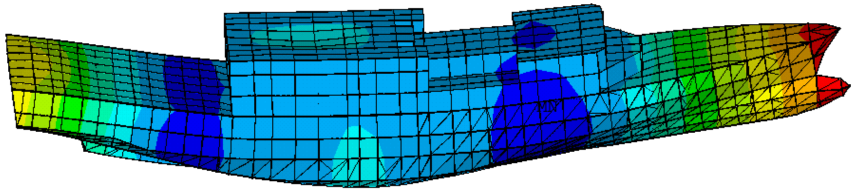


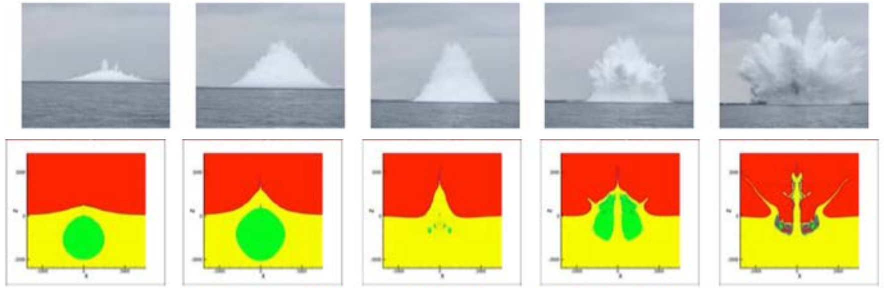
# Numerical simulation of surface ship hull beam whipping response due to submitted underwater explosion


