Numerical Crashworthiness Analysis of a Spar Floating Offshore Wind Turbine Impacted by a Ship (influencing parameters)

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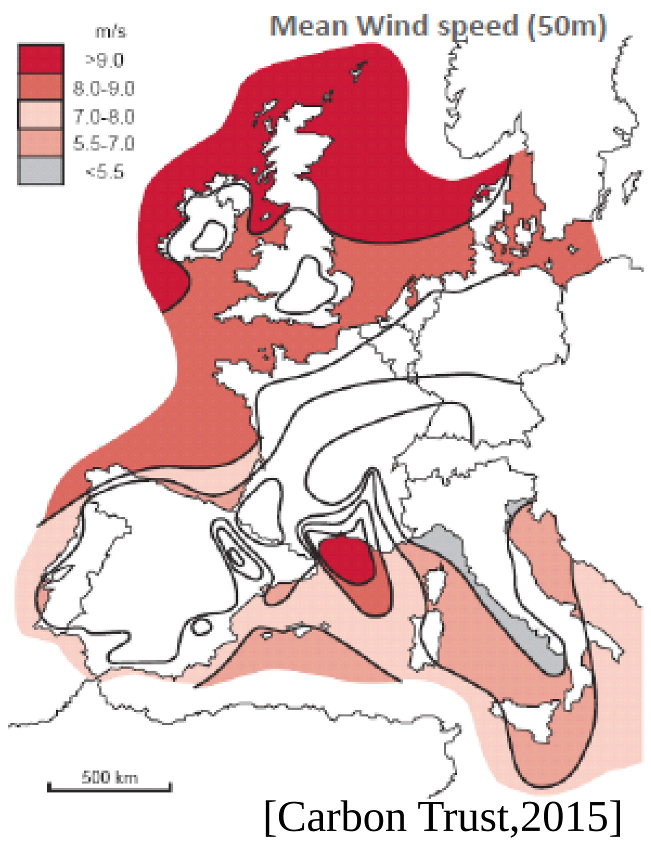
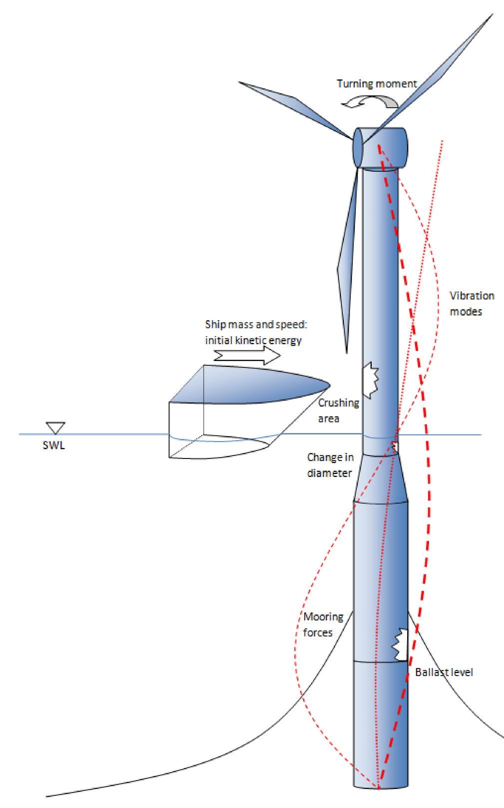
Introduction

- New floating wind farms
- Deeper water
- Closer to traffic lanes
- Regular maintenance
- Higher risk of collision



[Carbon Trust,2015]

Collision scenario



Inputs
Ship
- Mass
- Initial Velocity
- Hydrodynamic properties
- Collision direction

