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

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Wölfel

Fraunhofer IWES

Ludwig-Franzius-Institute
for Hydraulic, Estuarine and
Coastal Engineering

ONP Management

AVIMo
Active Work Vessels in Motion

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

DNV·GL

DOC® OFFSHORE

INNOVEN
INNOVATIVE ENERGY SYSTEMS

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.

Origin: El-Karim et al. (2017)

- 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

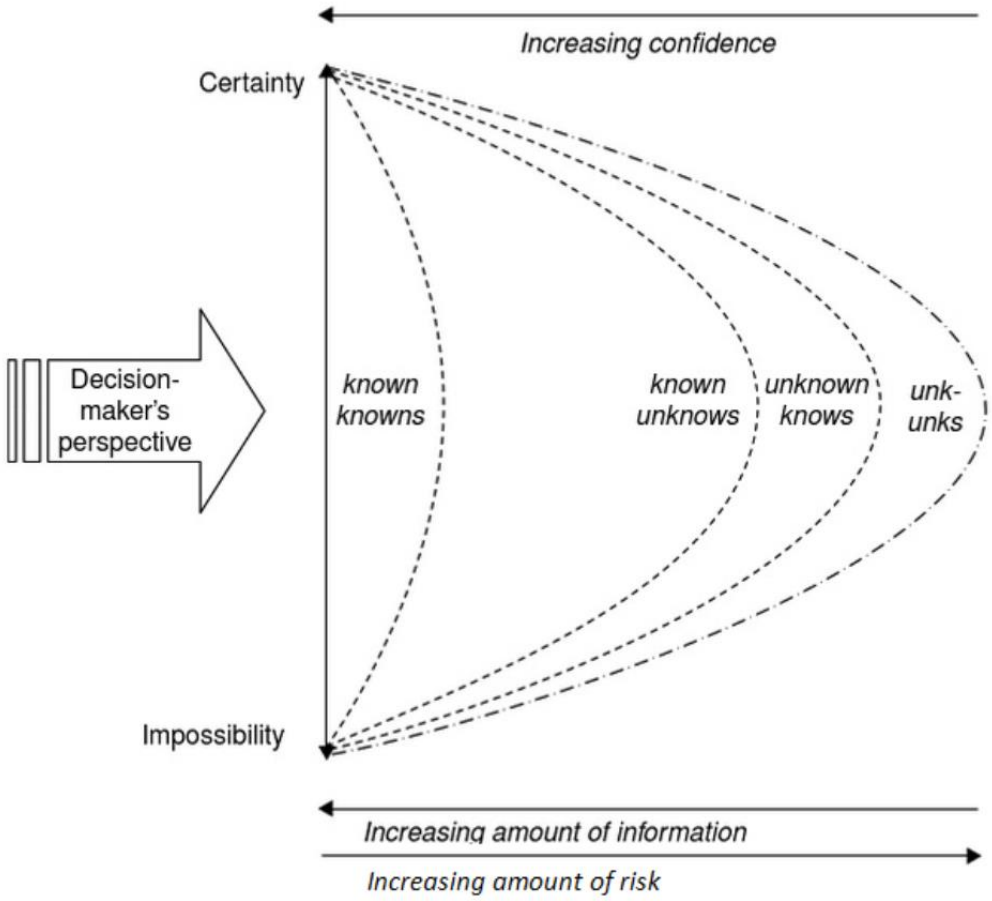
➡ Loss

➡ Time

➡ Costs

⇩

- Decision maker's (Investors, Insurance, Customer, …)



Origin: Winch (2010)

Weather Risk

- E.ON, A2Sea, Aarsleff & Bilfinger Berger

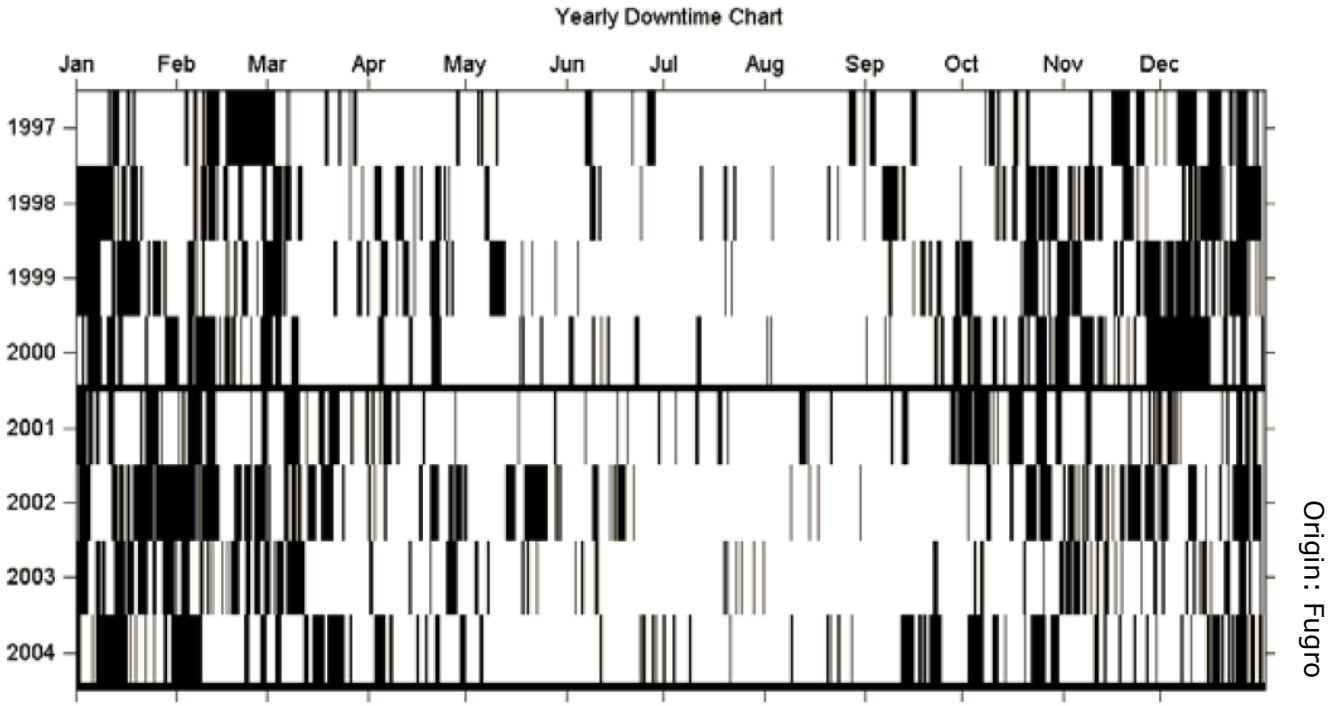
Origin: Ahlgren & Grudic (2017)

  - 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

Weather Risk

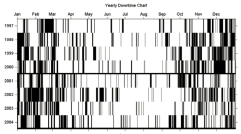


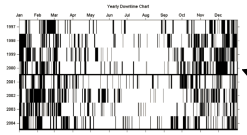
- Identifying weather windows
  - Likelihood
- Schedule operations
  - Transport
  - Installation
  - Maintenance

