Simulate the PMM model tests of a container ship with OpenFOAM

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Outline

Background

- PMM model tests

  - Static PMM model tests
    ① Oblique towing
    ② Advancing with heel angle
    ③ Oblique towing with heel angle

  - Dynanmic PMM model tests
    ① Pure sway
    ② Pure yaw
    ③ Pure yaw with drift angle
    ④ Pure yaw with heel angle
    ⑤ tests with propeller and rudder

Background

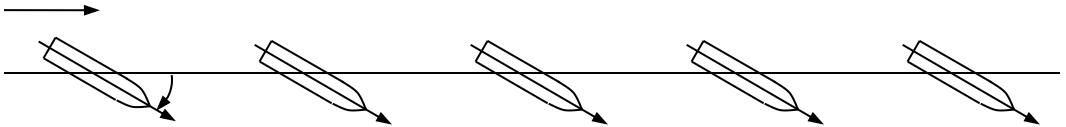
- **Purpose of PMM model tests**

  - **To get hydrodynamic derivatives**
    ① Y_v , N_v from oblique towing tests
    ② Y_{va} , N_{va} from pure sway tests
    ③ Y_r , N_r Y_{ra} , N_{ra} from pure yaw tests
    ④ .....

  - **These hydrodynamic derivatives can be used in MMG model to simulate maneuvering motions like full turning, zig-zag, stopping motion of ships**

Background

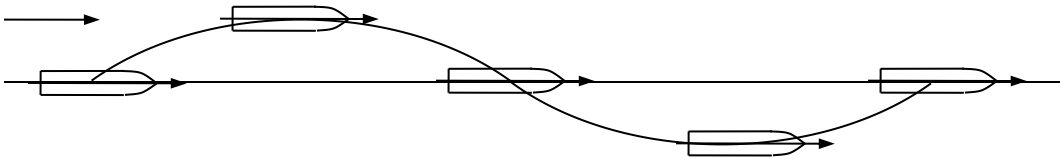
- **PMM model tests**
  - **Oblique towing tests**



constant advancing speed u
constant drift angle

Background

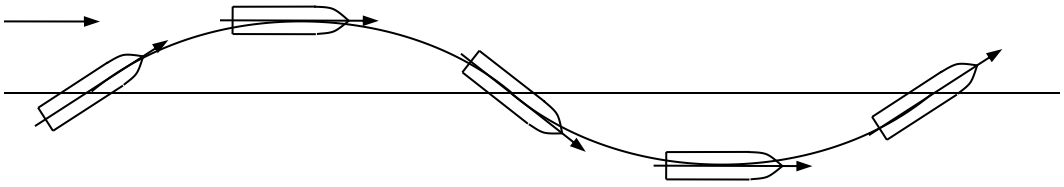
- **PMM model tests**
  - **Pure sway tests**



constant advancing speed u
sinusoidal oscillation lateral speed v

Background

- PMM model tests
  - Pure yaw tests



constant advancing speed u
sinusoidal oscillated lateral speed v
sinusoidal oscillated yaw motion that satisfy drift angle = 0

Background

- **Feature of PMM model tests**
  - Large sway or yaw motion amplitude
  - For some tests the propeller and rudder are attached
  - Vortex separations increase with the growing of the drift angle

- **Solutions**
  - Overset mesh
  - DDES turbulence model

Outline

1. Background
2. Implementation of overset grid in OpenFOAM
3. Case setup
4. Results & Conclusions

Overset grid assembly:TIOGA

- Task: Identify, in parallel, among all points in the overlapping mesh system, at which points the flow solution should be computed (field points), interpolated (receptor points), or ignored (hole points).

- Using auxillary grid and flood fill algorithm for hole cutting
- Using EIM and ADT algorithm for donor cell searching
- No limit for the CFD solver

- B. Roget and J. Sitaraman, "Robust and efficient overset grid assembly for partitioned unstructured meshes," Journal of Computational Physics, vol. 260, pp. 1–24, 2014.