Presenter / Ssu-Chieh Tsai

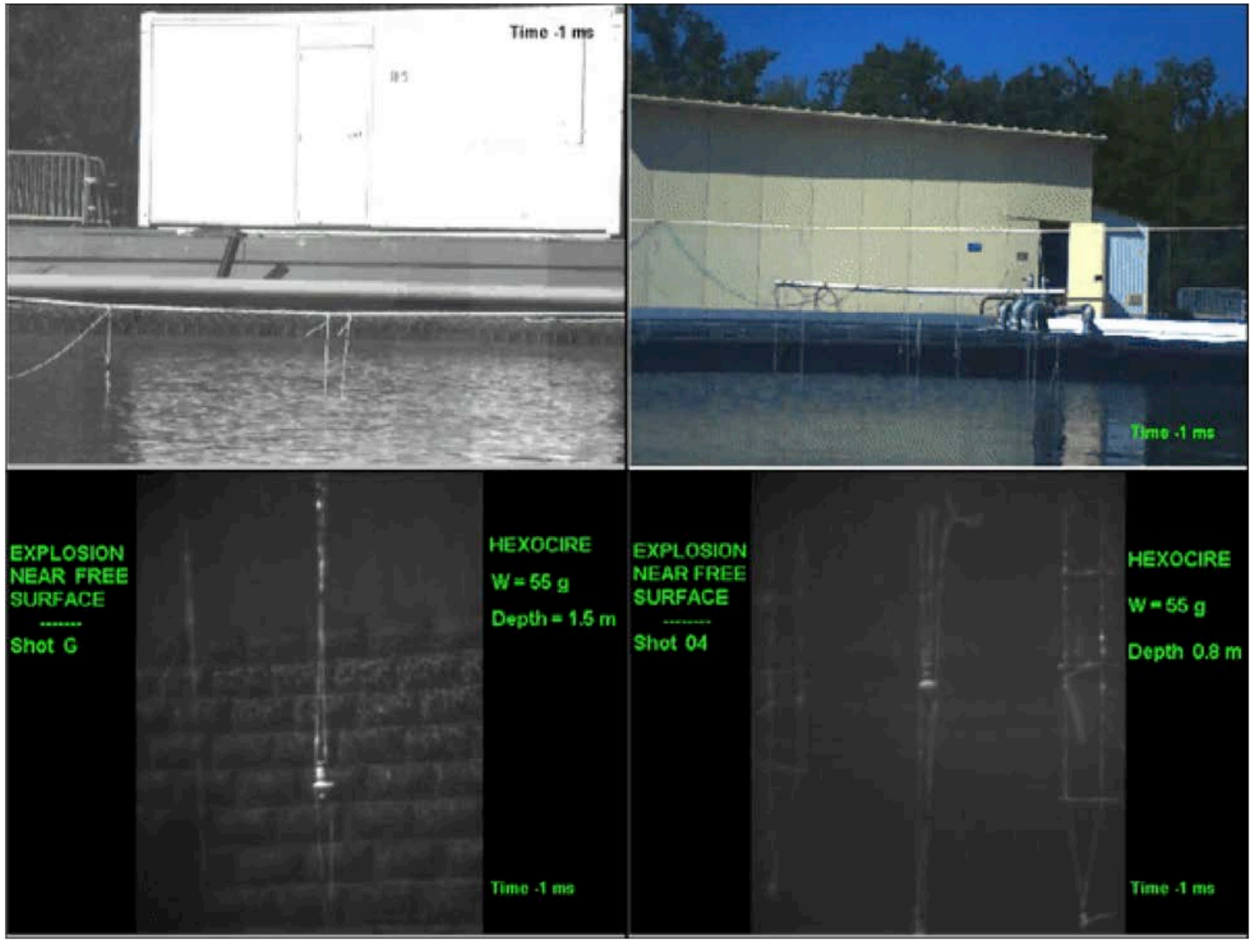
Supervisor / Pr. Hervé Le Sourne


1 March 2017, Rostock

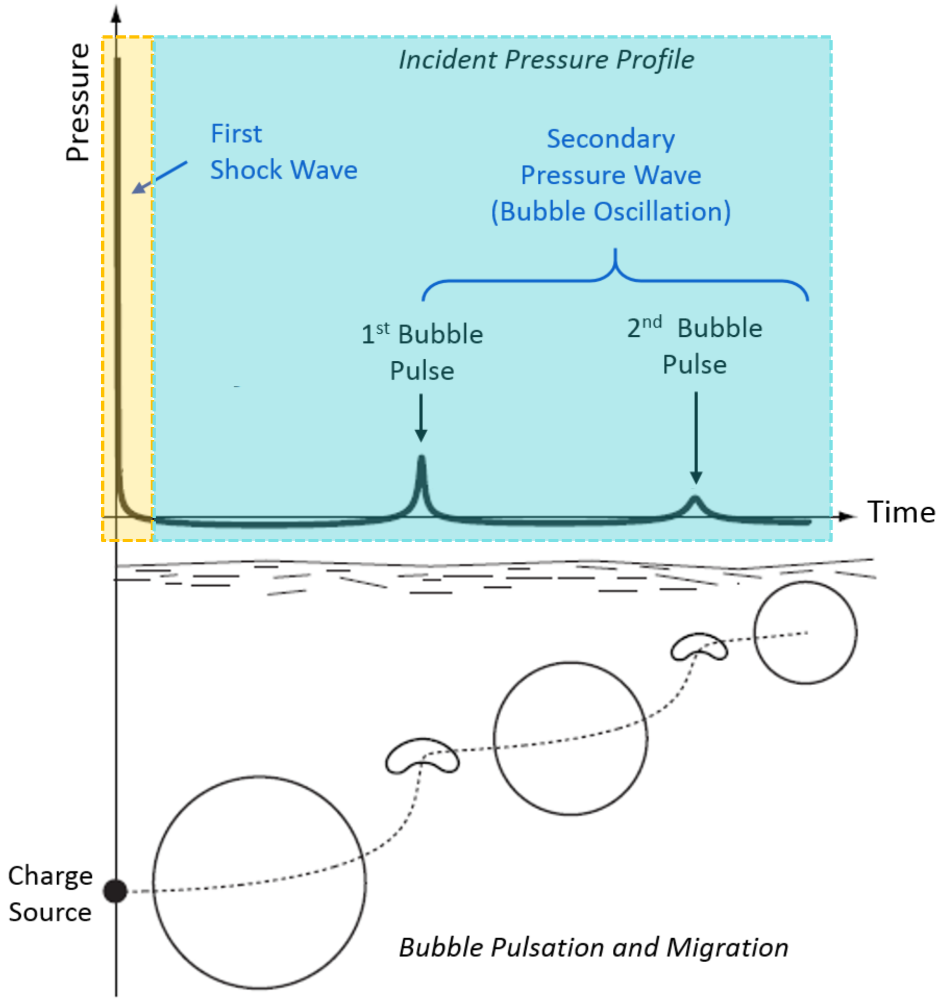
# Motivation




UNDEX Plume Above-Surface Effects



# Background

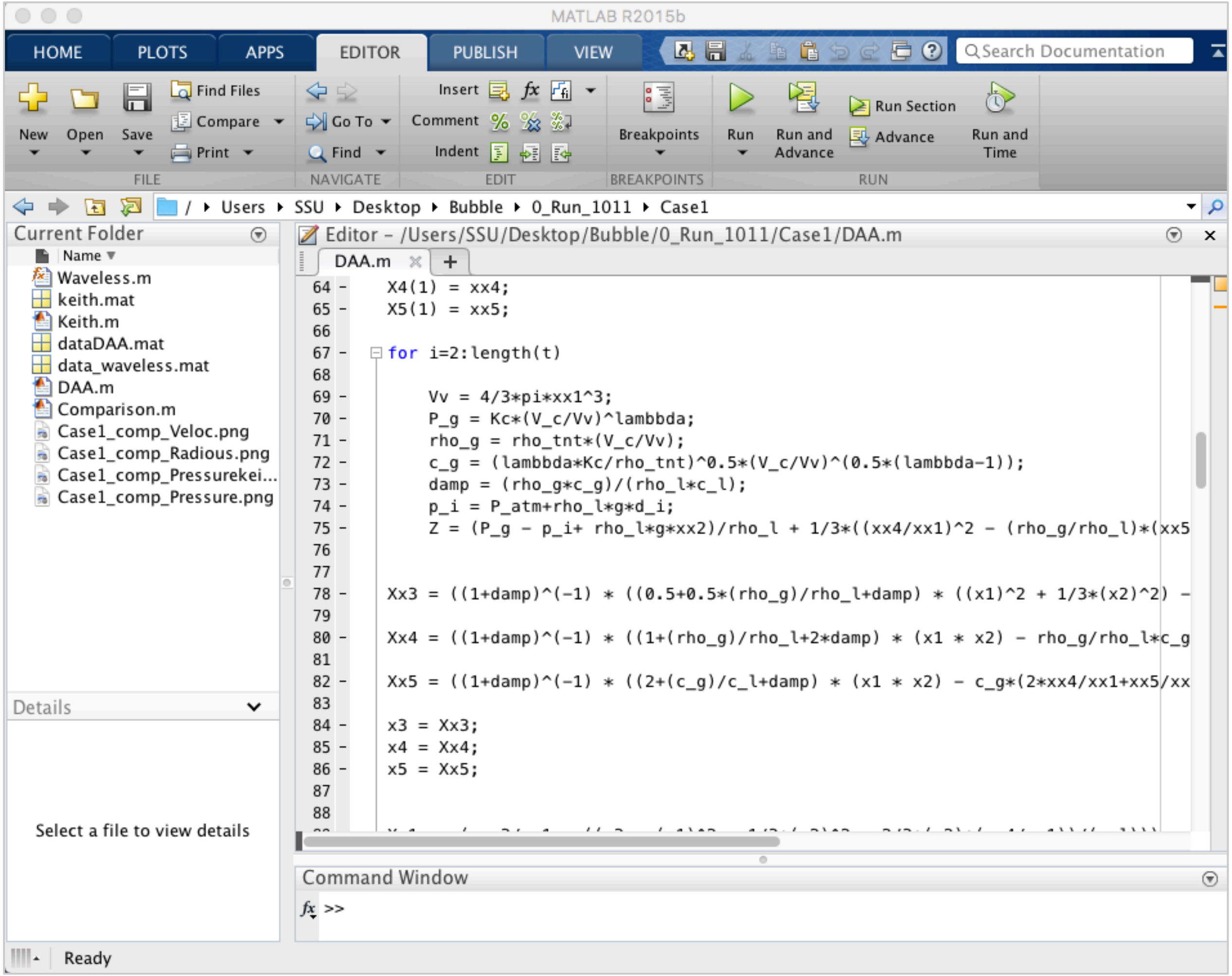



- Complete bubble migration process
- First shock wave (Mauricio,2015)
  - Exponential decay
  - Empirical approach
  - Very short time duration (ms)
- Bubble oscillation phase
  - Non-linear
  - Longer time duration
  - Motion of bubble migration
  - Radius and vertical displacement

# Methodology – 3 models

- **Waveless model**
  - Consider as an ideal fluid
  - Without damping effect and the effect of gas bubble pressure inside bubble
- **DAA model** (*Doubly Asymptotic Approximation*)
  - Considering the interaction between the liquid and gas bubble
  - Including damping effect in the liquid
- **Empirical model**
  - Peak approximation method
  - Restricted to experienced coefficients, specific material cases

# Development of Matlab programs




- Developed code in Matlab
- Empirical and analytical models