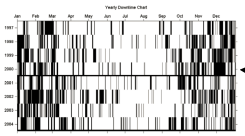
Limits of work vessels & technicians

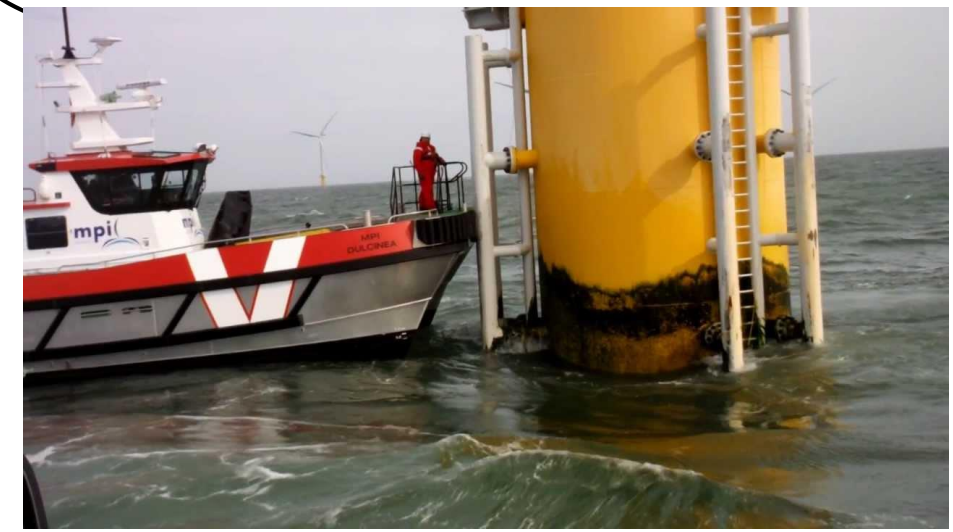
➡ Downtime

f(R&D, climate, experience)









Limits of work vessels & technicians

- Lifting:
  - ≈ < 10 m/s Wind
  - ≈ < 1.25 m Hsig
- Shipping/Towing:
  - ≈ < 5.0 m/s Hsig
- Bad Weather:
  - Stand-by
  - Evacuation
  - Safety measures

AM INTERNATIONAL
24/7 Duty Meteorologist
Phone: +44(0)1330 825519
E-mail: amioffshore@amiwx.com

MetOcean Operations Safety Checklist
Forties Field @ 57.73N / 0.87E

Tue 15 Feb 11 18:00

GMT	Evacuation	Diving	Helicopter Ops	Workboats	Pipe Laying	Flaring	Lifting	Other
Tue 15 / 18	Safe	Critical	Safe	Critical	Critical	Critical	Critical	Safe
Tue 15 / 21	Safe	Critical	Safe	Critical	Critical	Critical	Critical	Safe
Wed 16 / 00	Safe	Critical	Safe	Critical	Critical	Critical	Critical	Safe
Wed 16 / 03	Safe	Critical	Safe	Critical	Critical	Critical	Critical	Safe
Wed 16 / 06	Safe	Critical	Safe	Critical	Critical	Critical	Critical	Safe
Wed 16 / 09	Safe	Critical	Marginal	Critical	Critical	Critical	Critical	Safe
Wed 16 / 12	Safe	Critical	Safe	Critical	Critical	Critical	Critical	Safe
Wed 16 / 15	Safe	Critical	Safe	Critical	Critical	Critical	Critical	Safe
Wed 16 / 18	Safe	Critical	Safe	Critical	Critical	Safe	Critical	Safe
Wed 16 / 21	Safe	Critical	Safe	Critical	Critical	Safe	Critical	Safe
Thu 17 / 00	Safe	Critical	Safe	Safe	Critical	Safe	Critical	Safe
Thu 17 / 03	Safe	Critical	Safe	Safe	Critical	Critical	Critical	Safe
Thu 17 / 06	Safe	Marginal	Safe	Safe	Marginal	Critical	Critical	Safe
Thu 17 / 09	Safe	Safe	Safe	Safe	Marginal	Critical	Critical	Safe
Thu 17 / 12	Safe	Safe	Safe	Safe	Marginal	Critical	Critical	Safe
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Thu 17 / 18	Safe	Marginal	Safe	Safe	Marginal	Critical	Critical	Safe
Thu 17 / 21	Safe	Critical	Safe	Safe	Critical	Critical	Critical	Safe
Fri 18 / 00	Safe	Critical	Safe	Safe	Critical	Critical	Critical	Safe
Fri 18 / 03	Safe	Critical	Safe	Safe	Critical	Critical	Critical	Safe
Fri 18 / 06	Safe	Critical	Safe	Safe	Critical	Critical	Critical	Safe
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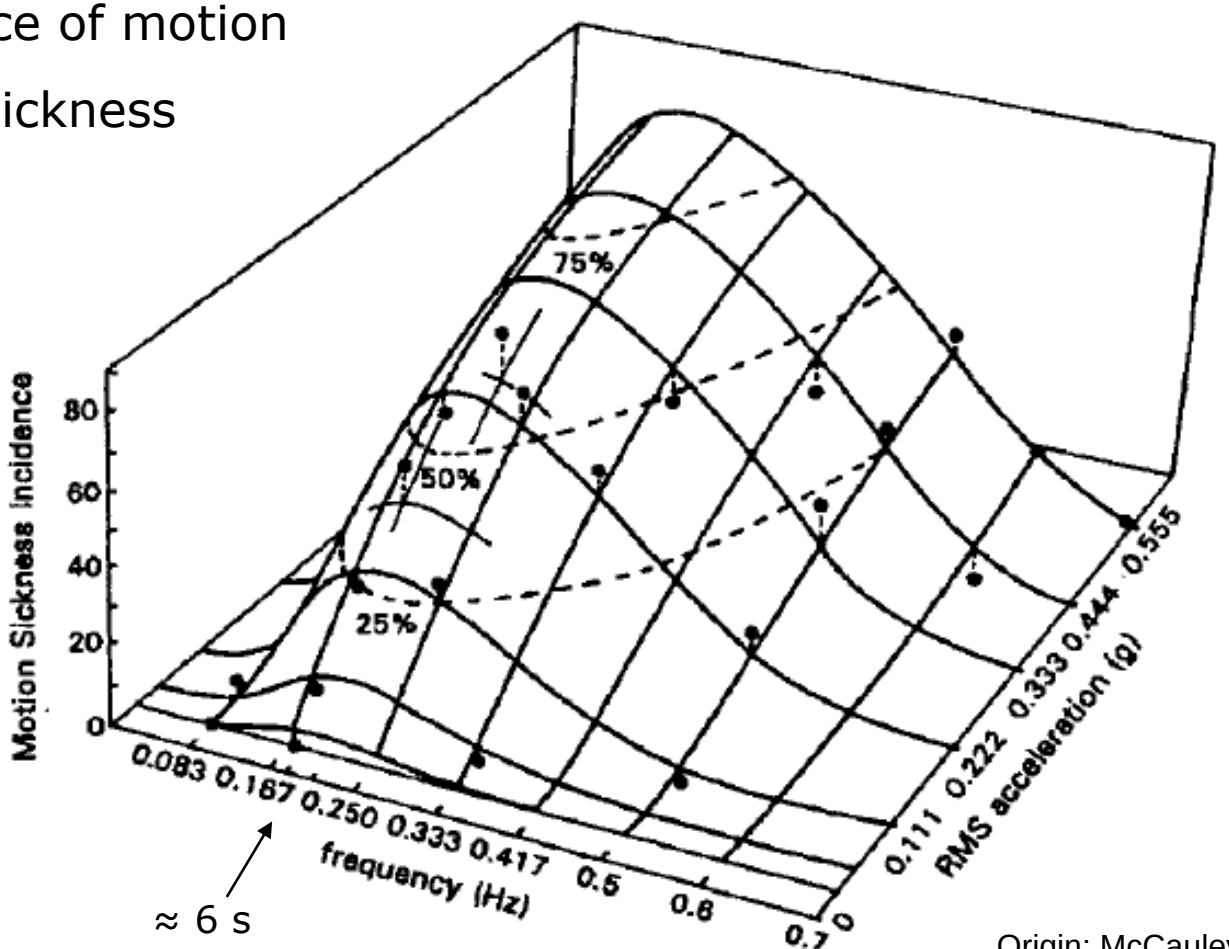
Fri 18 / 15	Safe	Critical	Safe	Marginal	Critical	Critical	Critical	Safe
Fri 18 / 18	Safe	Critical	Safe	Critical	Critical	Critical	Critical	Safe

