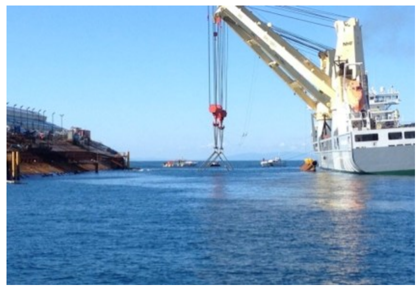
Presentation for
Defense of Master Thesis

Hydrodynamic Analysis of a Heavy Lift Vessel during Offshore Installation Operations



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Supervisor: Prof. Robert Bronsart

23rd Feb, 2015 Nantes

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- I. Comparison on Seakeeping Codes
- II. Zero speed case study: multi-body interaction
- III. Zero speed case study: offshore lifting
- ✓ Key remarks

General Information

Assumption

- Potential flow theory
- Airy wave
- With / without additional viscous damping
- As engineering supports

Implementation method

- Numerical simulations

Verification

- By testing cases
  - Comparing with existing database/ other software
  - Comparing with data from published paper

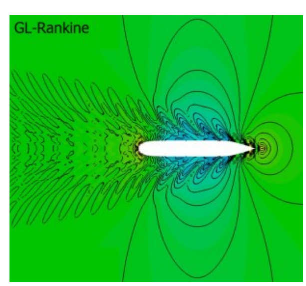
I. Comparison on Seakeeping Codes

Seakeeping methods in Comparisons:

- ✓ Rankine Source Method
- ✓ Approximate Forward Speed (AFS) Method
- ✓ 2-D Strip Method

Related Software:

- GL-Rankine: 3-D source distribution. i.e. →
- DNV/Wasim: 3-D source distribution
- Octopus: 2-D strip method

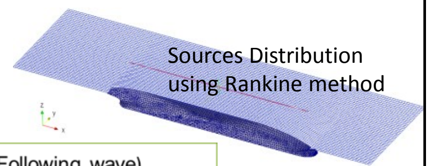


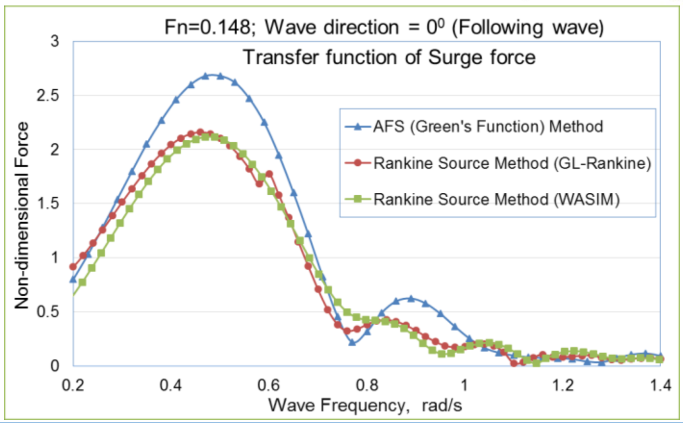
Wave Pattern
(Rankine Source Method)