FOWT
- Structural parameters
- Hydrodynamic properties

Outputs
- Deformation modes
- Contact force
- Rigid body kinematics

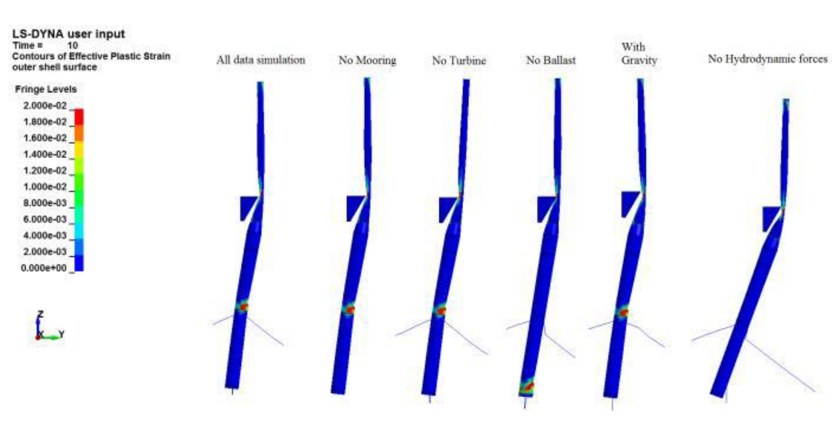
Crew Transfer Vessel
Northern Offshore Group

CMA CGM
Maersk-Safmarine

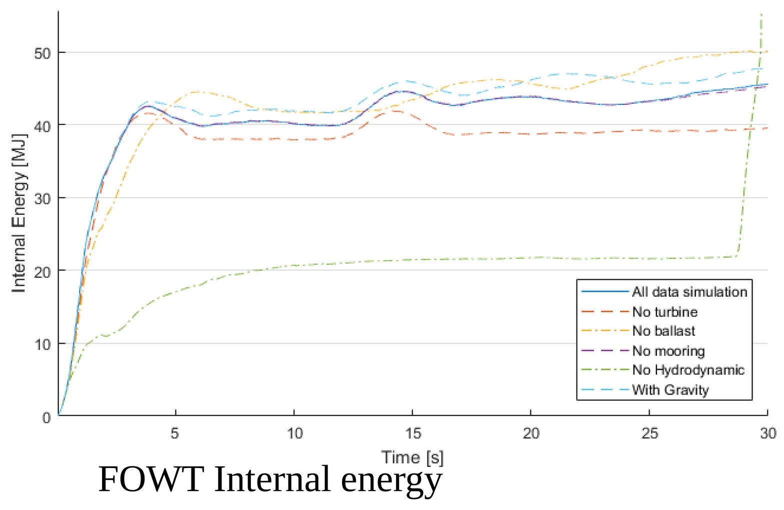
Example of ships considered in the collision scenario

