Analytical method to assess the crashworthiness of a Floating Offshore Wind Turbine (FOWT)

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Introduction

With the purpose of using more renewable energies and the decarbonisation of EU, some European countries are implementing floating wind farms, which are closer to traffic lanes. It is important to have a complete scope of the structure's response to a ship impact, in order to implement a risk assessment of the floating wind turbines. In this regard, finite elements solvers are widely used nowadays, which provide accurate results but are time-demanding, not suitable for an early design stage. A faster and reliable method is required in order to study a wide range of parameters: impact velocity, impact location, wind-wave-structure interaction, mooring system response and overall dynamics.
This poster presents the methodology used to develop an analytical method to compute the crashworthiness of FOWT.

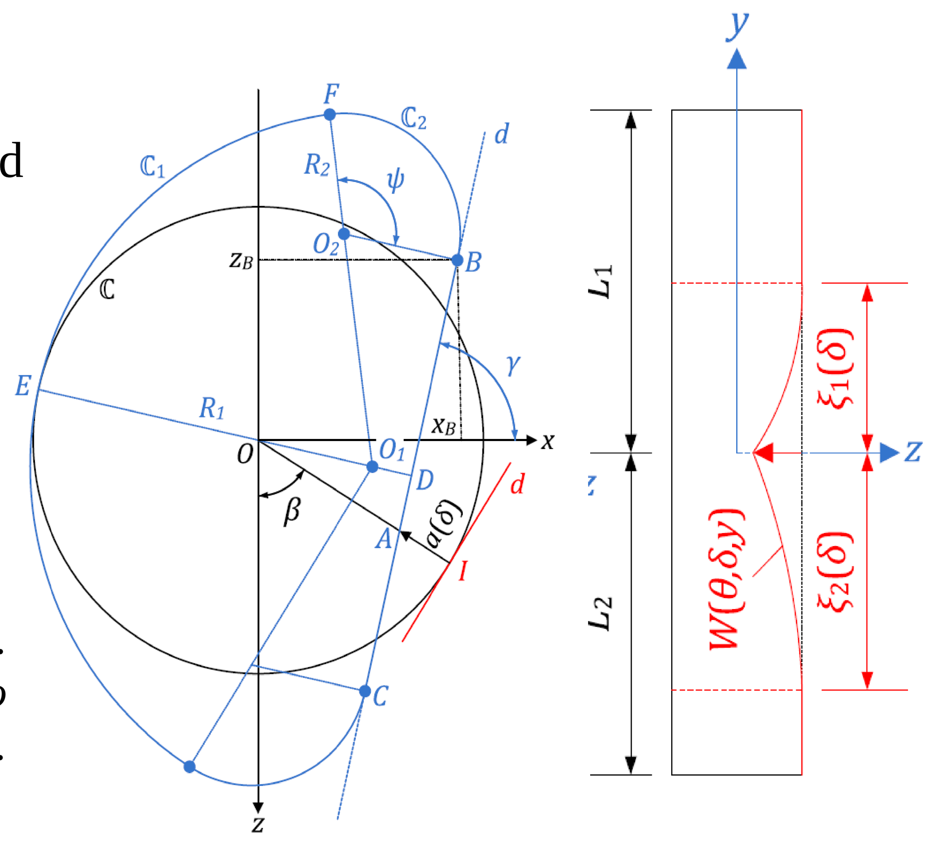
Description

First, a **local indentation** appears near the impact point, but since the structure is floating, there is a global response that varies according to the type of structure (spar-buoy or TLP) and the environmental conditions (waves and wind).