Connection between OpenFOAM & TIOGA

- libdynamicOversetFvMesh.so
- liboversetFvPatchField.so
- A few modifications on the top-level solver
  - alpha1Eqn.boundaryManipulate(alpha1.boundaryField())
  - UEqn.boundaryManipulate(U.boundaryField())
  - p_rghEqn.boundaryManipulate(p_rgh.boundaryField())
  - The same manipulation for turbulence properties

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Mesh generation

- Generate each mesh block separately
  - blockMesh + snappyHexMesh
- Merge all the mesh blocks using mergeOversetMesh utility
- Scale the mesh to model scale

Case setup

I. Boundary and initial conditions

II. Setup physical properties of ship (CoG, Mass, moments of inertia et al)

III. Setup test type

IV. fvSchemes & fvSolution & controlDict

Outline

1. Background
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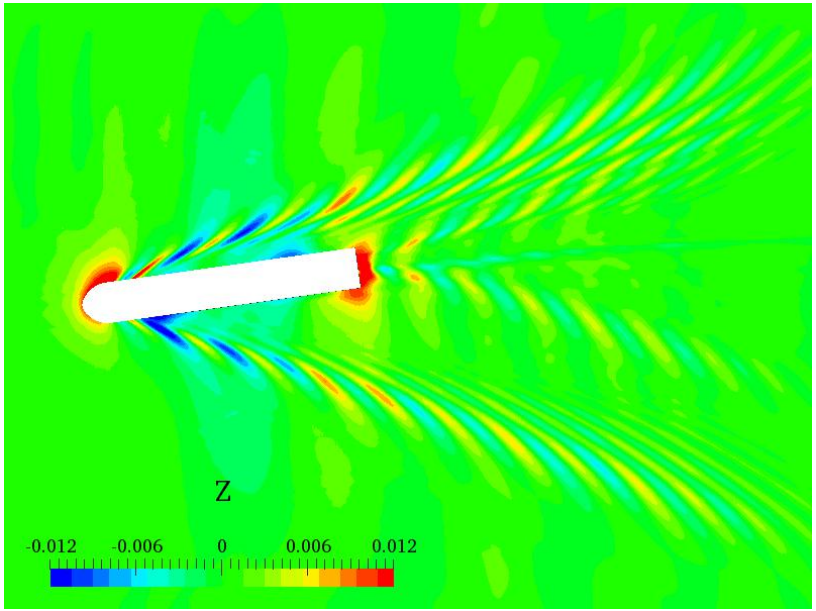
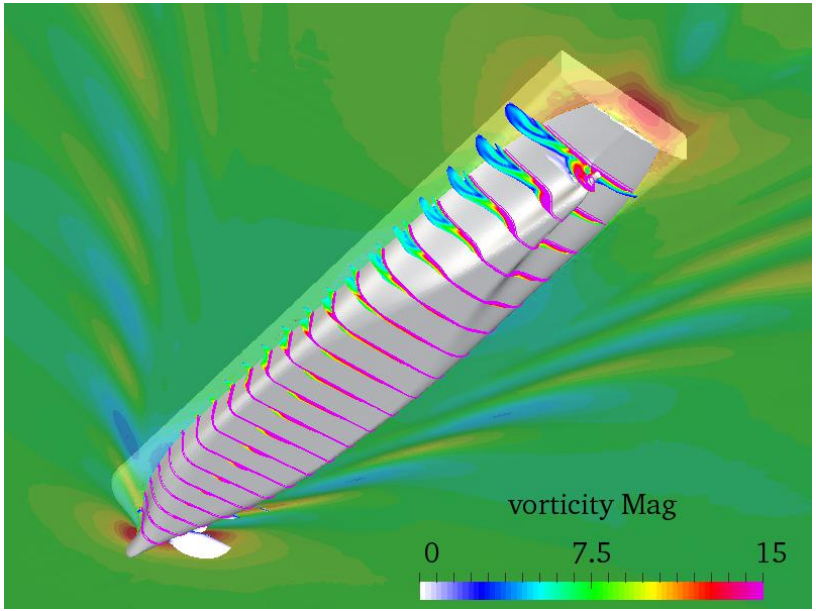
PMM model tests of a container ship

- Grid convergence study
- Expert intellegence

Static PMM Test

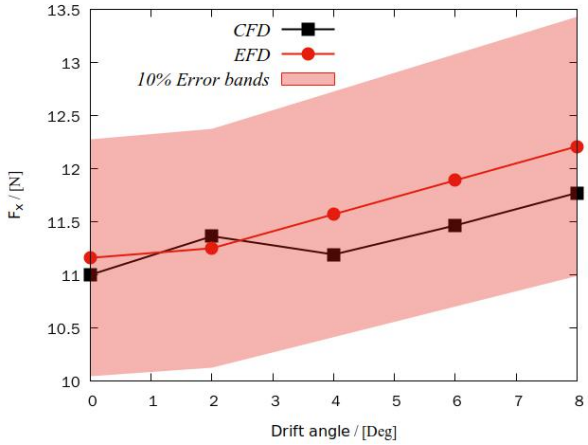
- **Drift angle = 8°**
- **Wave pattern and vortex separation**