I. Comparison on Seakeeping Codes

1. Rankine Source Method vs. AFS Method

- ✓ Selected case: Fn=0.148
- ✓ No viscosity

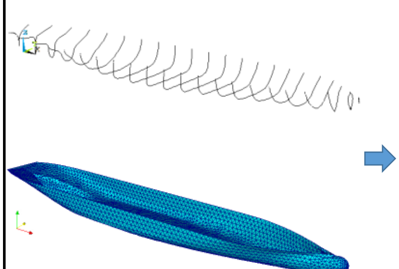




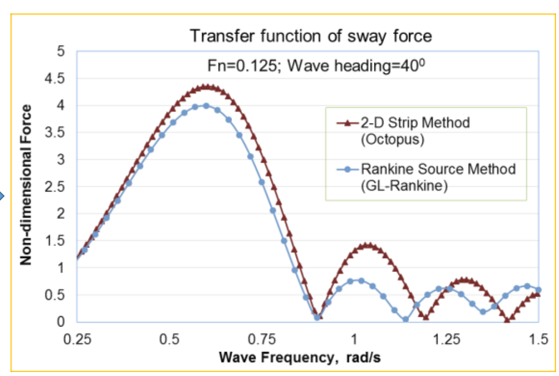
I. Comparison on Seakeeping Codes

2. Rankine Source Method vs. 2-D Strip Method

- ✓ Selected case: Fn=0.125
- ✓ No viscosity



2-D strips vs. 3-D panels

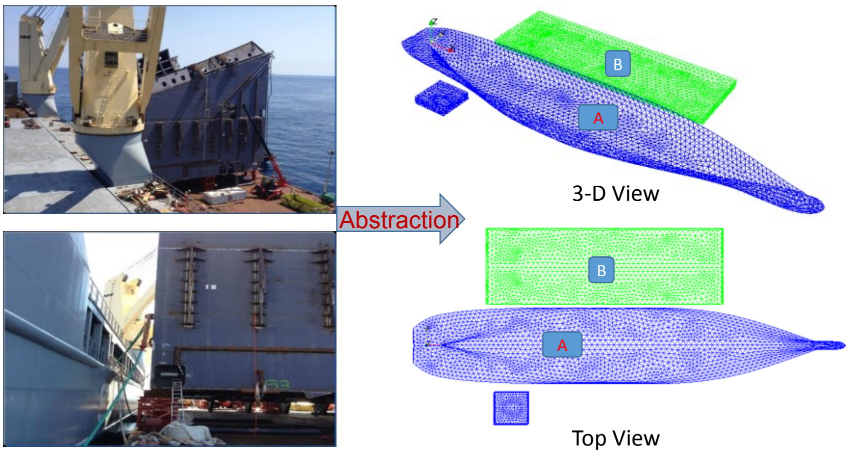


Transfer functions
(using different methods)

II. Case Study: Multi-body interaction

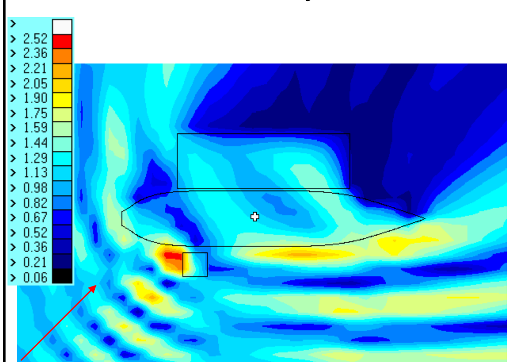
Studied case: Heavy Lift Vessel (HLV) + Transport Barge

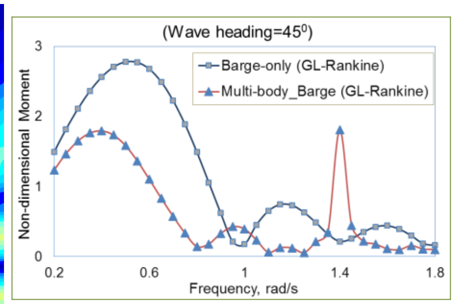
- ✓ Frequency-domain analysis
- ✓ Additional roll damping ratio
- ✓ Free-free interaction
- ✓ 'Shallow' water



II. Case Study: Multi-body interaction

Studied case: Heavy Lift Vessel + Transport Barge





Resulting wave field at ω=1.27 rad/s (wave heading=45 degree)

Barge: Transfer Function of Roll moment

(Single body vs. Multi-body case)

II. Case Study: Multi-body interaction

Studied case: Heavy Lift Vessel + Transport Barge

Discussion aspects:

- Asymmetric structure ➡ ✓ Products of inertia matrix:

For HLV: Main hull+ Pontoon — Ixy, Iyx; Ixz, Izx; Iyz, Izy;

- Irregular frequency ➡ ✓ Standing waves inside the body

'Noisy' transfer function — Internal boundary with sources distribution

II. Case Study: Multi-body interaction

Studied case: Heavy Lift Vessel + Transport Barge

Discussion aspects:

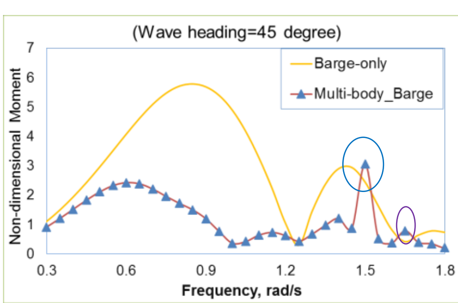
- Resonance Trapped Waves In the gap ➡ Resonant motions: 3 modes

✓ Piston mode motion

✓ Longitudinal sloshing mode

✓ Transverse sloshing mode

Estimation (methods in DNV rules): ωn= 1.46 rad /s (Piston mode)