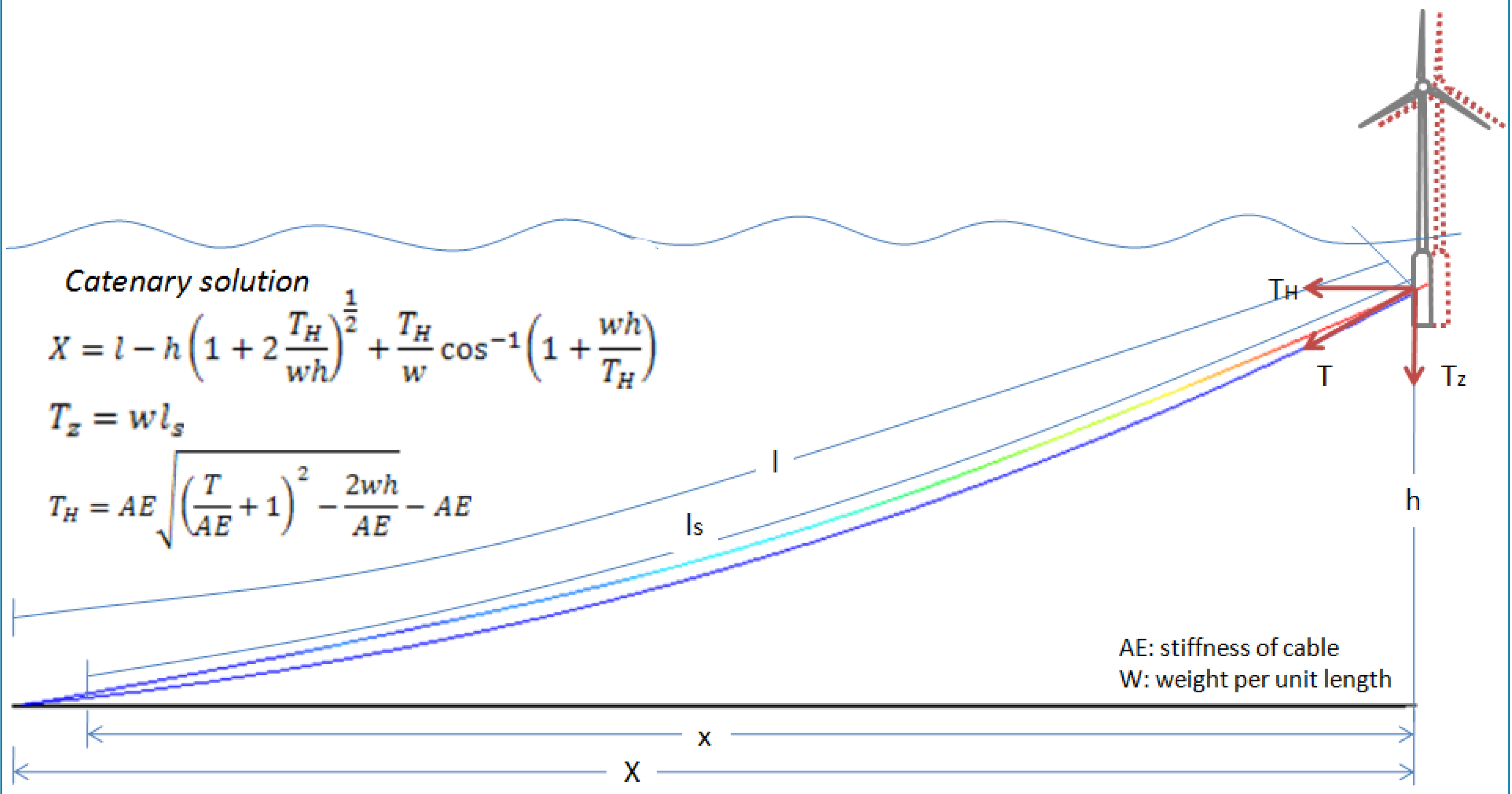
Virtual power principle and upper-bound theorem (Jones, 2003)

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

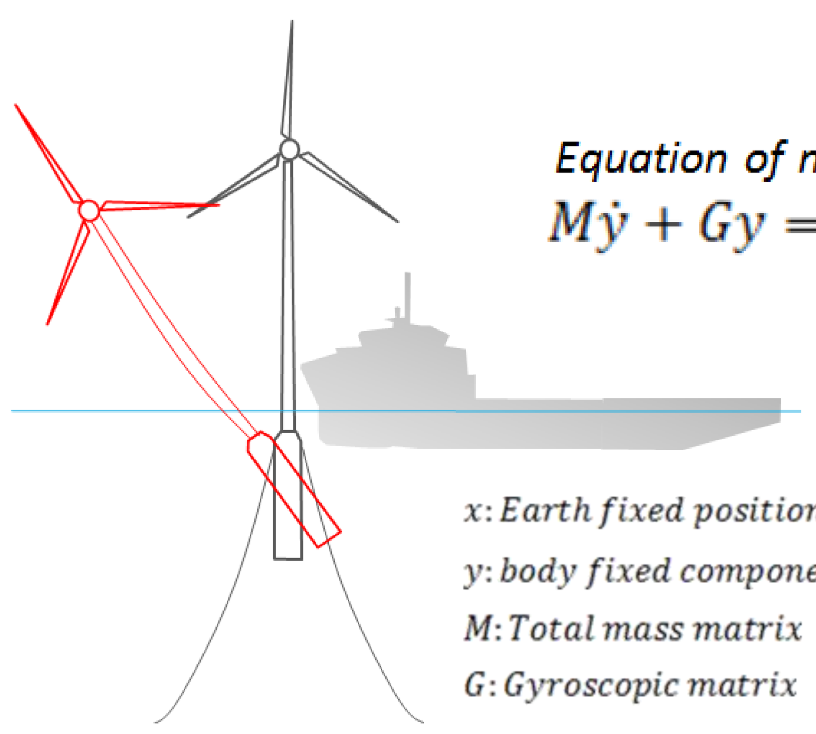
Buldgen L., Le Sourne H. and Pire T. 2014. Extension of the super-elements method to the analysis of a jacket impacted by a ship. Marine Structures, 38.



