for general jack-up incident
- Special structural analysis for jack-up recovery and salvage
- RPD Training

## Naval Architecture

- Afloat stability of jack-up unit
- Wind heeling moment analysis
- Hydrostatic tables
- Tank tables
- Hull form for self-propelled Jack-up vessels
- General arrangement plans for Jack-up vessels
- Cargo plans for wind turbine vessels
- Bollard pull calculation for towing
- Mooring forces calculation
- Probabilistic damage stability for SPS notation
- Ballast water management plan

## Advanced Structural Engineering

- Rack Phase Difference (RPD) limit analysis
- Fatigue analysis
- Boat impact analysis
- Dropped object analysis
- Computational Fluid Dynamic (CFD) analysis
- Explosion response analysis
- Earthquake response analysis
- Vibration response analysis
- Push over analysis

## Geotechnical Engineering

- Geotechnical site investigation data review
- Leg penetration analysis
- Foundation bearing and sliding capacities
- Geotechnical stiffness assessment
- Spudcan/Leg extraction assessment
- Geotechnical hazard mitigation
- Other Foundation Types Design

## Hydrodynamic Analysis

- Wave excitation force computation
- Motion analysis
- Green water analysis
- Offloading mooring analysis
- DP Calculation
- Propulsion and resistance calculation
- Speed and power performance prediction by virtual sea trials
- Cavitation performance prediction
- Virtual testing and validation and optimisation for vessel energy saving devices
- Captive maneuvering tests by CFD simulations

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