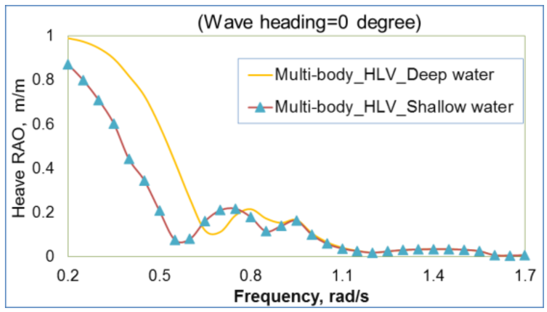
Barge: Transfer function of yaw moment (single body vs. multi-body case)

II. Case Study: Multi-body interaction

Studied case: Heavy Lift Vessel + Transport Barge

Discussion aspects:

- Limited water depth ➡ D/λ



HLV: Heave RAO under different water depths
(D_shallow =20 m vs. D_deep =1000 m)

III. Case Study: Offshore lifting

Different phases of a typical subsea lift

- Phase I: lift off / object clear of transportation vessel.
- Phase II: lowering through the wave zone.
- Phase III: further lowering down to sea bed.
- Phase IV: positioning and landing

Simulation tool: Orcaflex

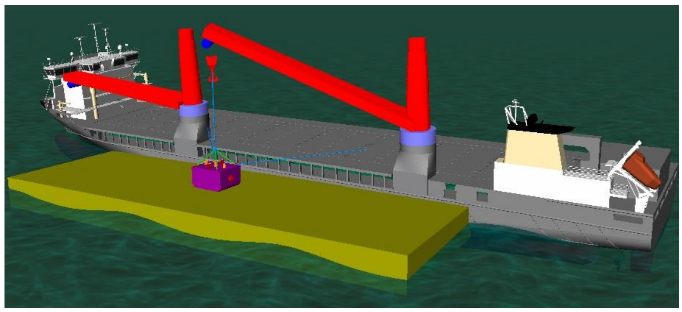
Settings

- In time domain, in limited water depth
- RAOs of vessels imported
- Rigid crane
- No heave compensating assumed

III. Case Study: Offshore lifting

Case I: Lift-off simulation

- ✓ Regular waves
- ✓ Motion constraints
- ✓ Multi-body: HLV + Barge



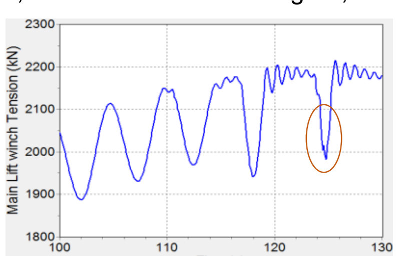
Models in Orcaflex (whole model)

III. Case Study: Offshore lifting

Case I: Lift-off simulation

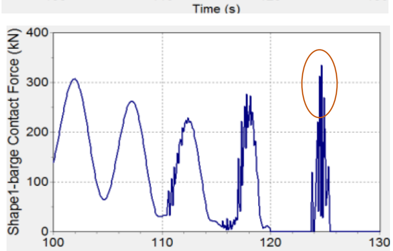
i.e. U=0.02 m/s, Wave direction=195 degree, H=0.75 m/s, Tz=5.25 s