Limits of work vessels & technicians

- Influence of motion on seasickness



Origin: McCauley et al. (1976)

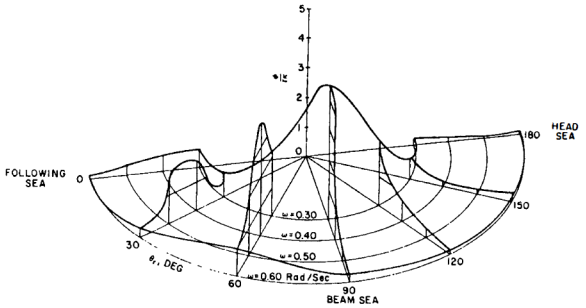
Core Objectives of "AVIMo"

- 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

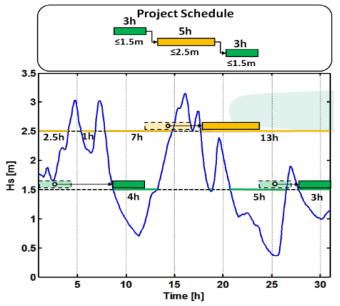
⇨ Risk and cost reduction by means of case-dependent operational limits

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

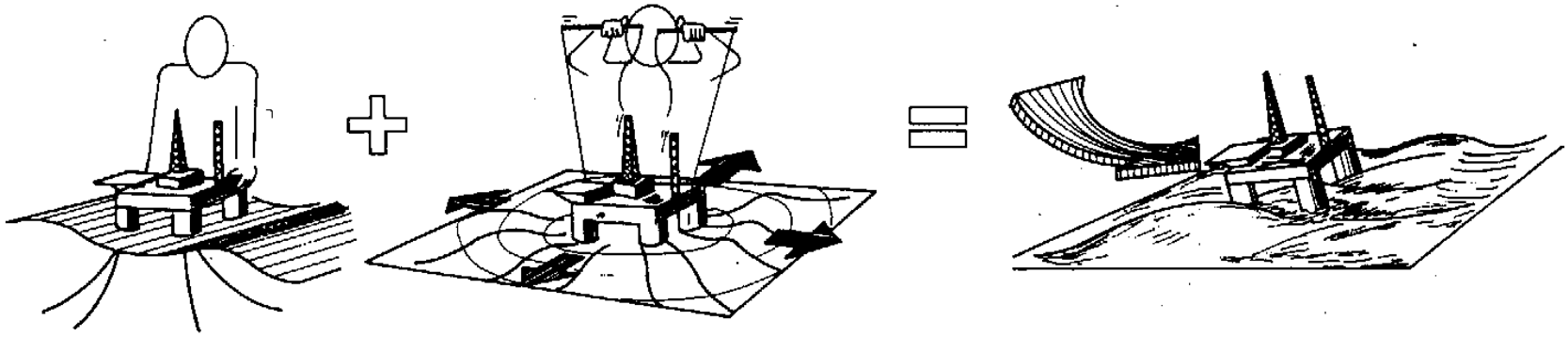


- Demonstration of cost and risk prevention by assessing work assignments with "COAST"



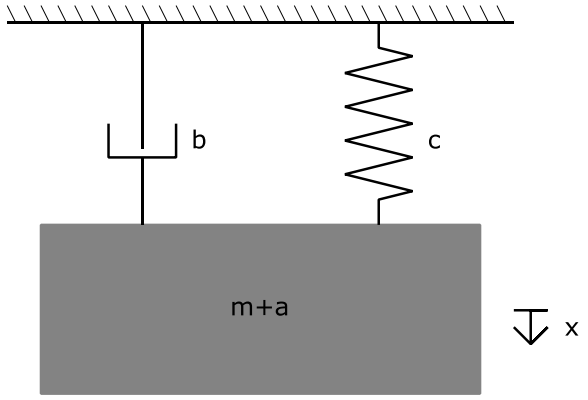
Modelling of structural response

- Structural motion and response in waves



Origin: Faltinson (1990)