- Calculate motion of bubble
- Pressure loads
- Test program by 3 charge cases

# Comparison on 3 different UNDEX cases

- The 3 models are tested on:
  - Case 1: Barras Guillaume's Case
  - Case 2: Hunter & Geers' Case
  - Case 3: Keith G, Webster's Case

| Case 1 | Description |
|---|---|
| $m_c$ | TNT charge mass, $m_c$= 500 kg |
| | Distance from charge to free surface, = 50 m |
| r | Distance from charge to standoff point, r = 50 m |
| | Density of charge, = 1600 kg/$m^3$ |

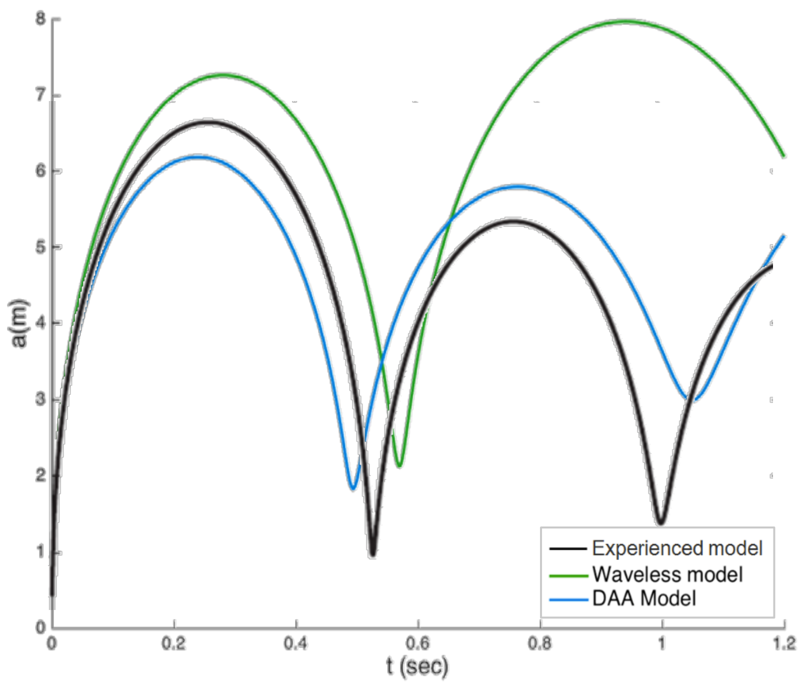
| Case 2 | Description |
|---|---|
| $m_c$ | TNT charge mass, $m_c$= 0.3 kg |
| | Distance from charge to free surface, = 92 m |
| | Density of charge, = 1500 kg/$m^3$ |

| Case 3 | Description |
|---|---|
| $m_c$ | TNT charge mass, $m_c$= 1.45 kg |
| | Distance from charge to free surface, = 178 m |
| | Density of charge , = 1500 kg/$m^3$ |
| | Radial distance from charge, |

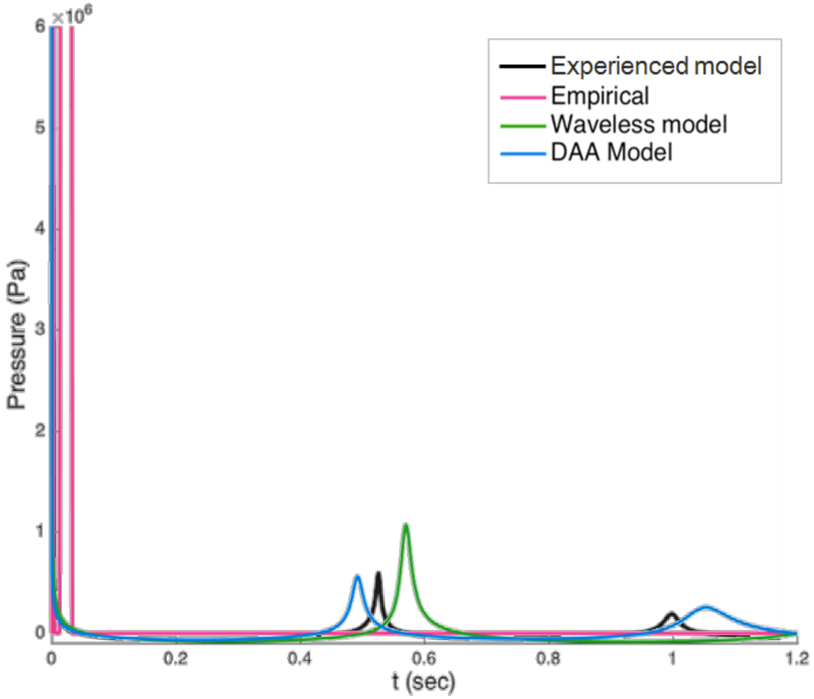
# Comparison with experience (Case 1)

**Experience:** *Barras Guillaume, Numerical simulation of underwater explosions using an ALE method. The pulsating bubble phenomena. (2012)*