Crane Wire Tensions



→ Re-hit happens

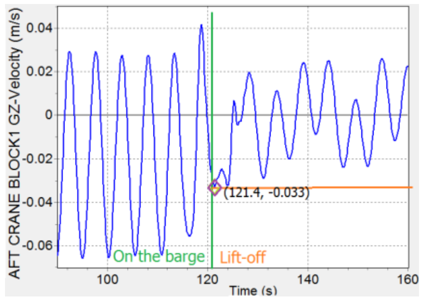
Contact Forces on Barge



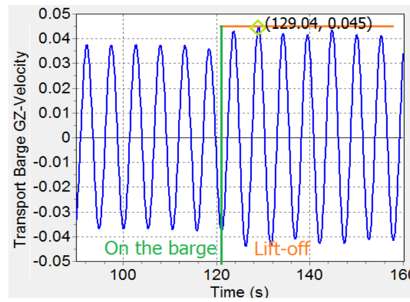
III. Case Study: Offshore lifting

Case I: Lift-off simulation

i.e. U=0.02 m/s, Wave direction=195 degree, H=0.75 m/s, Tz=5.25 s



Vertical velocity of crane tip



Vertical velocity of transport barge

Max. negative velocity | Max. positive velocity

Fast estimation:
Lifting speed U = 0.033+ 0.045 = 0.078 m/s

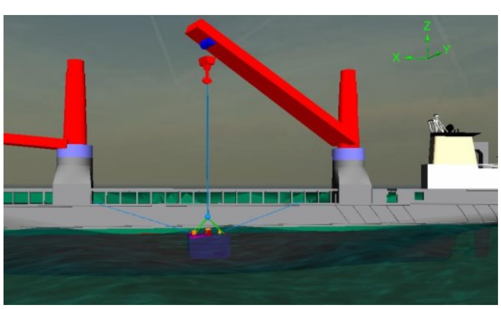
Conservative

III. Case Study: Offshore lifting

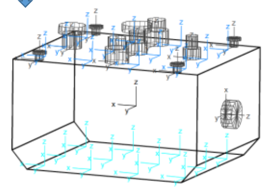
Case II: Lowering Through the Splash Zone

- ✓ Irregular waves
- ✓ Single vessel: HLV
- ✓ Critical positions (Analyzed without lowering speed)

Lifted object:
- Weight and inertial loads.
- Buoyancy, added mass, damping and drag.
- Slam forces.



Models in Orcaflex

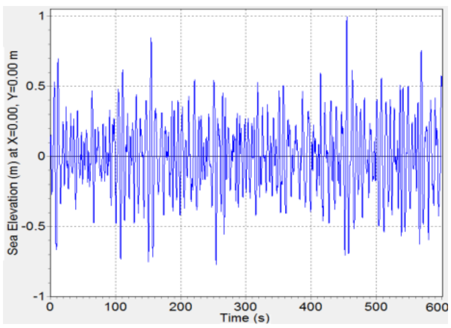


Cargo model

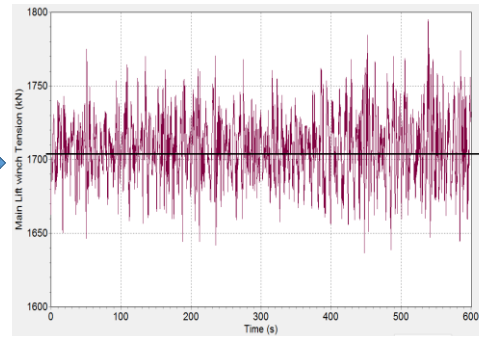
III. Case Study: Offshore lifting

Case II: Lowering Through the Splash Zone

- ✓ Irregular waves
- ✓ Critical positions (Analyzed without lowering speed)



Wave train
(Jonswap: Hs= 1.0 m; Tp= 7.5 s)

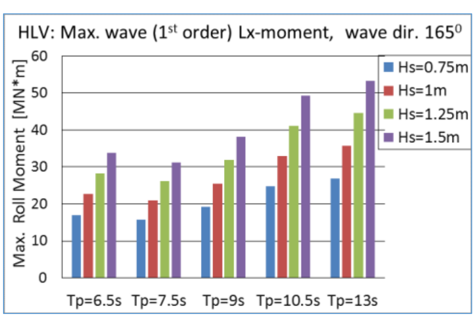


Rigging loads, fully submerged position
(wave heading=165^0)

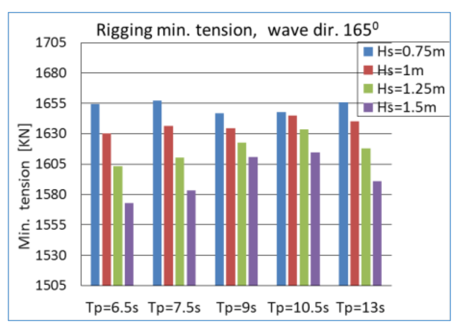
III. Case Study: Offshore lifting

Case II: Lowering Through the Splash Zone

- ✓ i.e. Fully submerged position



HLV: severe roll moments
(Wave heading=165^0)



Min. rigging tensions
(Wave heading=165^0)

→ Risk of snap forces(compression on wires):

Does dynamic tension fall below 10 % of F_static ⟶ No

Key remarks

- ✓ Seakeeping (Fn>0)

  Comparing with Rankine source method:
  - AFS method : workable estimation at low Fn
  - 2-D strip method: conservative

- ✓ Multi-body interaction in frequency domain
  - Additional radiation
  - Resonance trapped waves
  - Shallow water effect

- ✓ Offshore lifting in time domain
  - Lift-off speed → avoid re-hit
  - Lowering through splash zone: Variable hydrodynamic loads (time-dependent, position-dependent)