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



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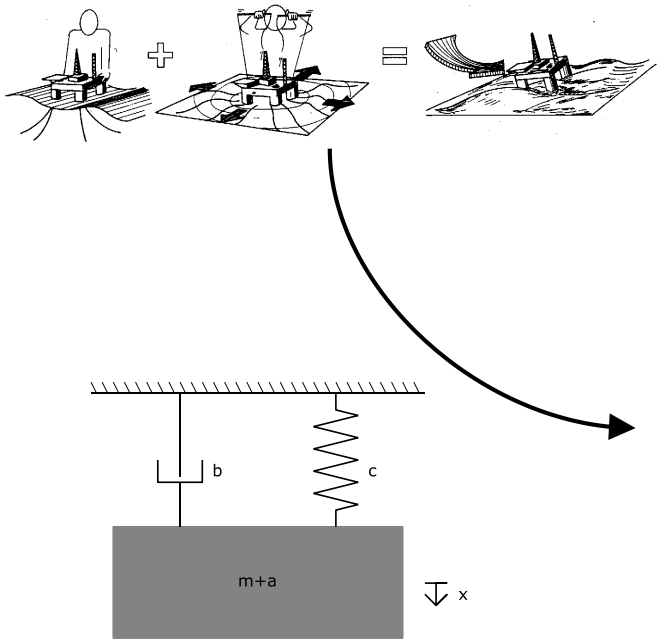
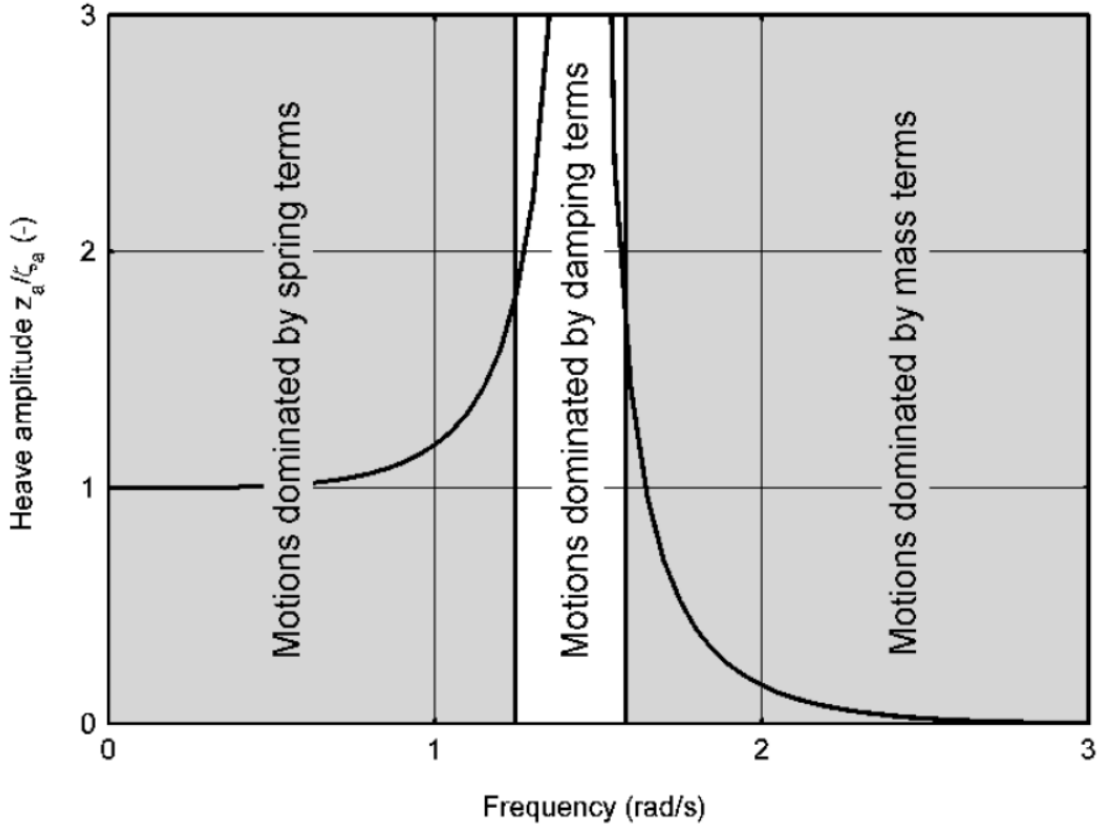




Modelling of structural response

$$(m+a)\,\ddot{z} + b\dot{z} + cz = a\ddot{\zeta}^{*} + b\dot{\zeta}^{*} + c\zeta^{*}$$

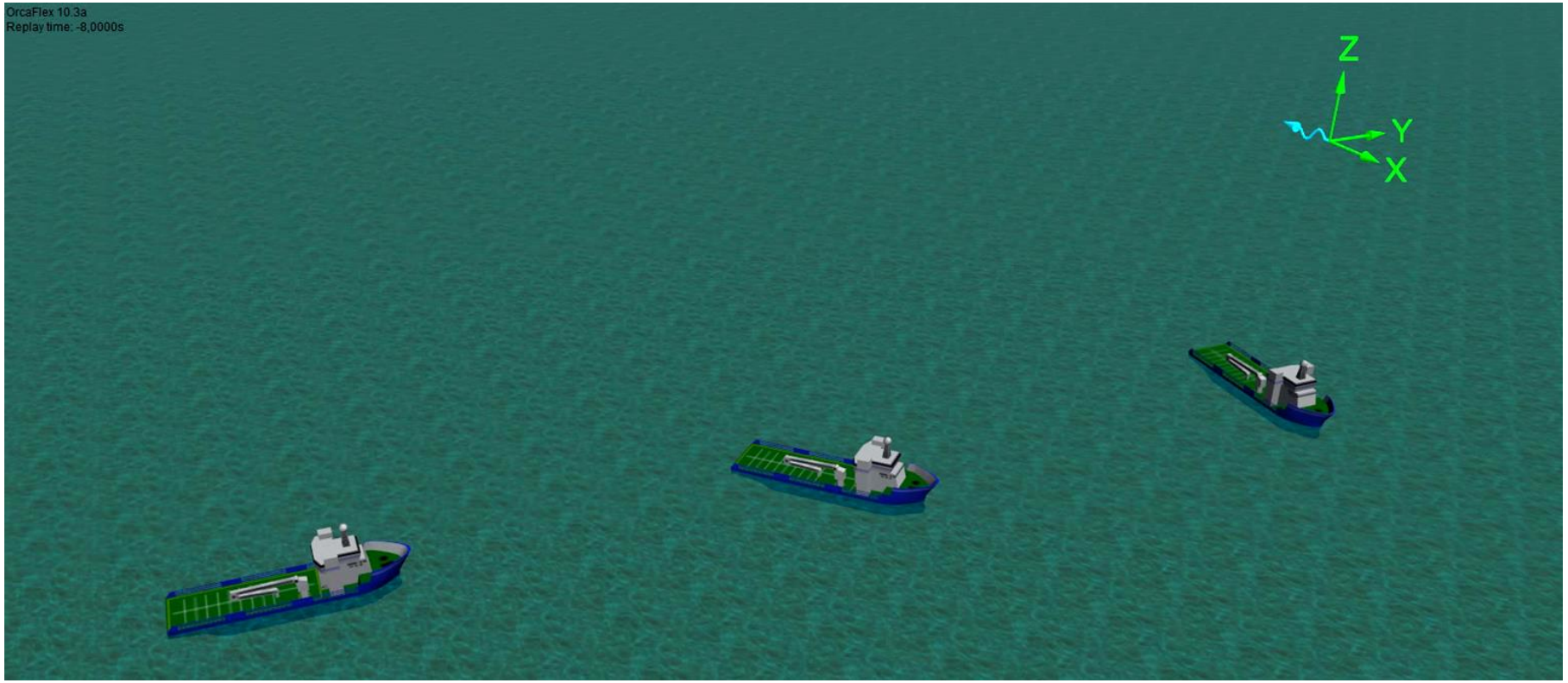
$$\begin{aligned} z &= z_a \cos(\omega t + \varepsilon_{z\zeta}) & \zeta^{*} &= \zeta_a e^{-kT} \cos(\omega t) \\ \dot{z} &= -z_a \omega \sin(\omega t + \varepsilon_{z\zeta}) & \dot{\zeta}^{*} &= -\zeta_a e^{-kT} \omega \sin(\omega t) \\ \ddot{z} &= -z_a \omega^2 \cos(\omega t + \varepsilon_{z\zeta}) & \ddot{\zeta}^{*} &= -\zeta_a e^{-kT} \omega^2 \cos(\omega t) \end{aligned}$$

$$\begin{aligned} & z_a \left\{c - (m+a)\,\omega^2\right\} \cos(\omega t + \varepsilon_{z\zeta}) - z_a \left\{b\omega\right\} \sin(\omega t + \varepsilon_{z\zeta}) = \\ = \; & \zeta_a e^{-kT} \left\{c - a\omega^2\right\} \cos(\omega t) - \zeta_a e^{-kT} \left\{b\omega\right\} \sin(\omega t) \end{aligned}$$