## Case 1 / Radius: a



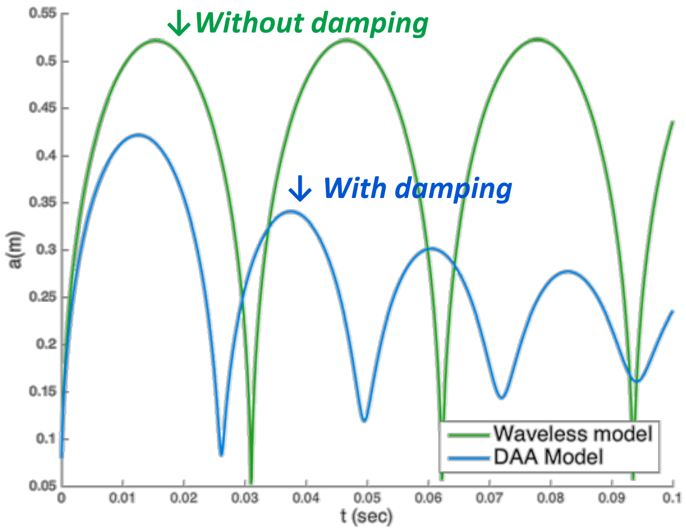

## Case 1 / Pressure



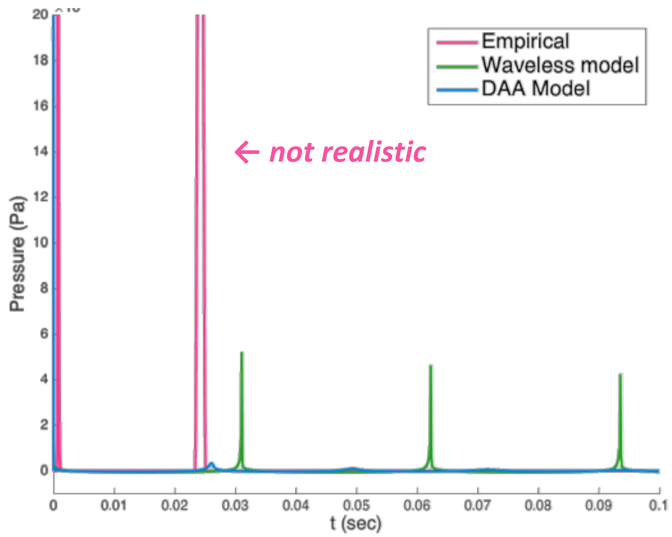

***DAA model is close to Experience model !***

- Comparison 3 models for Case 2 & Case 3

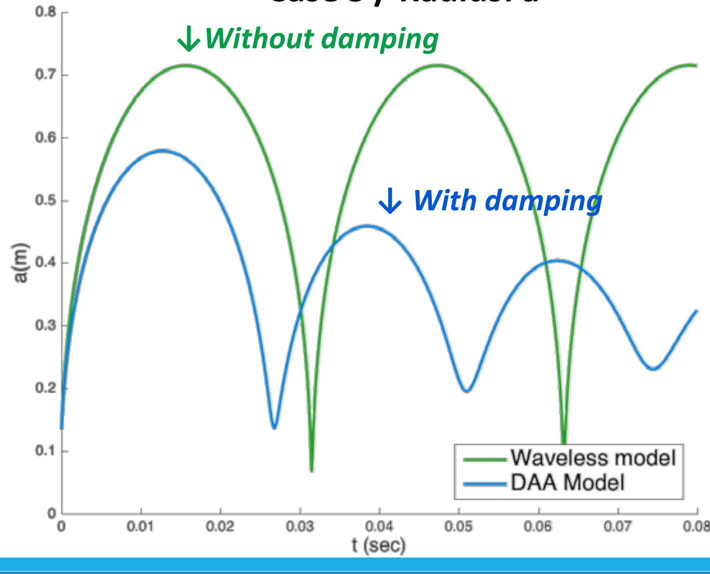
Case 2 / Radius: a



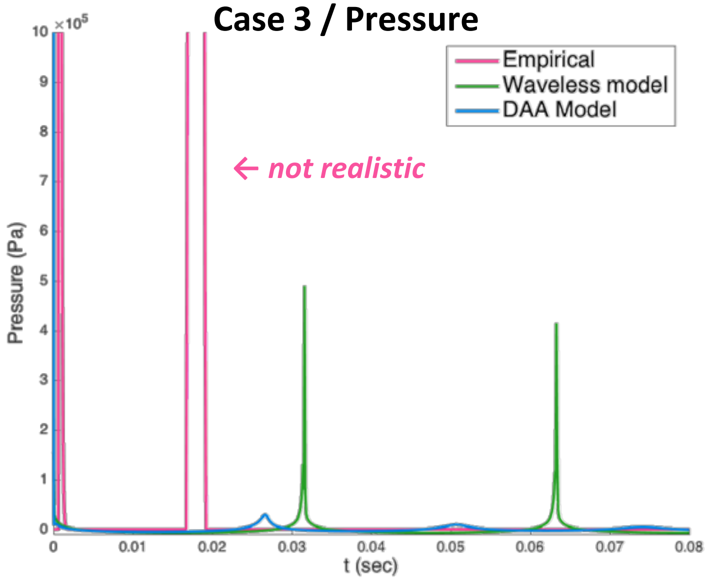

Case 2 / Pressure




Case 3 / Radius: a



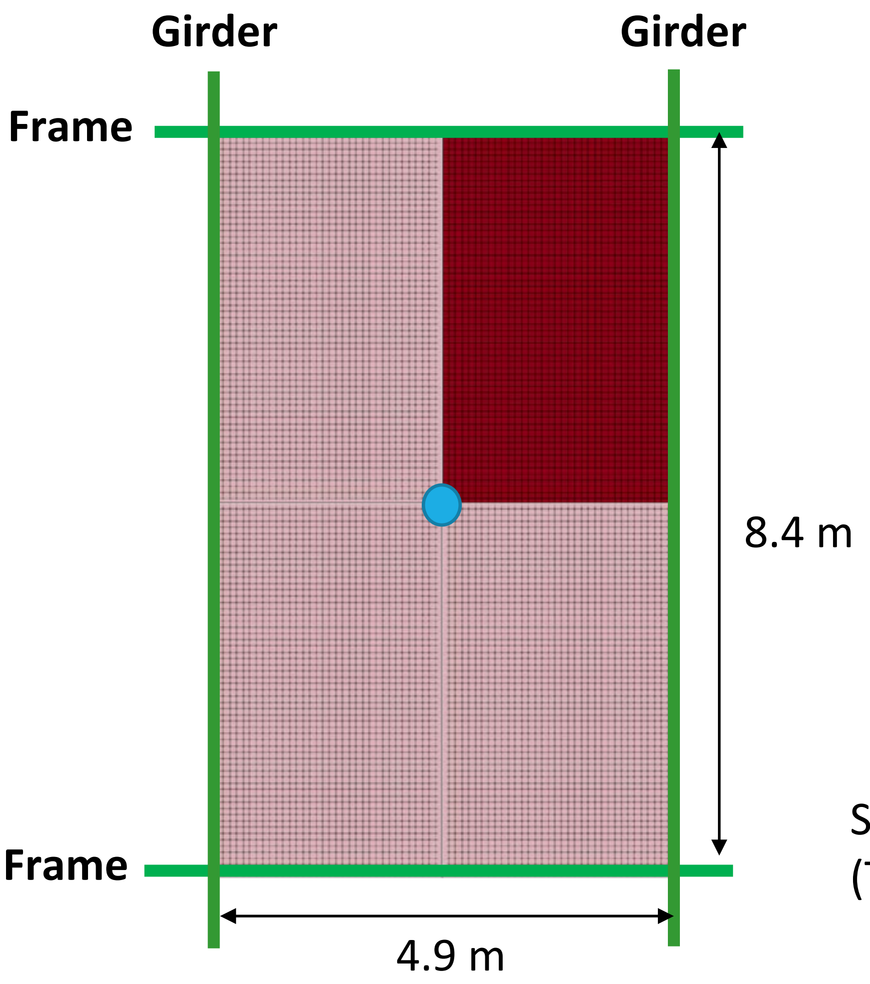

Case 3 / Pressure

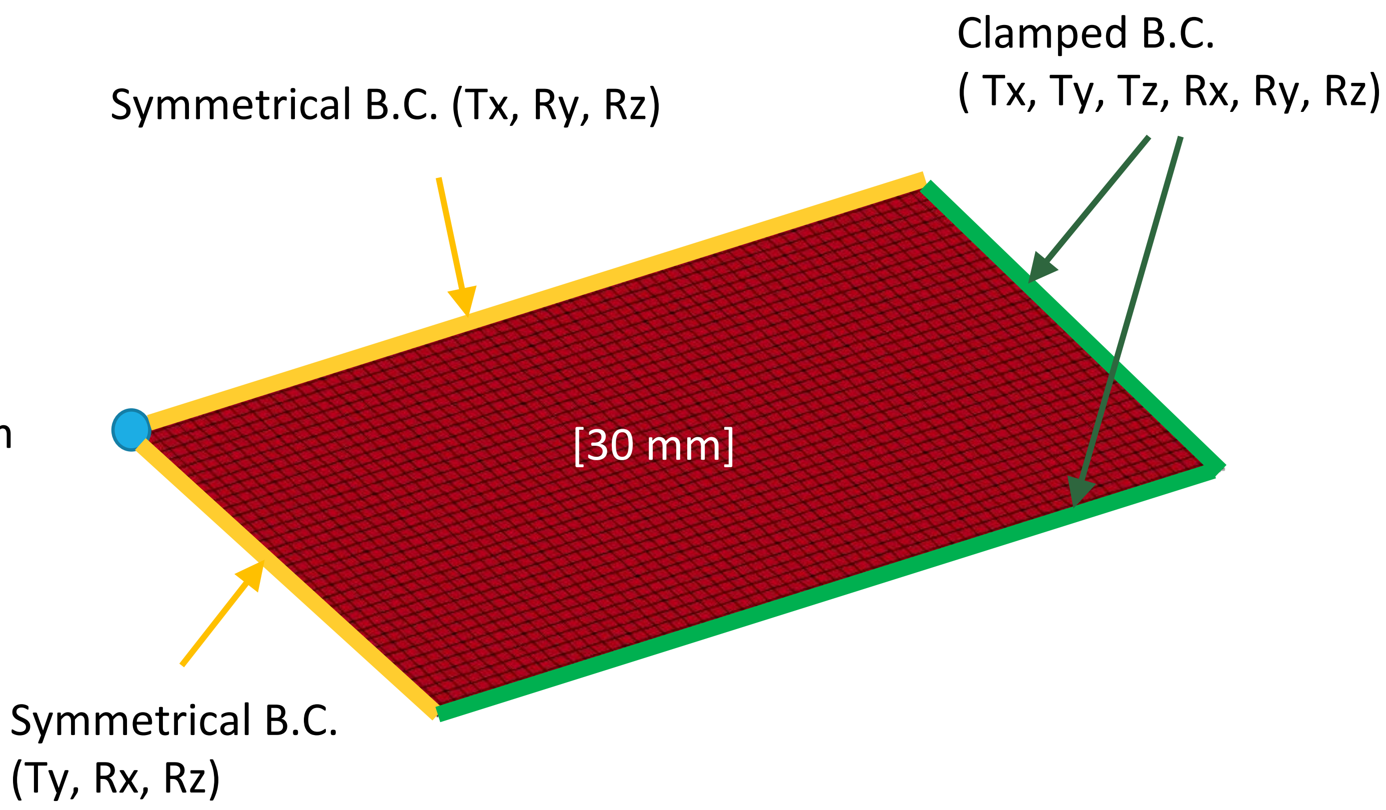


# Conclusions

- ✓ **Analytical models** can be used for various charge materials, mass and water depth
- ✓ **DAA model** is more representative of the reality than **waveless model**