Then, the **mooring system** responds to these dynamics. If the reaction force of the mooring system is higher than the ultimate strength, the possibility of capsizing increases due to rupture of a line, and as a consequence the total collapse of the tower.



Finally, during the response of the whole structure, a **dynamic behavior** and energy dissipation occurs, leading either to the collapse, capsizing or stabilization of the FOWT- due to damping effects, depending on the initial conditions and crushing force.



Equation of motion

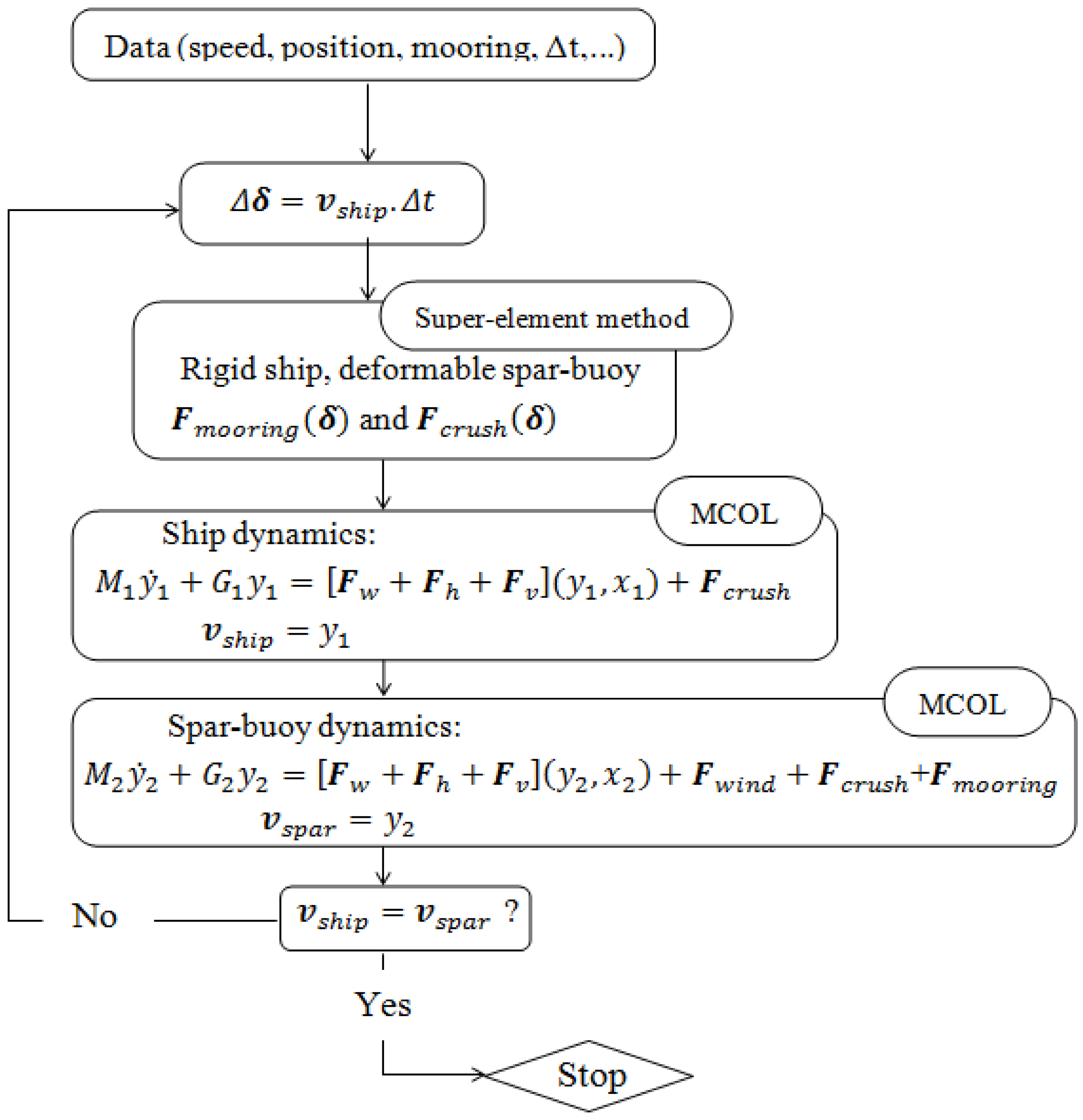
$$M\dot{y} + Gy = [F_W + F_H + F_V](y,x) + F_c + F_A + F_m$$

x: *Earth fixed position of CM*
y: *body fixed components of velocity of CM*
M: *Total mass matrix*
G: *Gyroscopic matrix*