- Estimation of operational limits by

  field-, **laboratory-**, and **numerical** investigations

Modelling of structural response



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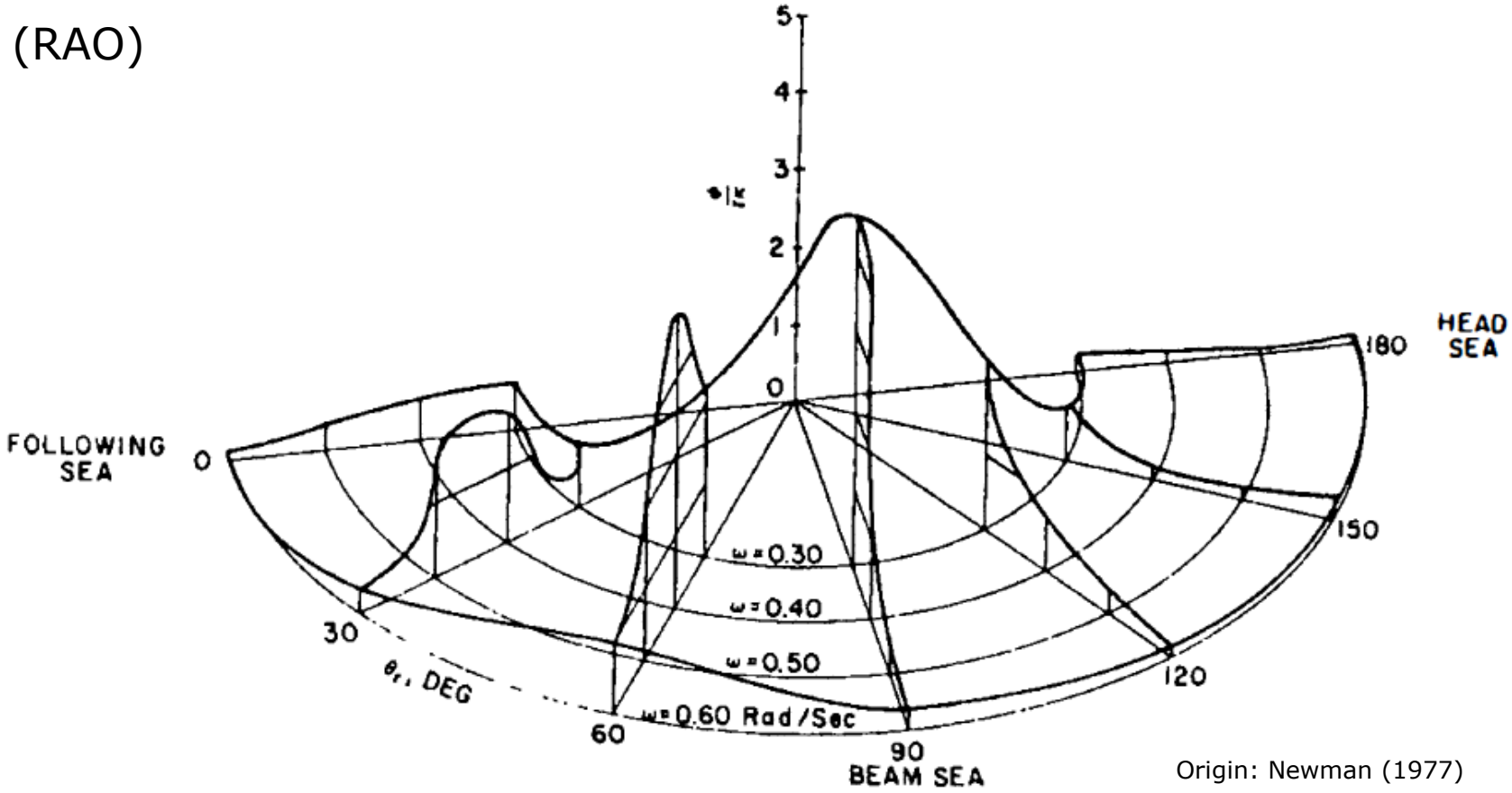
Improved Considerations

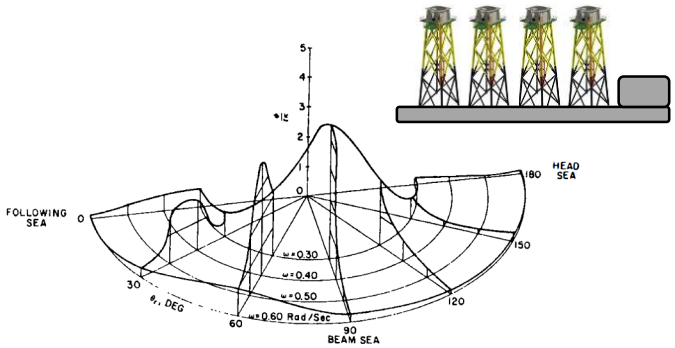
- Response Amplitude Operator (RAO)

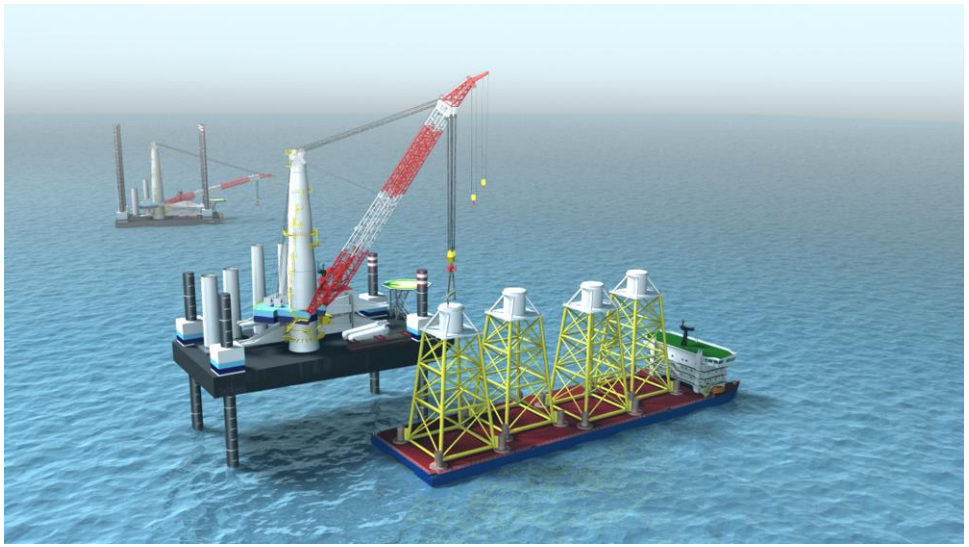


Origin: Newman (1977)