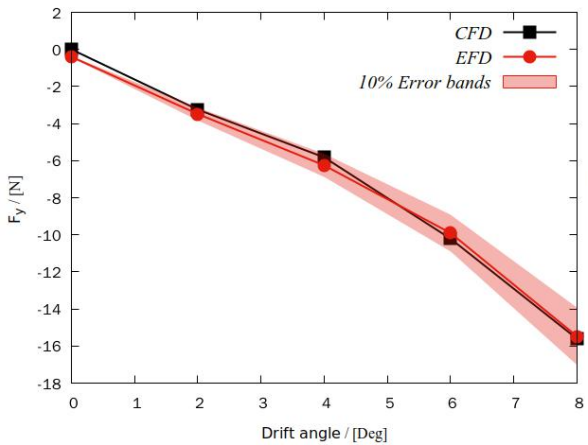


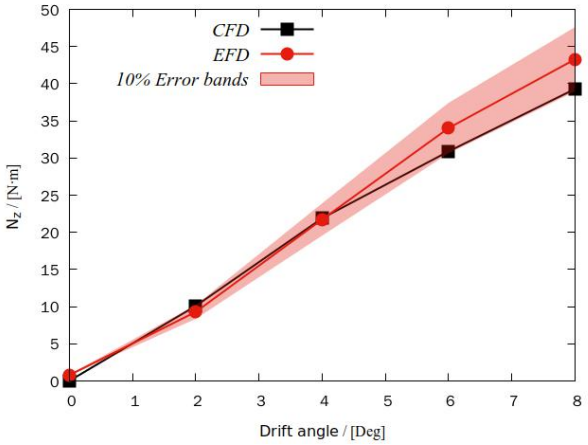


Static PMM Test

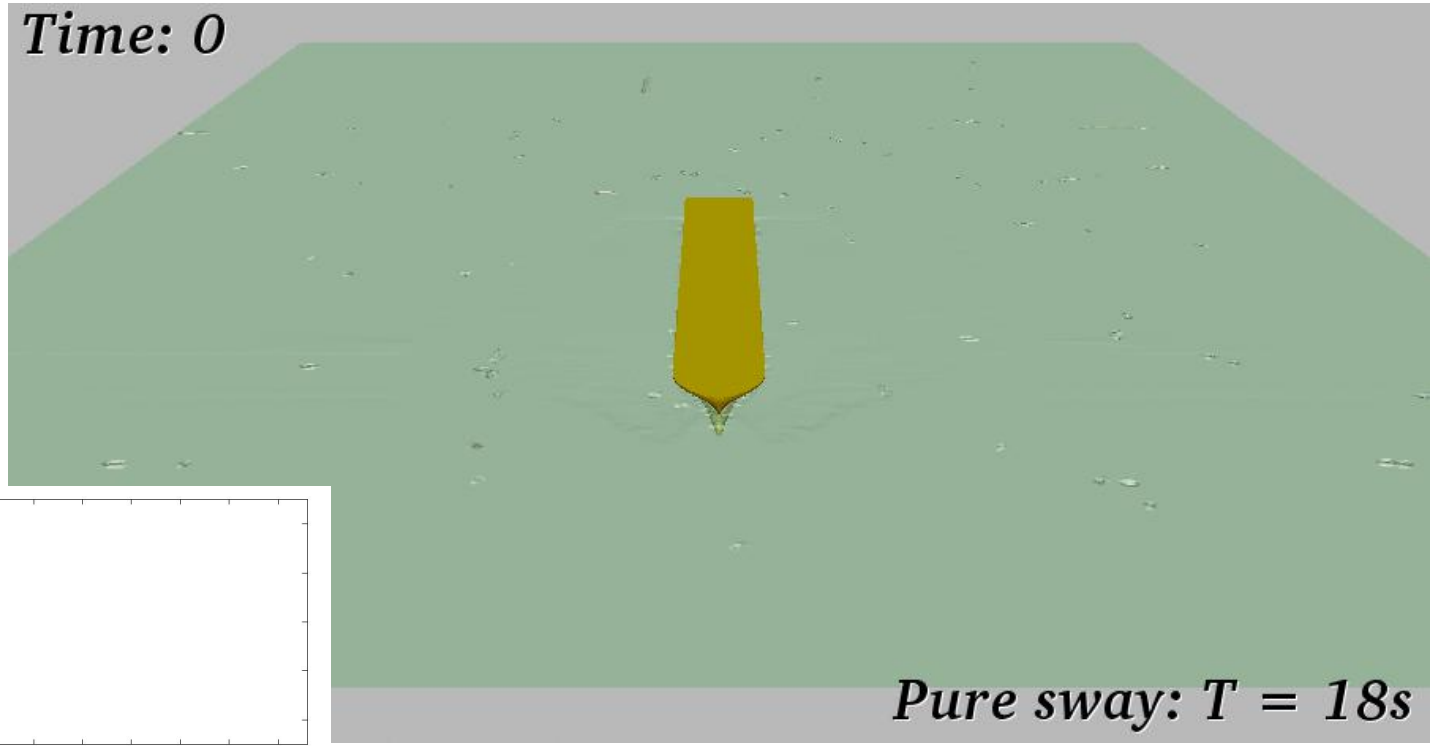
- **Longitudinal, lateral forces and moments along Z axis**