F_W: *Wave memory effects*
F_H: *Restoring forces and moments*
F_V: *Viscous forces and moments*
F_c: *Impact force*
F_A: *wind force*
F_m: *Mooring system force*

General algorithm

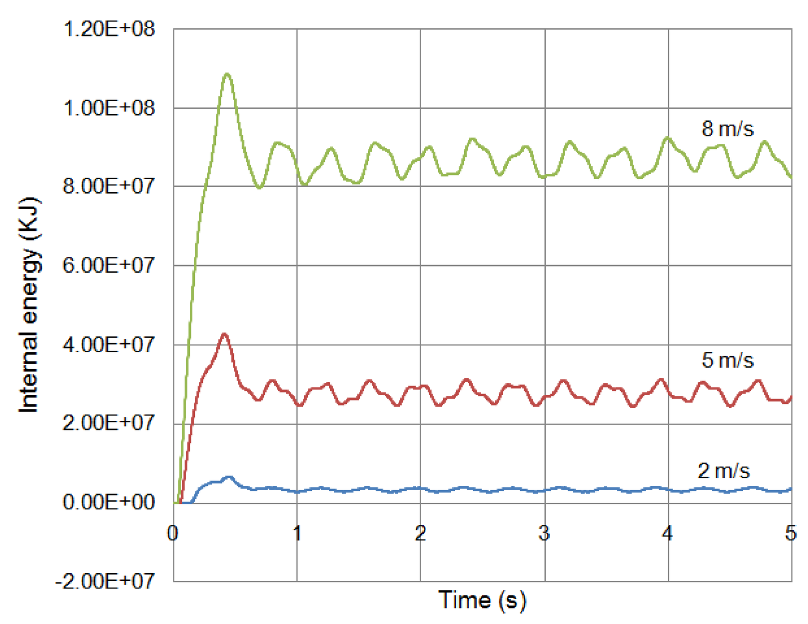
The general algorithm presented here combines the developed super-element method for internal mechanics with the existing MCOL external dynamics solver, which calculates the position, velocity and acceleration of both ship and FOWT at each time step, taking into account the hydrodynamic forces acting on the structures.



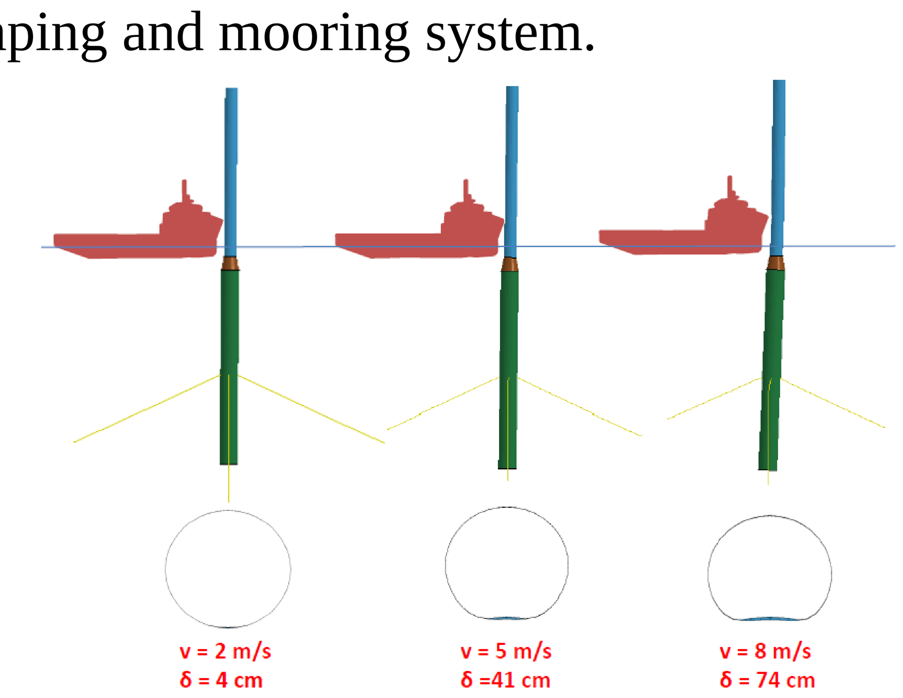
The required data are number of mooring lines (and properties), shape of the ship, impact velocity and direction of ship and FOWT structural information. The ship displacement for a given time-step is introduced in the super-element method, which provides the mooring and crushing forces, then MCOL calculates the external dynamics of both floating bodies.

Preliminary results

Impact velocity is one of the main influential parameters to study the dynamic response of a FOWT during a collision but not crucial for the structural deformation. This is because the majority of the energy is dissipated through hydrodynamic damping and mooring system.



Internal energy corresponding to different Impact velocities



Crushed area indentation for different impact velocities

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