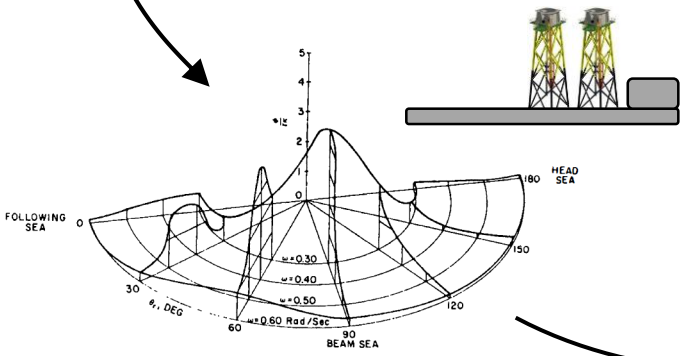
Improved Considerations

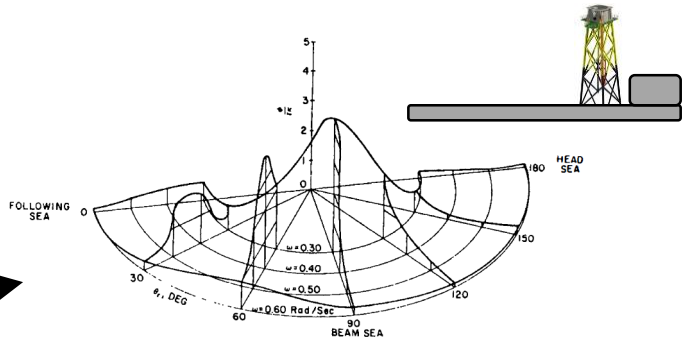
- Case sensitive RAO





Quelle: MBM Consultancy





Core Objectives of "AVIMo"

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Recommendations & Practical Applications

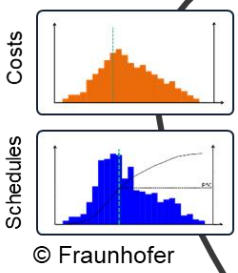
Model tests for selected work vessels

Industrial Partners & Technical committee

Vessel motion analysis & Offshore field measurements

Indications of extended, vessel based, operational limits

Effects on logistics and risk assessment => Costs



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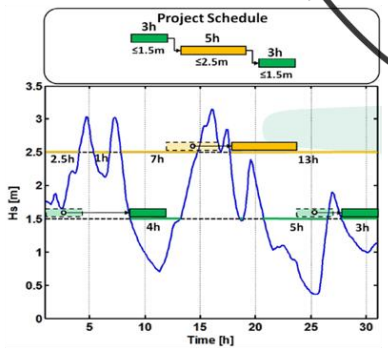
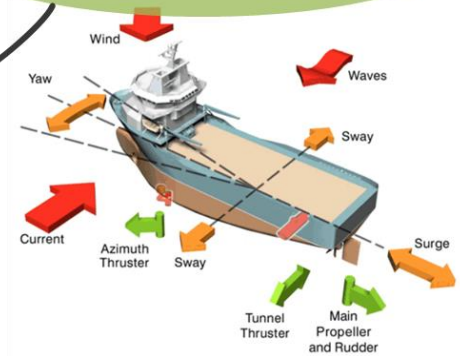
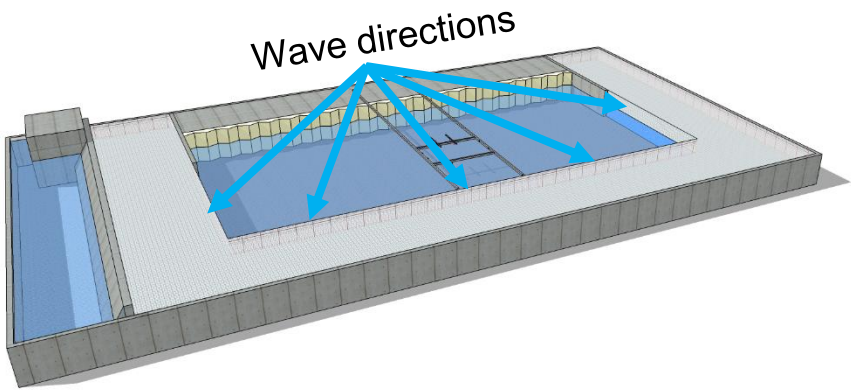




Physical & Numerical modelling

- Wave generation
  - Regular waves
  - Irregular sea states
- Directional spectra
  - 5° - 175°
- Wave height:
  - max. 0.47 m



