Reduction of logistical risks of offshore operations by improved consideration of limits for ships and technicians

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Content

- Logistical risks of offshore operations
  - Weather risks

- Limits of work vessels & technicians

- Core objectives of “AVIMo”

- Improved considerations
  - Wave-current basin + Field measurements + Simulations
  - Logistics tool with multi parameter implementation
Logistical Risks

- Internal Risks
  - Organization, licenses, finances, human resources, etc.
- External Risks
  - Political, social, economic, environmental, availability, etc.

RIAM: Risk Impact Assessment Modelling
- Likelihood, costs, schedule, sensitivity analysis
Logistical Risks of Offshore Operations

- **Environmental**
  - Weather condition (wind, wave, current)
  - Unexpected surface & soil conditions
  - ...

- Physical damage
- Loss
- Time
- Costs

- Decision maker’s (Investors, Insurance, Customer, ...)

Origin: Winch (2010)
Weather Risk

- E.ON, A2Sea, Aarsleff & Bilfinger Berger
  - Not safe to leave the harbor
  - No crane operations possible, especially the blade lifting parts
  - Not safe to jack-up the vessel
  - No supply via barges, e.g. foundations, material, etc.
  - No transfer from service boat onto the wind turbine

⇒ Downtime
  - Stall the offshore construction phase
  - Longer project time and more costs

Origin: Ahlgren & Grudic (2017)
Weather Risk

- Identifying weather windows
  - Likelihood
- Schedule operations
  - Transport
  - Installation
  - Maintenance
Limits of work vessels & technicians

→ Downtime

\[ f(R&D, \text{climate, experience}) \]
Limits of work vessels & technicians

- **Lifting:**
  - $\approx < 10 \text{ m/s Wind}$
  - $\approx < 1.25 \text{ m Hsig}$

- **Shipping/Towing:**
  - $\approx < 5.0 \text{ m/s Hsig}$

- **Bad Weather:**
  - Stand-by
  - Evacuation
  - Safety measures
Limits of work vessels & technicians

- Influence of motion on seasickness

≈ 6 s

Origin: McCauley et al. (1976)
Core Objectives of “AVIMo”

- Operational limits due to environmental conditions are conservatively defined in guidelines (e.g. DNVGL-ST-N001)
- Project costs are sensitive to operational limits in terms of installation and maintenance costs (construction techniques, devices, time, readiness, etc.)
- The actual vessel motion or the direction of wave action is not efficiently considered for the operational limits

Risk and cost reduction by means of case-dependent operational limits
Core Objectives of “AVIMo”

- Operational limits of work vessels (and the well-being of technicians) under consideration of:
  - combined wave parameters,
  - generic ship parameters,
  - type of operation

- Demonstration of cost and risk prevention by assessing work assignments with “COAST”
Modelling of structural response

- Structural motion and response in waves
  
  Origin: Faltinson (1990)

- Spring-Damper System
  
  \((m + a)\ddot{x} + b\dot{x} + cx = f(t)\)
Modelling of structural response

- Structural motion and response in waves
Modelling of structural response

\[(m + a) \ddot{z} + b \dot{z} + cz = a\ddot{\zeta} + b\dot{\zeta} + c\zeta\]

- \(z = z_a \cos(\omega t + \varepsilon z\zeta)\)
- \(\dot{z} = -z_a \omega \sin(\omega t + \varepsilon z\zeta)\)
- \(\ddot{z} = -z_a \omega^2 \cos(\omega t + \varepsilon z\zeta)\)
- \(\ddot{\zeta} = \zeta_a e^{-kT} \cos(\omega t)\)
- \(\dot{\zeta} = -\zeta_a e^{-kT} \omega \sin(\omega t)\)
- \(\dot{\zeta} = -\zeta_a e^{-kT} \omega^2 \cos(\omega t)\)

\[z_a \{c - (m + a) \omega^2\} \cos(\omega t + \varepsilon z\zeta) - z_a \{b\omega\} \sin(\omega t + \varepsilon z\zeta) = \]

\[= \zeta_a e^{-kT} \{c - a\omega^2\} \cos(\omega t) - \zeta_a e^{-kT} \{b\omega\} \sin(\omega t)\]

- Estimation of operational limits by
  - field-, laboratory-, and numerical investigations
Reduction of logistical risks of offshore operations

Modelling of structural response

- Estimation of operational limits by field-, laboratory-, and numerical investigations
Improved Considerations

- Response Amplitude Operator (RAO)

Origin: Newman (1977)
Improved Considerations

- Case sensitive RAO

Quelle: MBM Consultancy
Core Objectives of “AVIMo”

- Industrial Partners & Technical committee
- Model tests for selected work vessels
- Vessel motion analysis & Offshore field measurements
- Effects on logistics and risk assessment => Costs
- Recommendations & Practical Applications

Reduction of logistical risks of offshore operations
Physical & Numerical modelling

- Wave generation
  - Regular waves
  - Irregular sea states

- Directional spectra
  - 5° - 175°

- Wave height:
  - max. 0.47 m
Physical & Numerical modelling

- Chosen vessel types:
  - Crew Transfer Vessel (CTV)
  - Offshore Service Vessel (OSV)
  - Jack-Up Vessel
Physical & Numerical modelling

- Num. vs Lab.
  - Analytical
  - Meshless
  - CFD
- Ext. scenarios
- Field data
Core Objectives of “AVIMo”

- Recommendations & Practical Applications
- Model tests for selected work vessels
- Vessel motion analysis & Offshore field measurements
- Industrial Partners & Technical committee
- Effects on logistics and risk assessment => Costs
- Indications of extended, vessel based, operational limits
Improved Consideration

- Wind Turbine Generator Installation
  - Modelling of project time and costs
Improved Consideration

- Wind Turbine Generator Installation
  - Modelling of project time and costs
- Time & cost estimation

\[ \Delta t = f(Nr. [WTG]) \]
Improved Consideration

- Wind Turbine Generator Installation
  - Modelling of project time and costs

- Time & cost estimation

- Optimization of installation and maintenance
Summary

- Weather and soil uncertainties are the major risks for offshore operations.
- Currently, the limits are set by conservative and one-dimensional parameter.
- Field measurements, tests and numerical simulations are used to investigate multi-dimensional parameters.
- Implementation in logistics planning tool and demonstrator „COAST“
- Mitigation of risks and downtime
- Cost and risk prevention
References


- McCauley, Michael E.; Royal, Jackson W.; Wylie, C. Dennis; O’Hanlon, James F.; Mackie, Robert R. (1976): *Motion Sickness Incidence: Exploratory Studies of Habituation, Pitch and Roll, and the Refinement of a Mathematical Model*

ONP Management

Reduction of logistical risks of offshore operations

THANK YOU