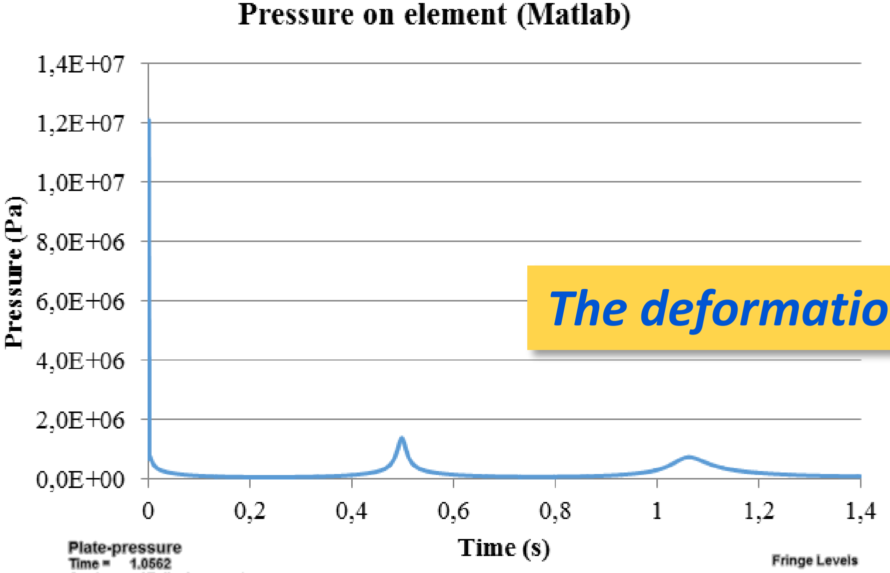
# Example 1 : Clamped plate model

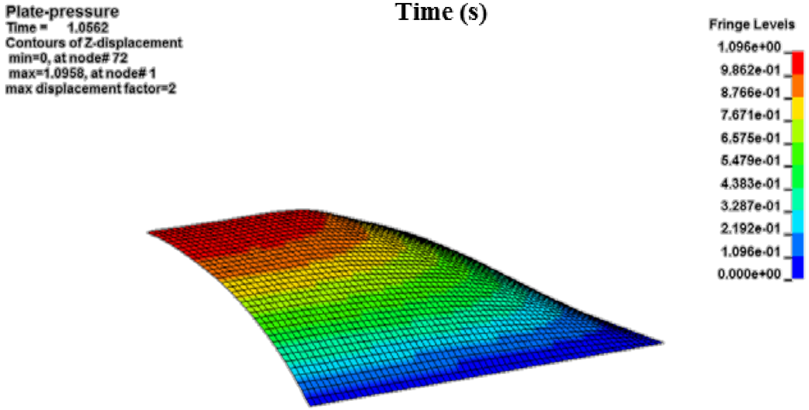


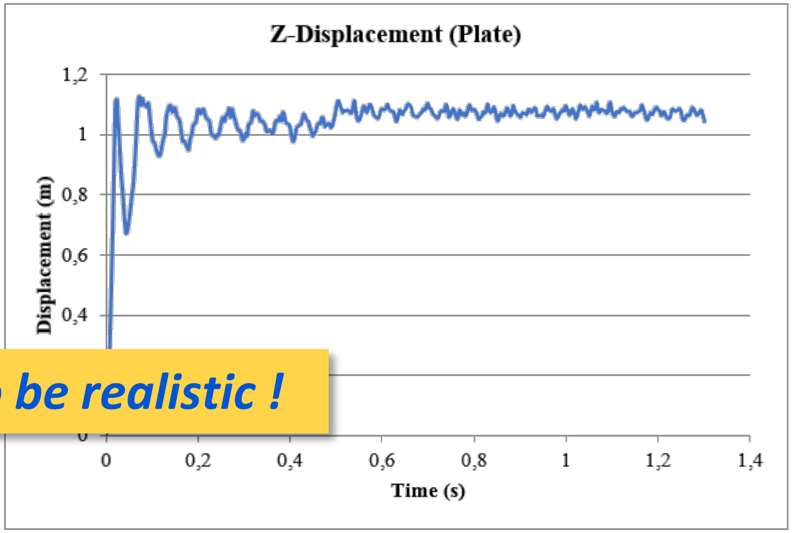



# Results of clamped plate

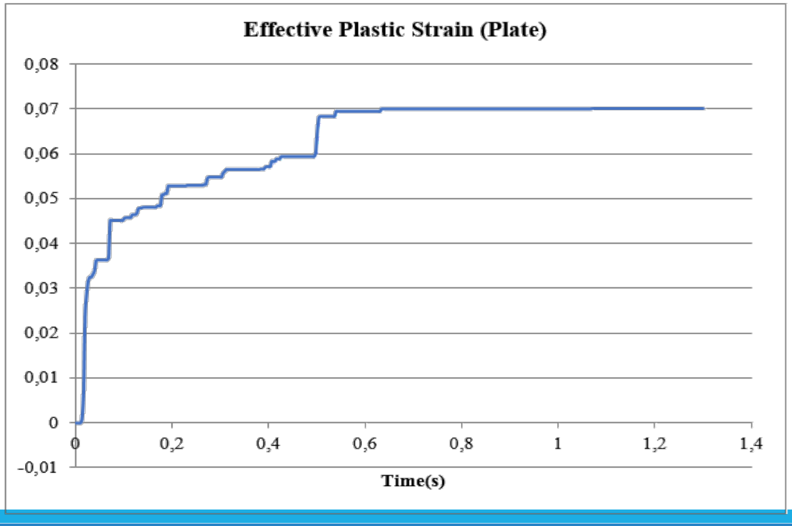
- *Case1*: $m_c$= 500 kg , $d_i$ = 50 m, $\rho_c$= 1600 kg/m$^3$