Main results

Parametric analysis

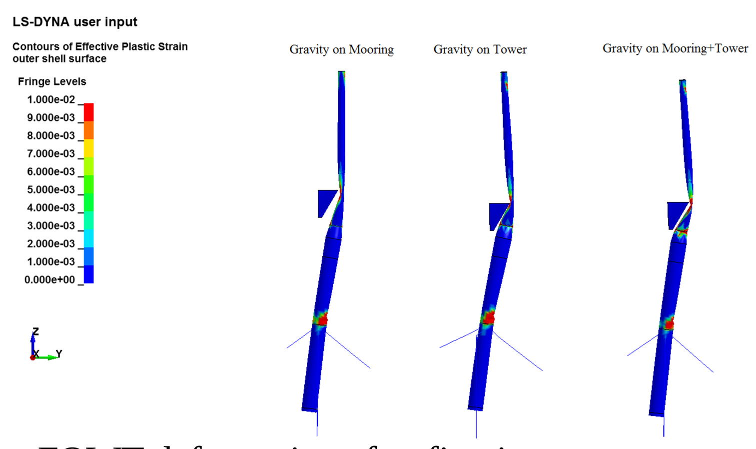


FOWT deformation after first impact
Collision with 6kton OSV at 5 m/s



FOWT Internal energy

Influence of Gravity loads



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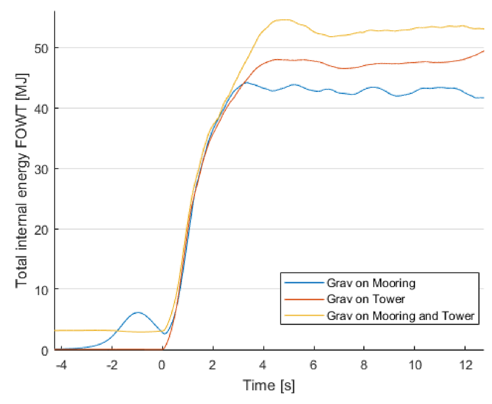
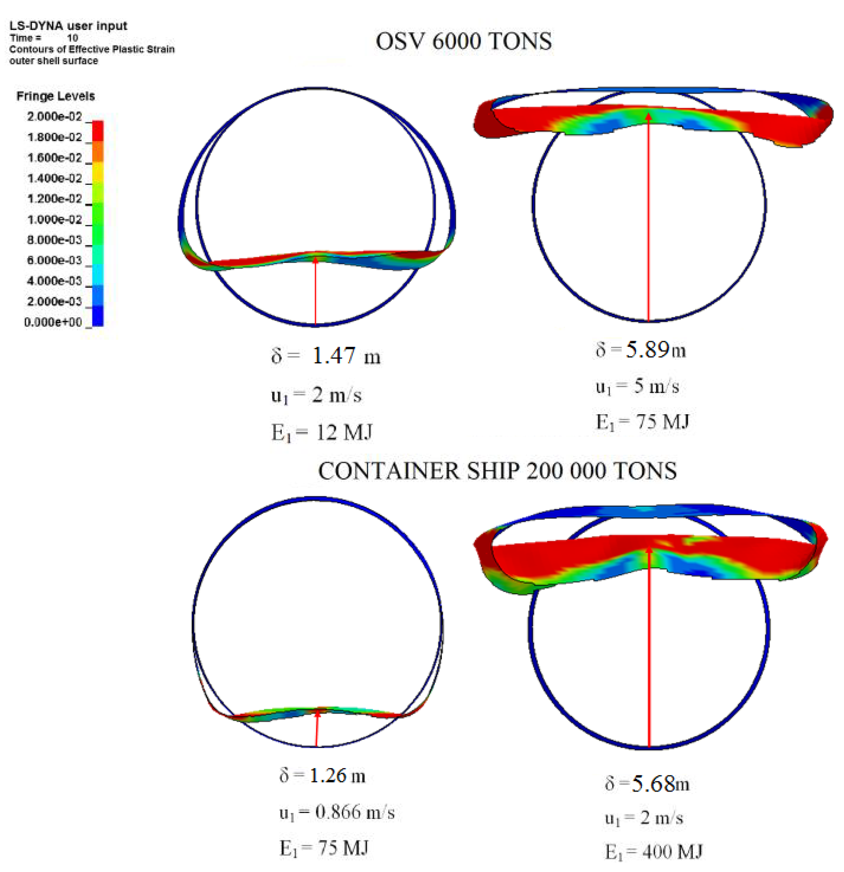


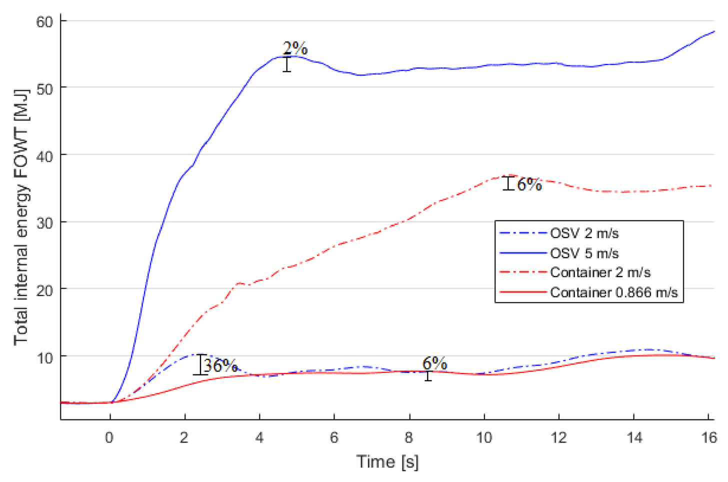
Internal energy for each gravity case (data in MJ)