Landmann, 2018

Kerpen, 2011

Physical & Numerical modelling

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

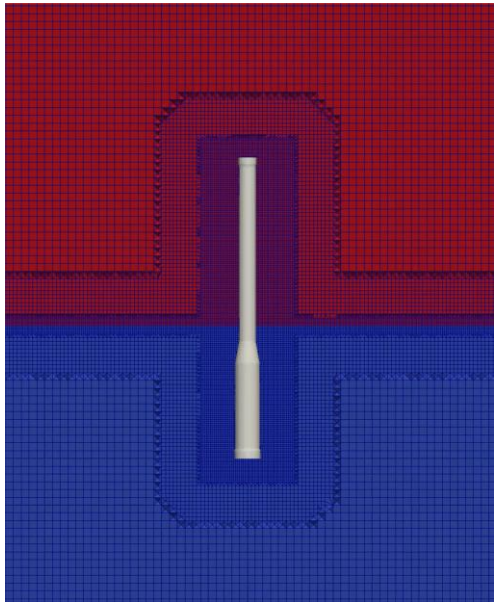
offshoreWIND, 2019

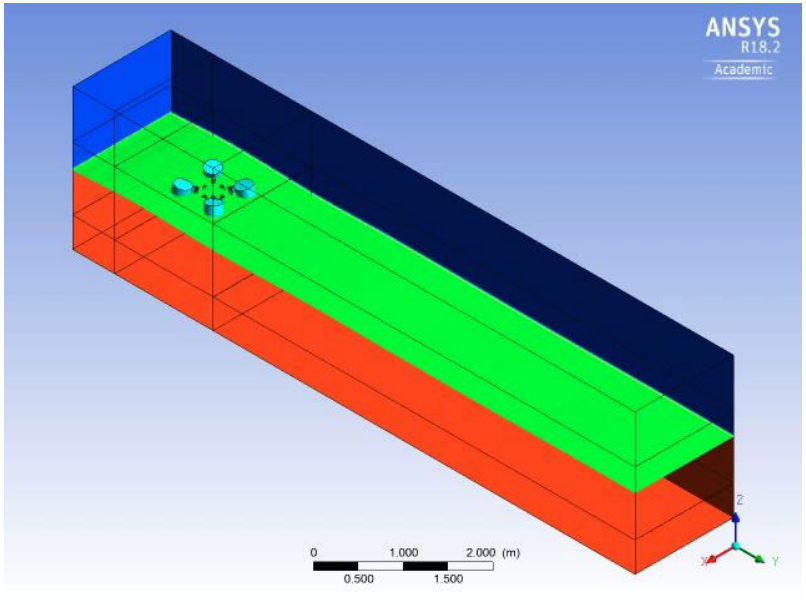
NauticExpo, 2019

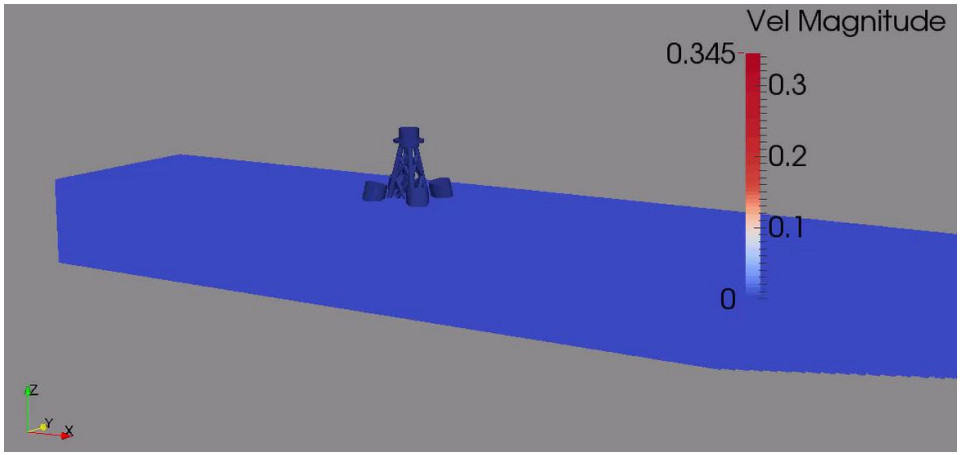
SeaInstaller, 2019

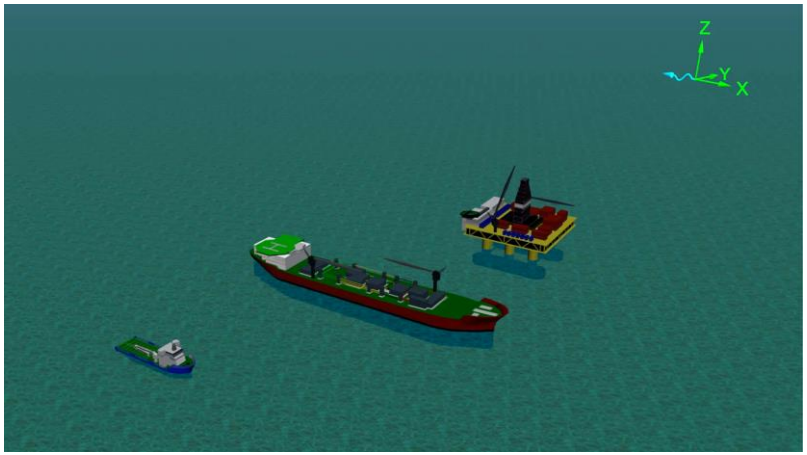
Physical & Numerical modelling

- Num. vs Lab.
  - Analytical
  - Meshless
  - CFD
- Ext. scenarios
- Field data









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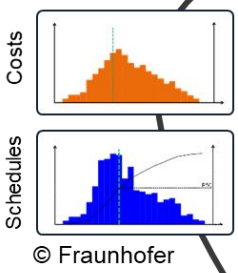

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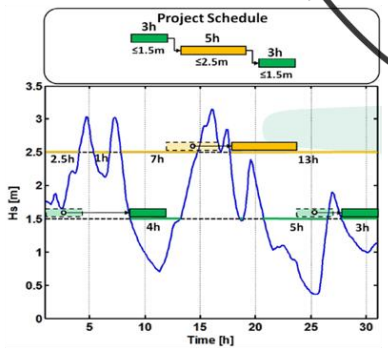
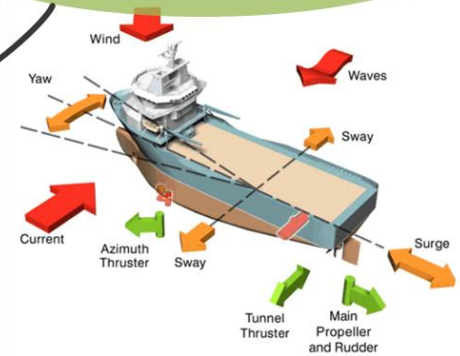
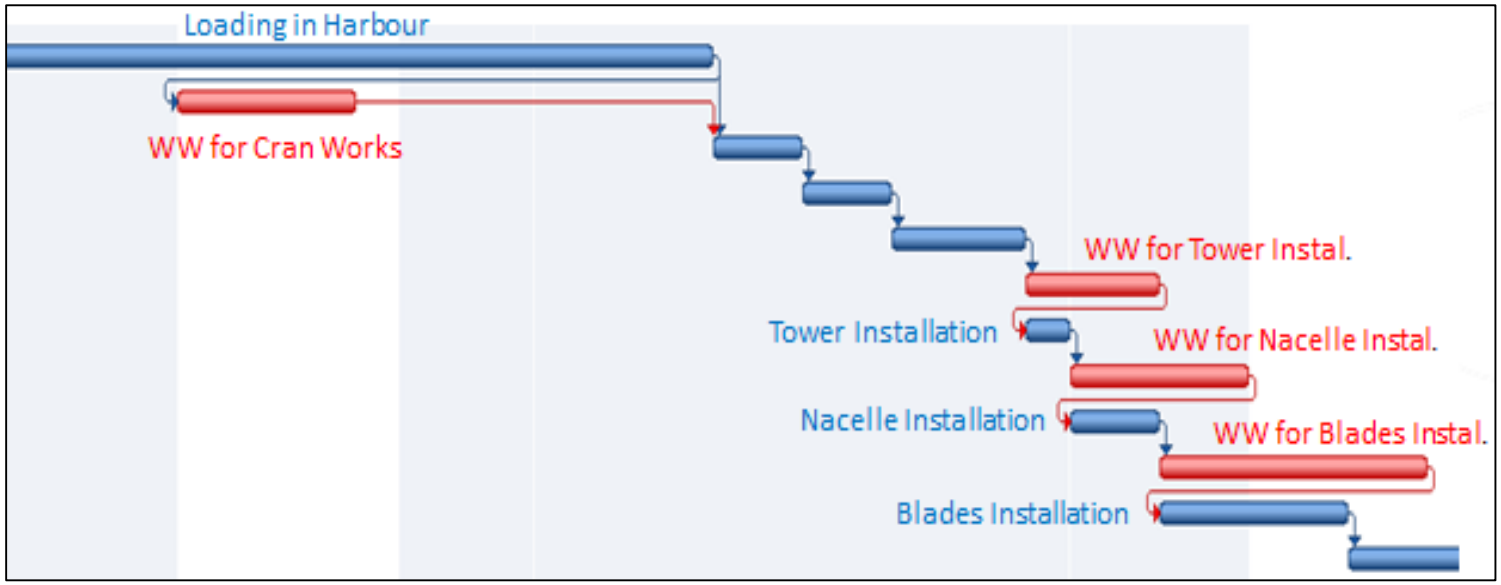