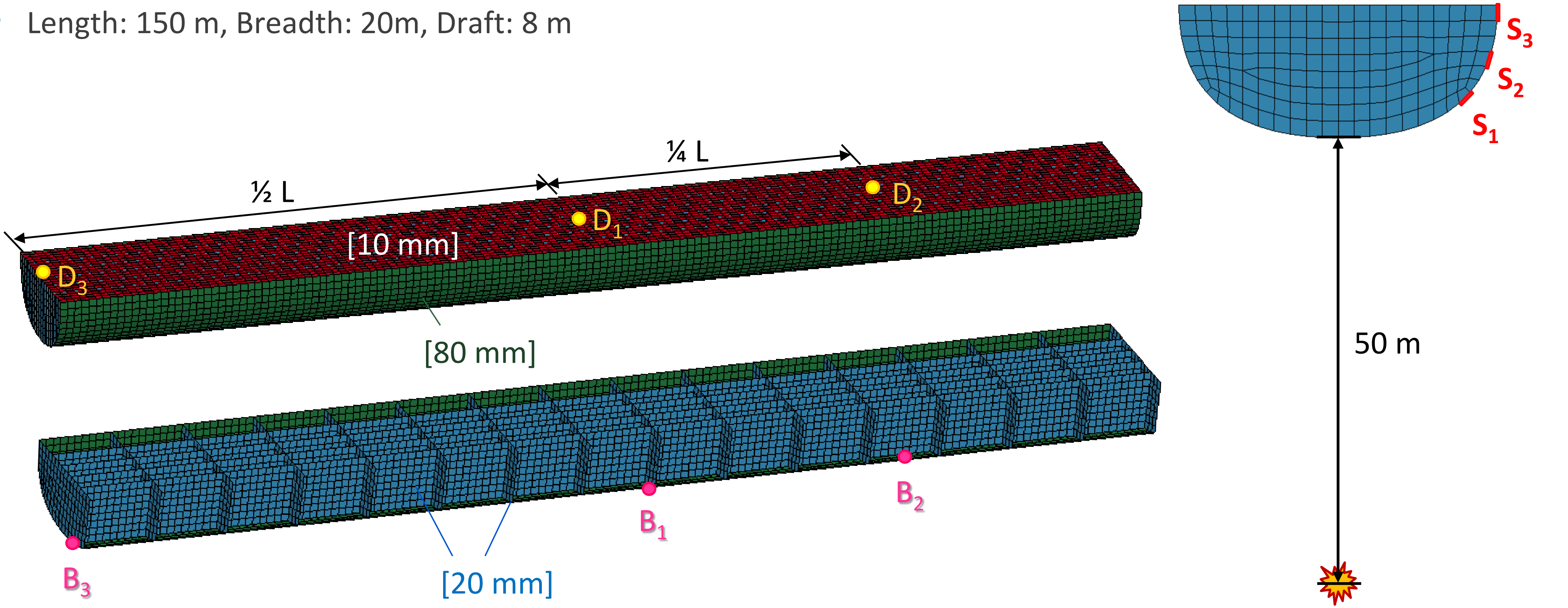




**The deformation seems to be realistic !**



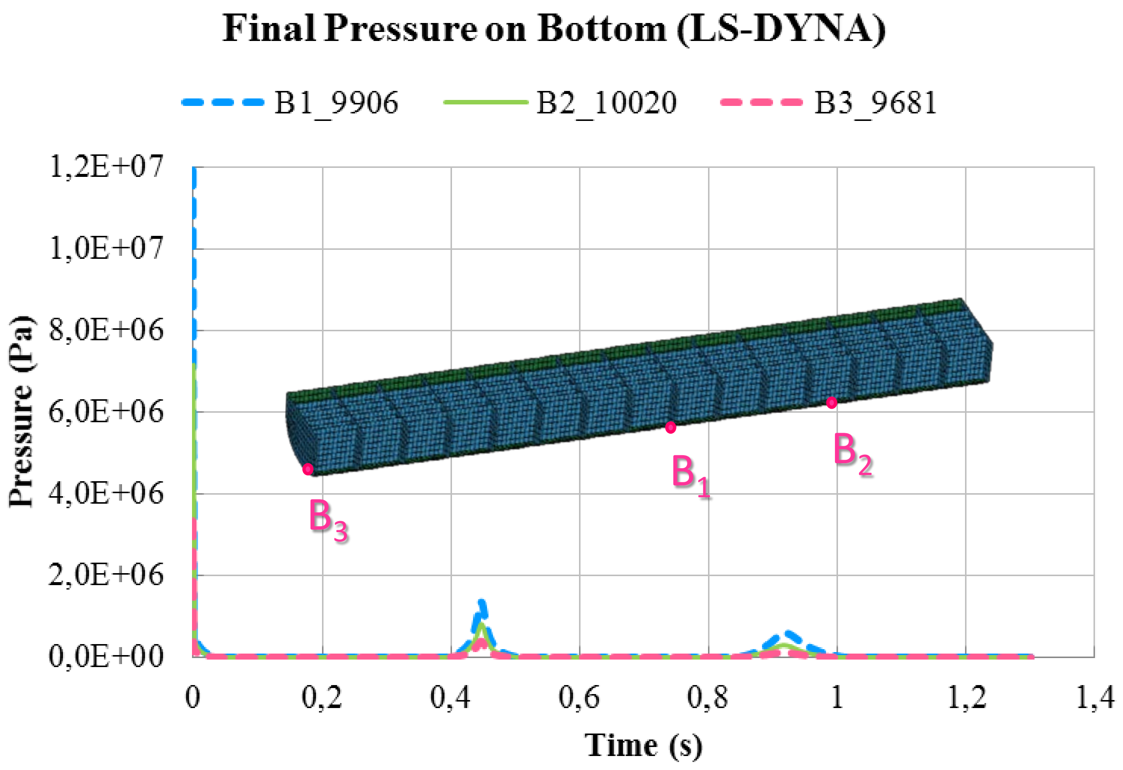
# Example 2 : Semi-cylinder model

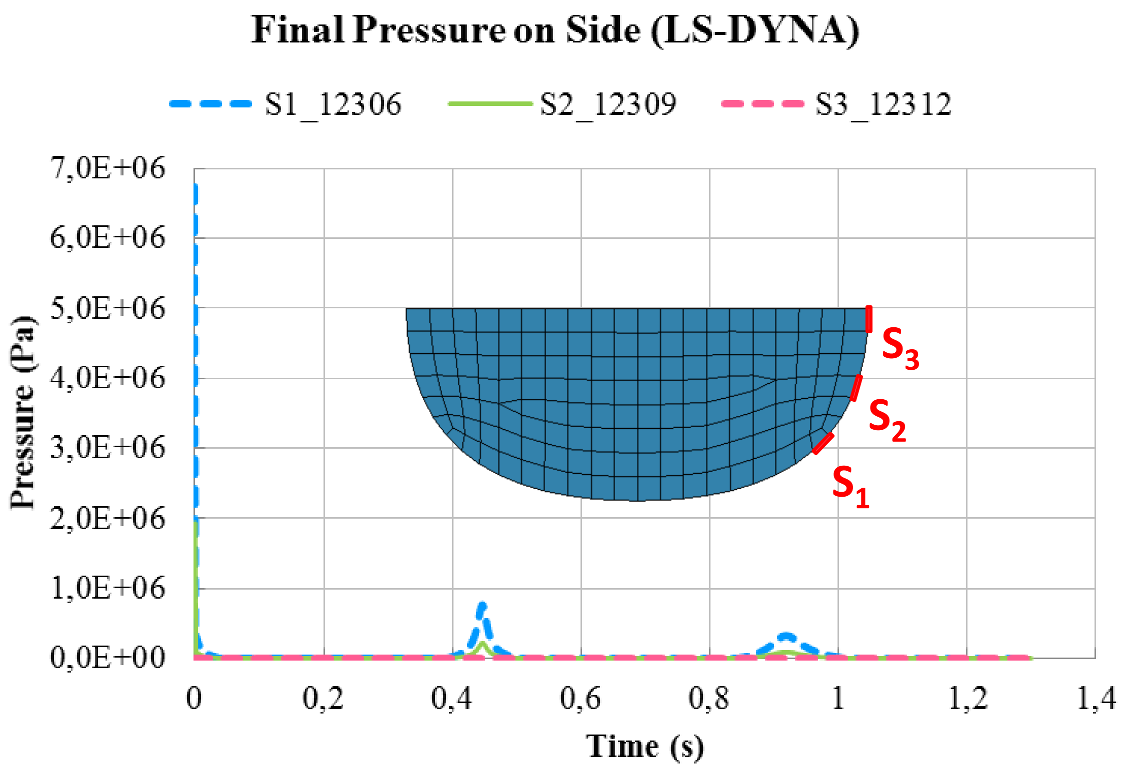
- Charge Case 1: $m_c$= 500 kg , $d_i$ = 50 m, $\rho_c$= 1600 kg/m$^3$
- Length: 150 m, Breadth: 20m, Draft: 8 m



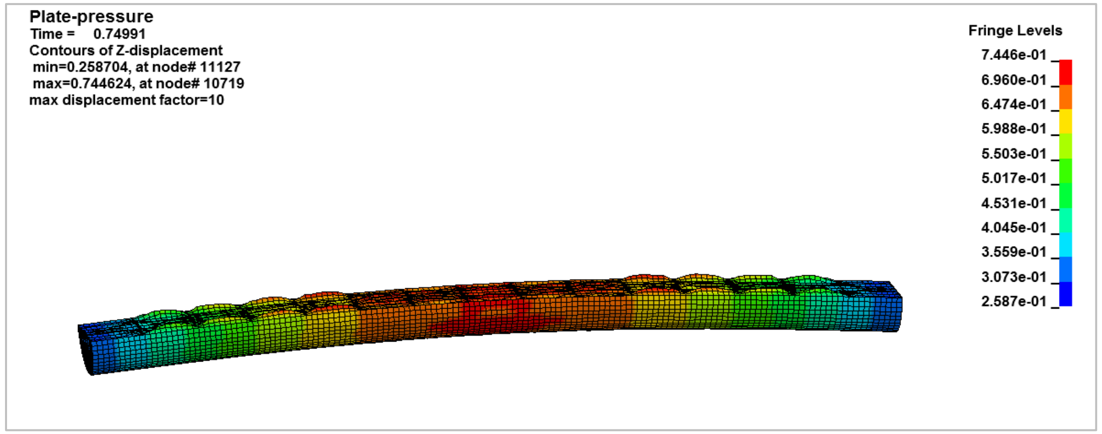
Pressure loads for semi-cylinder

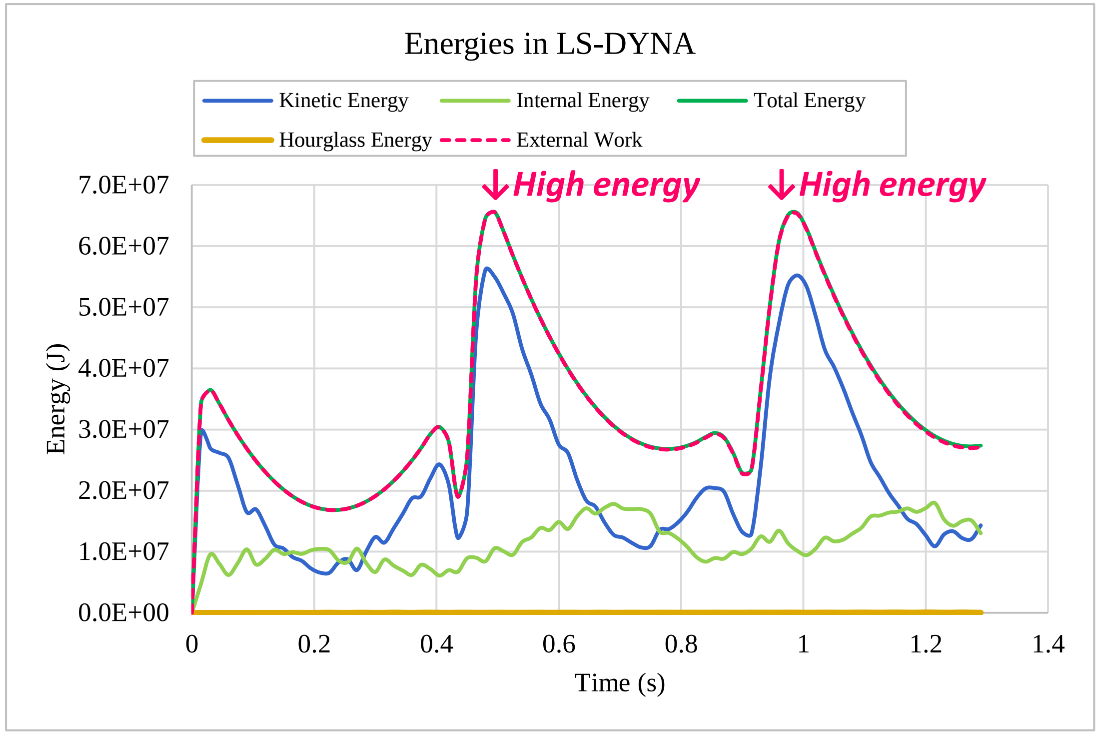
- Charge Case 1: $m_c$= 500 kg , $d_i$ = 50 m, $\rho_c$= 1600 kg/m$^3$