Part	No Gravity	G on Mooring	G on Tower	G on Mooring and Tower
Tower	17.4	18.2	20	30
Tank	21.9	20	26	15
Cone	0.84	0.8	1.2	5
Mooring	0.003	3	0.0012	3

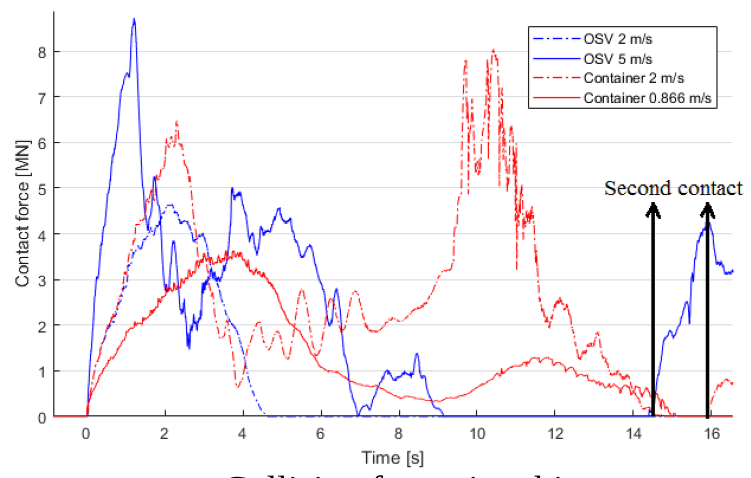
Two ships collision scenarios



FOWT crushed area
Collision with 200kton container ship and 6kton OSV

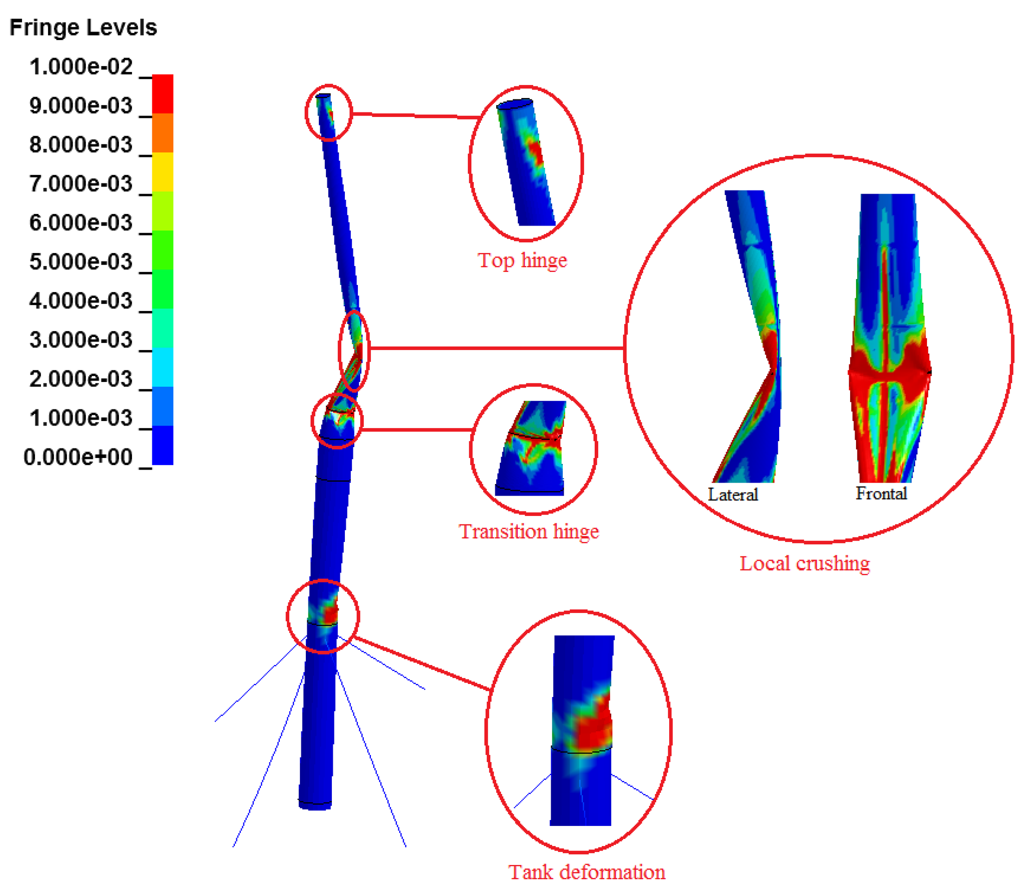


FOWT internal energy time history

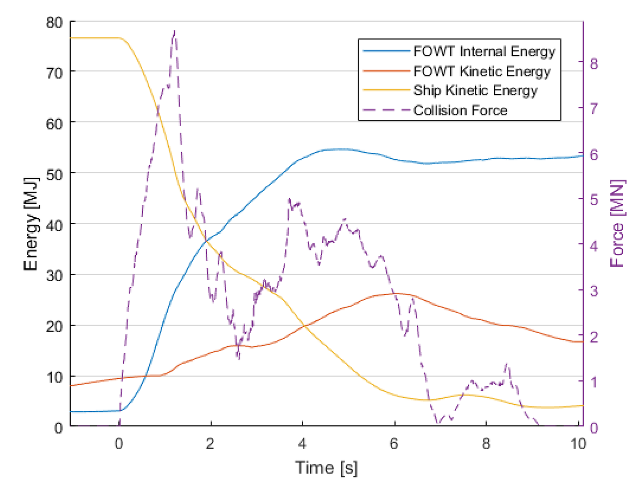


Collision force time history

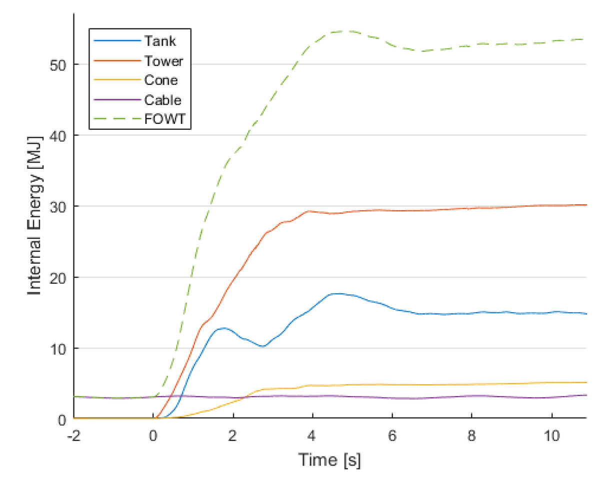
Deformation modes



FOWT deformation after first impact
Collision with 6kton OSV at 5 m/s



Energy balance



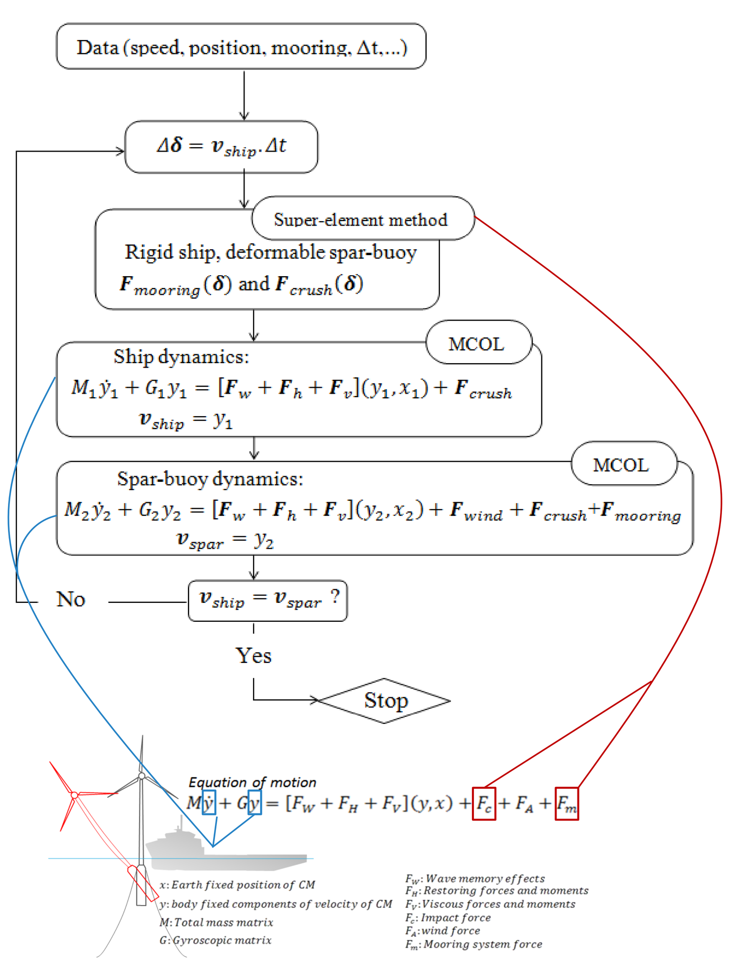