Improved Consideration

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



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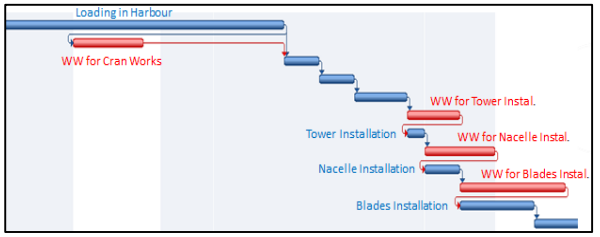
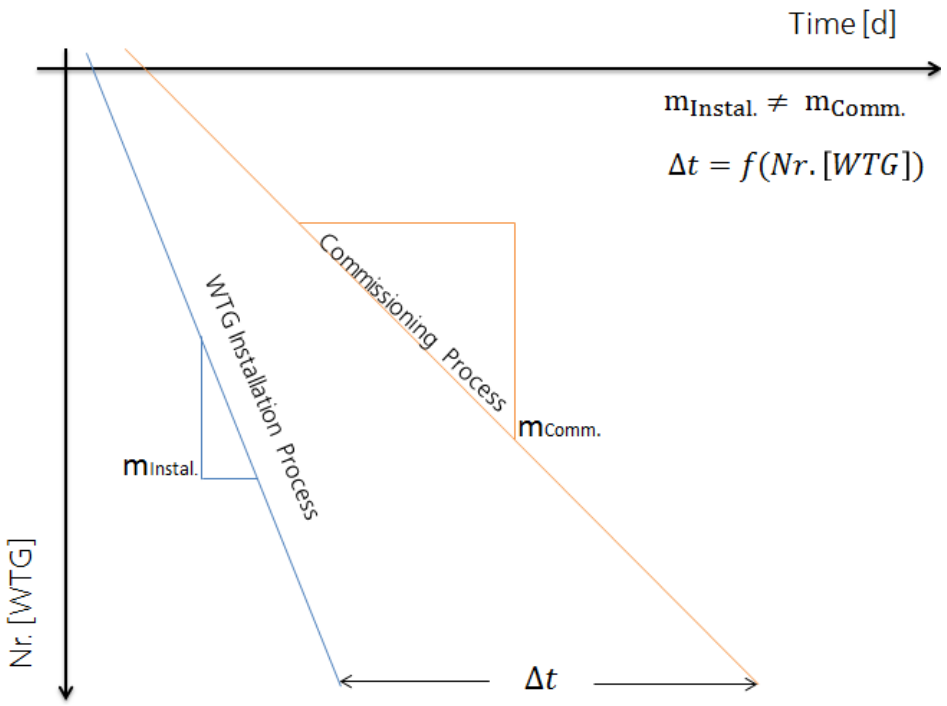


- Time & cost estimation



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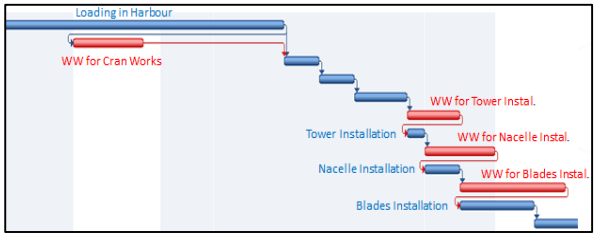
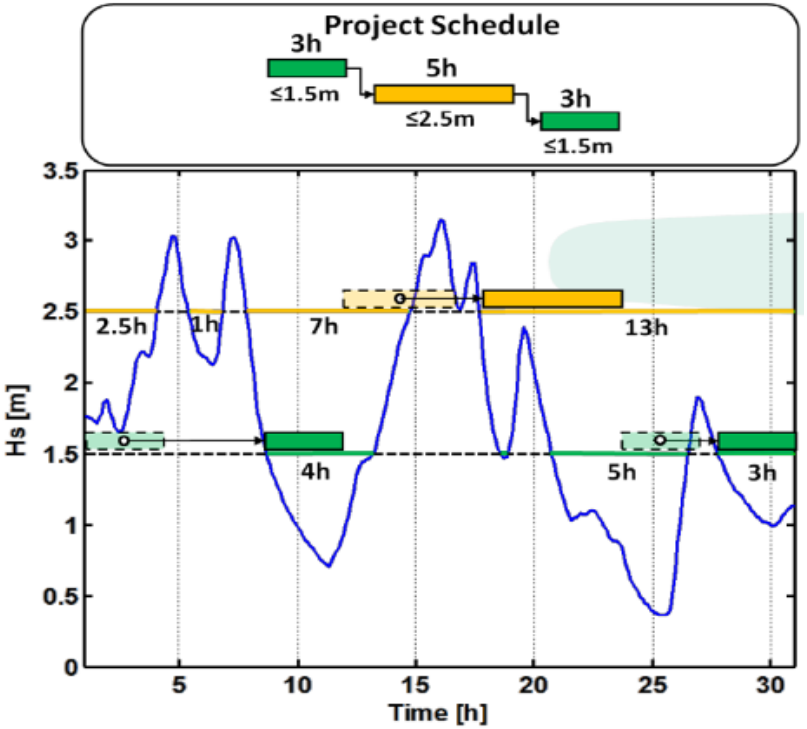


- Time & cost estimation

- Optimization of installation and maintenance

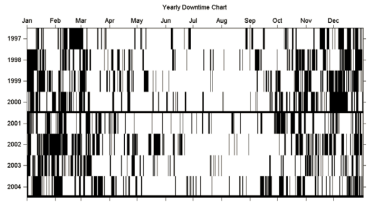


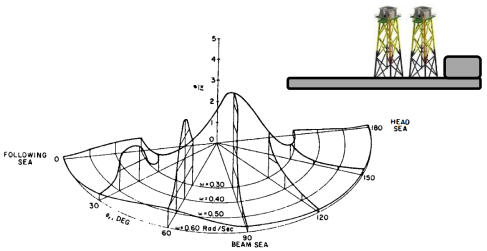
Summary

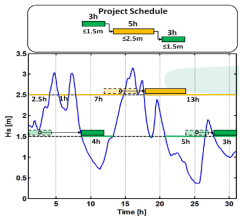
- Weather and soil uncertainties
  are the major risks for offshore operations
- Currently, the limits are set by conservative
  and one-dimensional parameter
- Field measurements, tests and
  numerical simulations are used to
  investigate multi-dimensional parameters
- Implementation in logistics planing
  tool and demonstrator „COAST“

⇨ Mitigation of risks and downtime

⇨ Cost and risk prevention







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AVIMo
Active Work Vessels in Motion

Gefördert durch:

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für Wirtschaft
und Energie

aufgrund eines Beschlusses
des Deutschen Bundestages

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THANK YOU