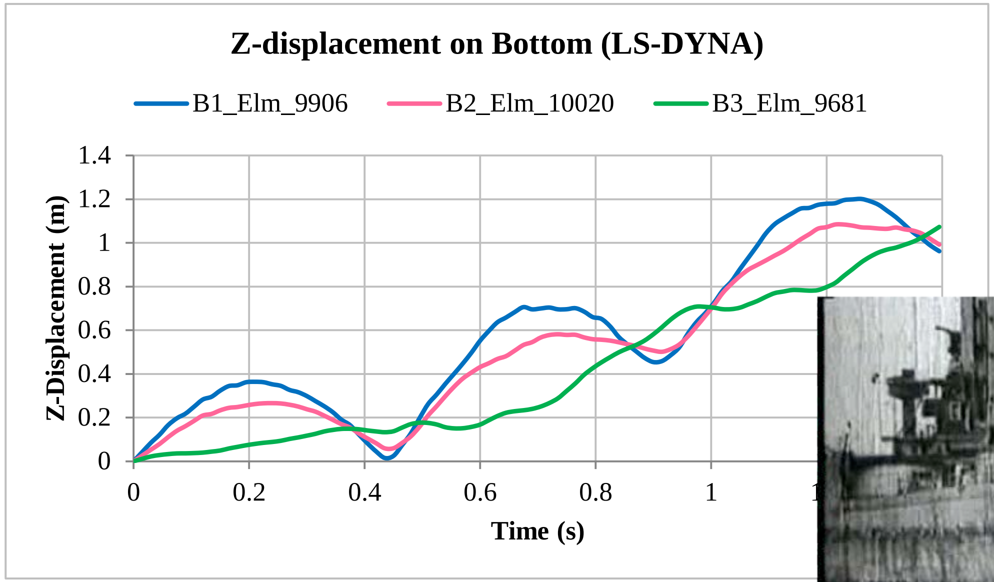


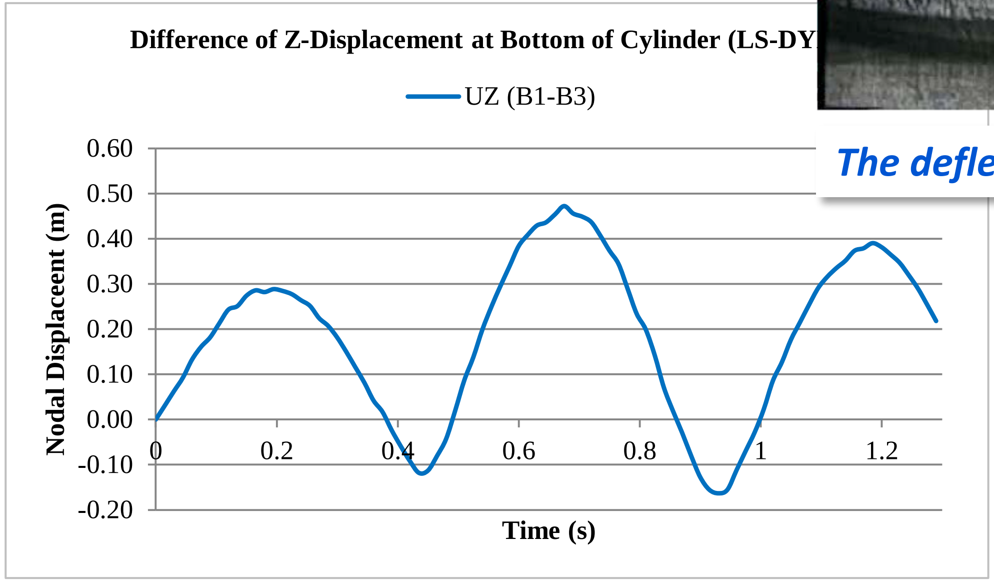



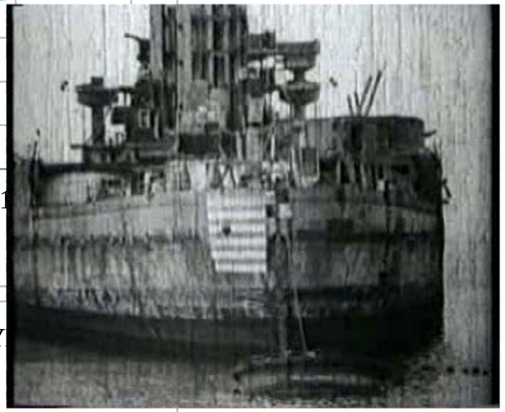
# Results of semi-cylinder model



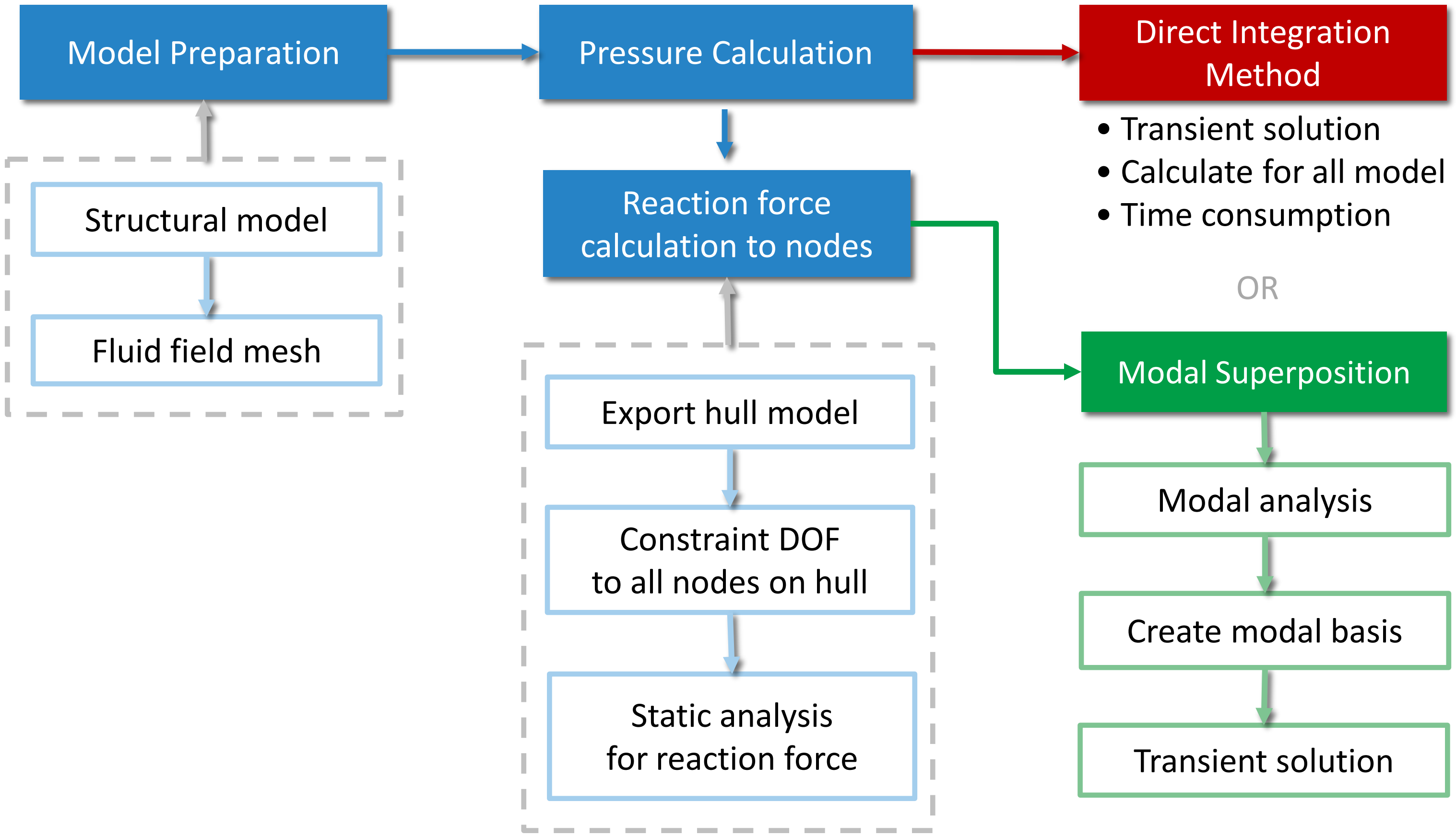



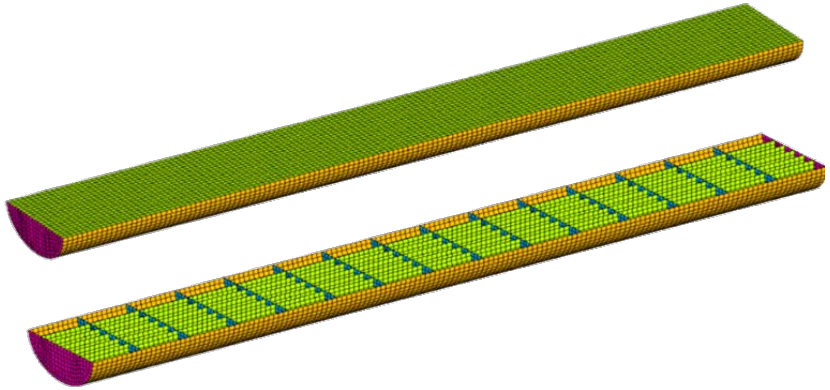
*The deflection is realistic.*

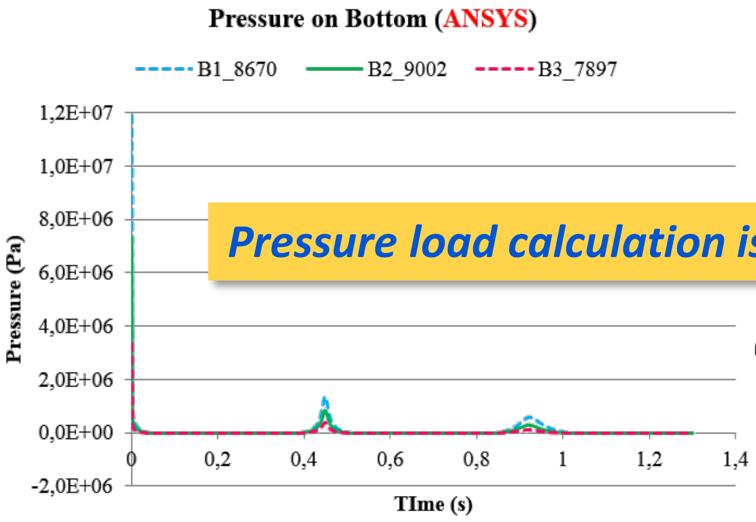
# Analysis process for ANSYS

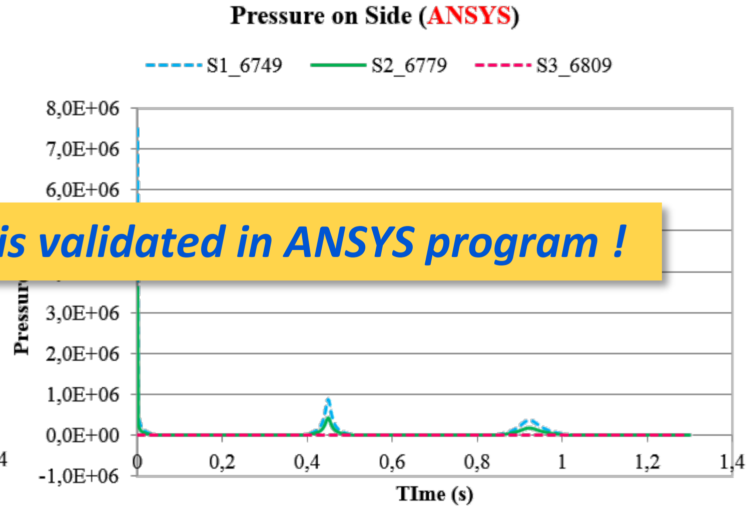
- *Objective: Convert code from MATLAB to ANSYS language*