Internal energy distribution

Conclusions

- Non-linear finite element simulations were run considering the striking ship as rigid, knowing that this assumption overestimates the FOWT deformation, in comparison with a deformable ship
- Gravity is of great influence in any collision case when a floating structure is involved. Moreover, when a catenary mooring system is used
- The main deformation modes of a spar buoy FOWT collided by a ship are: plastic indentation in the collided area (*local mode*), beam-like response of the overall FOWT (*global mode*), plastic deformation near the ballast level (*elephant foot*), and seakeeping response governed by mooring stabilization
- The hinge in the transition piece due to punching of the tower, will be accounted as part of the global mode in the semi-analytical method.

Current and future work

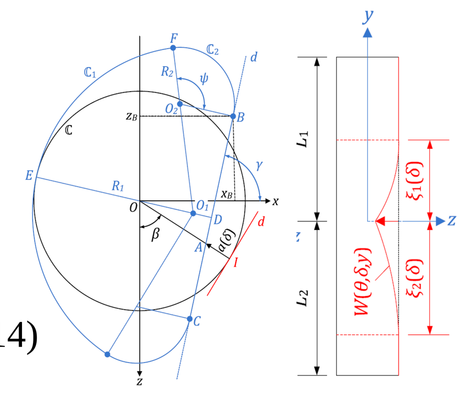
Semi-analytical method



Local crushing:

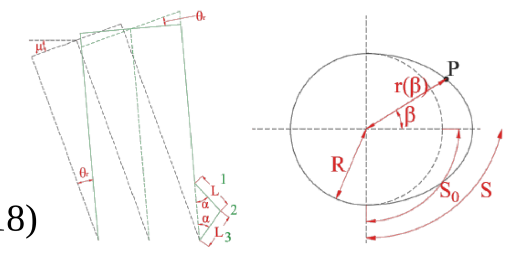
Virtual power principle and upper-bound theorem (Jones, 2003)

$$F \times \dot{\delta} = \dot{E}_{int}$$



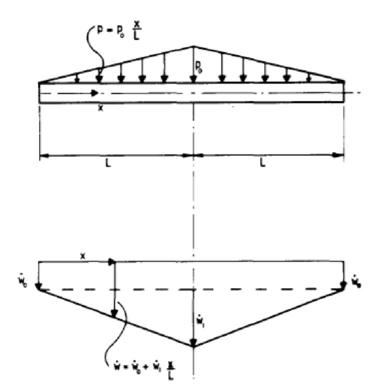
Buldgen et al (2014)

Tank deformation:



Pire et al (2018)

Global bending mode:



Jones (1987)

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