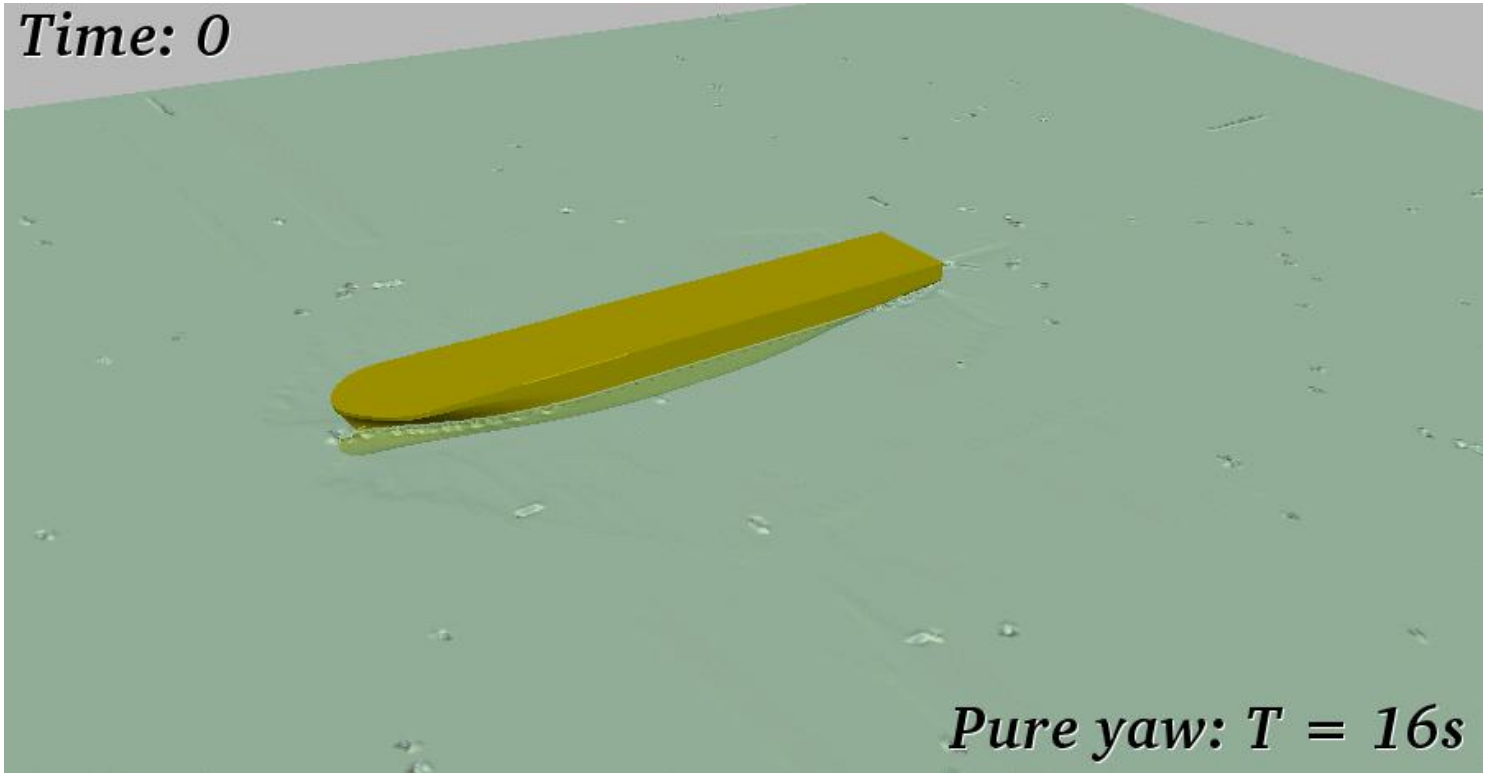




Dynamic PMM Test



Dynamic PMM Test



Thank You