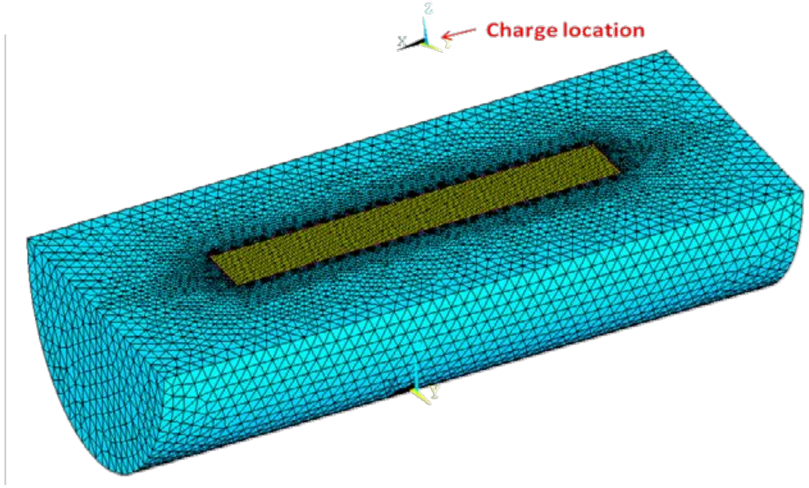
# Example 2: Semi-cylinder model

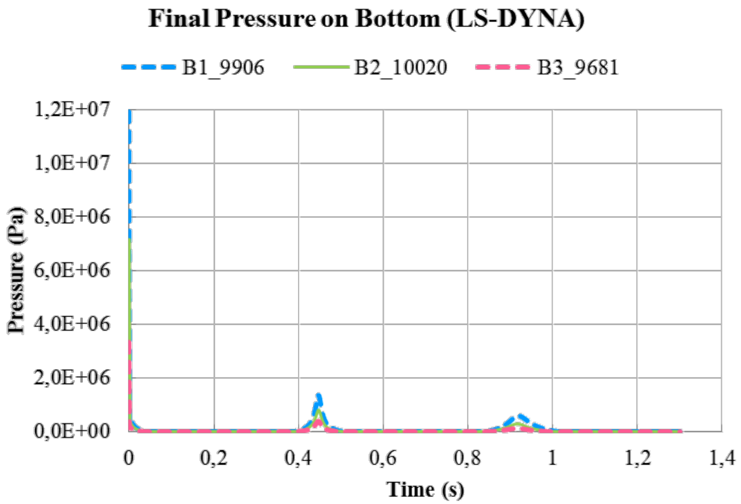


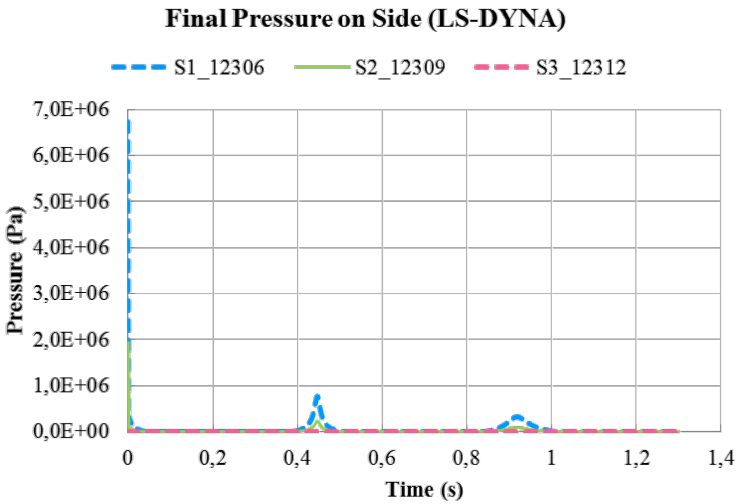



***Pressure load calculation is validated in ANSYS program !***

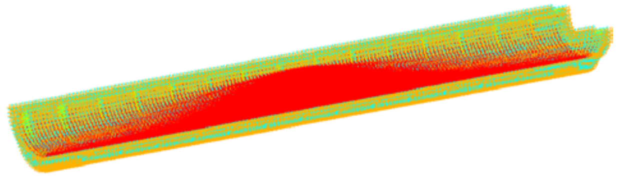


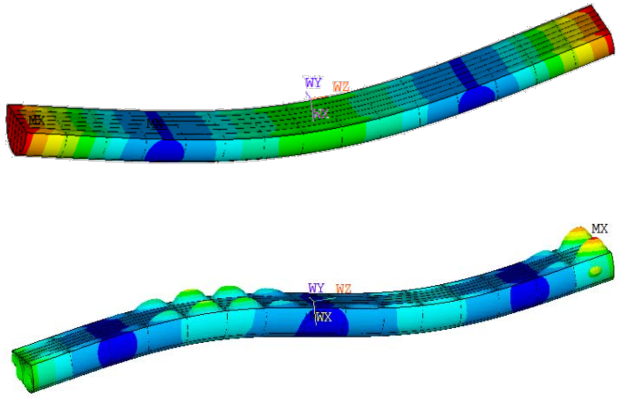



# Results of semi-cylinder model

- Static analysis



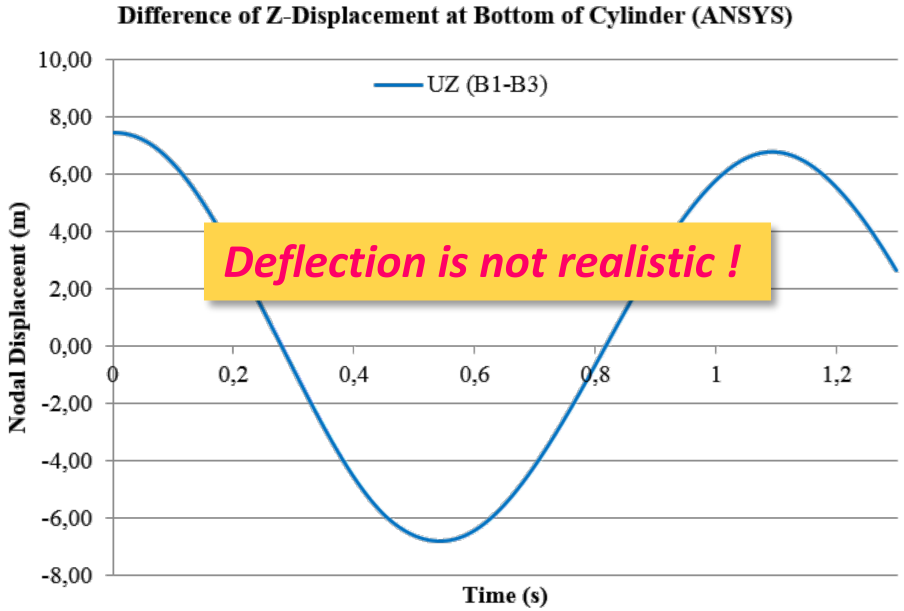
- Modal analysis

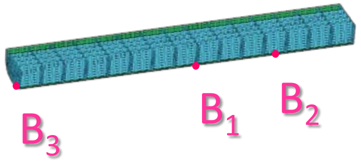


- Transient solution

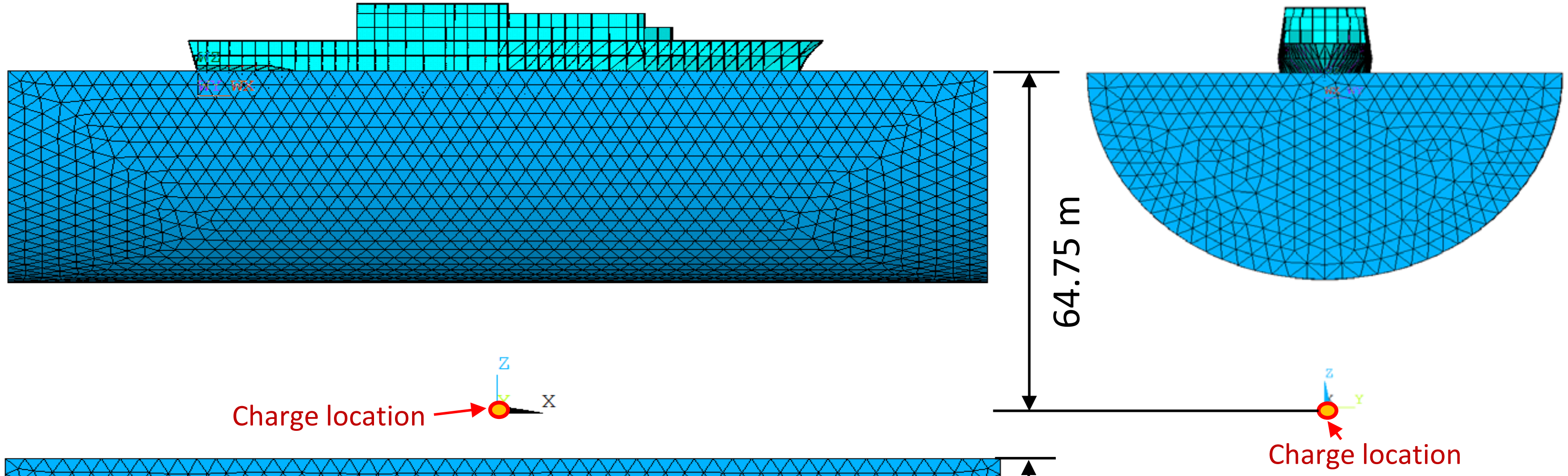
  by model superposition

  - Displacement is should be zero at time 0
  - Too high deflection > 14m !!!

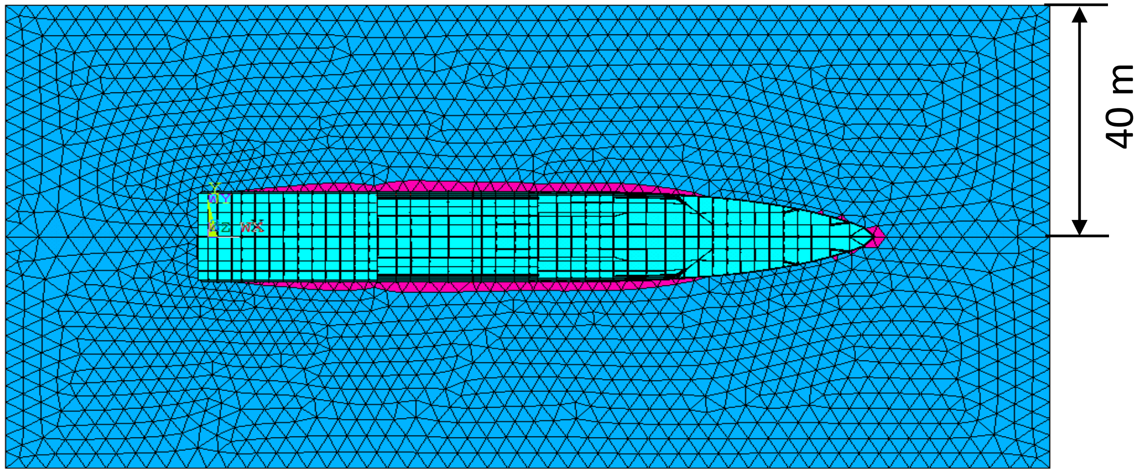


# Example 3 : Frigate ship model



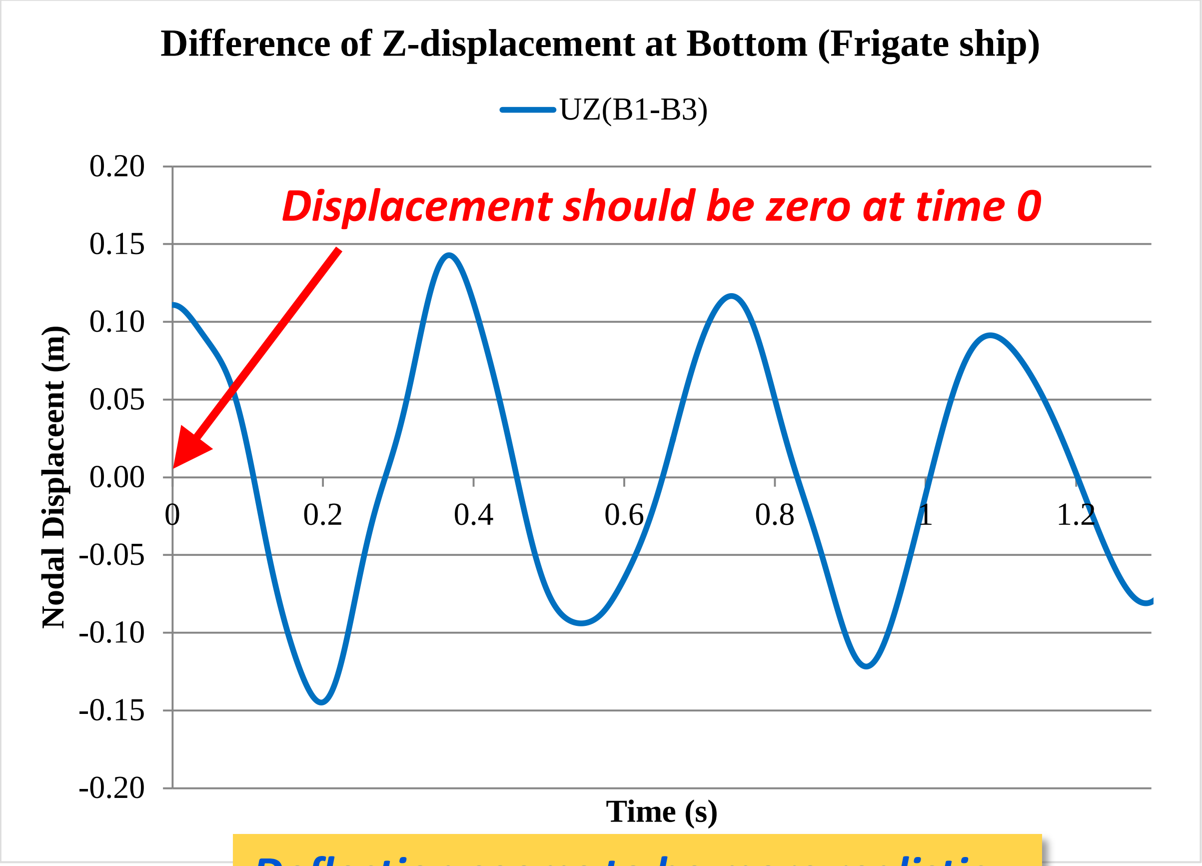

- Length of all: 95.0 m
- Breadth: 14.0 m
- Draught: 4.75 m




| | Case Description |
|---|---|
| **SF** | Shock factor = **0.6** |
| **$m_c$** | TNT charge mass, $m_c$= **1296** kg |
| | Distance from charge to free surface,  = 64.75 m |
| **r** | Distance from charge to standoff point, r = **60** m |
| | Density of charge, = 1600 kg/m$^3$ |

# Results of Example 3

- Transient solution by modal superposition




***Deflection seems to be more realistic***

# Conclusion

- DAA analytical model, representative of the reality, has been chosen
- Secondary bubble oscillation phase has significant influence on structure
- Model superposition method leads to unrealistic results

  ➔ This method is suitable only for small displacements (it is not the case here)

- **Direct integration method**

# Future work

- Perform shock response analysis for one or several embarked materials using Dynamic Design Analysis Method (DDAM)
- Examples : Shaft line or / and pipes line