Ocean Engineering Group (OEG)/EWRE

(August 28, 2018)

Spyros A. Kinnas

Professor and Director of OTRC's UT Office

(Offshore Technology Research Center)

Kinnas Home Page

@SpyrosKinnas on twitter

Research in the area of computational hydrodynamics with applications on the prediction of performance and design of high-speed marine propulsors or turbines, modeling of cavitating or separated flows, and wave/body interaction.

Teaching:

- ***CE358: Introductory Ocean Engineering (Fall '18 - 12:30-2:00, Tu & Th)***
- ***CE319F: Elementary Fluid Mechanics (Fall '18 - 9:30-11:00, Tu & Th)***
- ***CE380P.4: Boundary Element Methods (Spring '19 – tent.)***
- ***CE380T: Computational Environmental Fluid Mechanics (Fall '19 – tent.)***
- ***CE397-32: Theory of Propellers and Turbines (?? – tent.)***

Facilities:

- ***CHL (Computational Hydrodynamics Laboratory) in ECJ 8.502***

Fuel-Efficient marine propulsors …

Must comply with new EEDI (Energy Efficiency Design Index) regulations on CO_2 emissions from newly built ships

Contra-rotating props

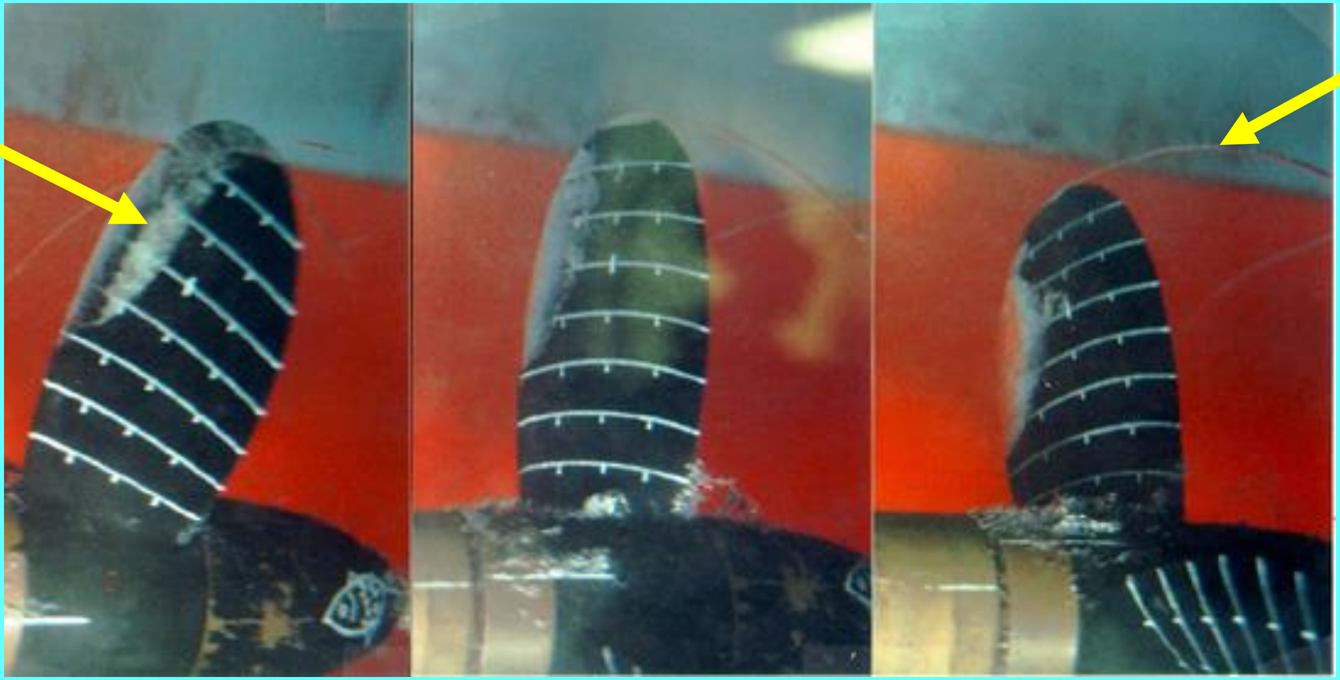
Ducted prop

…and some water-turbines (used to generate energy from ocean currents)

Twin turbines (each 0.6 MW) pulled out of the sea for maintenance

For high-speed propellers cavitation is often inevitable

Sheet Cavity

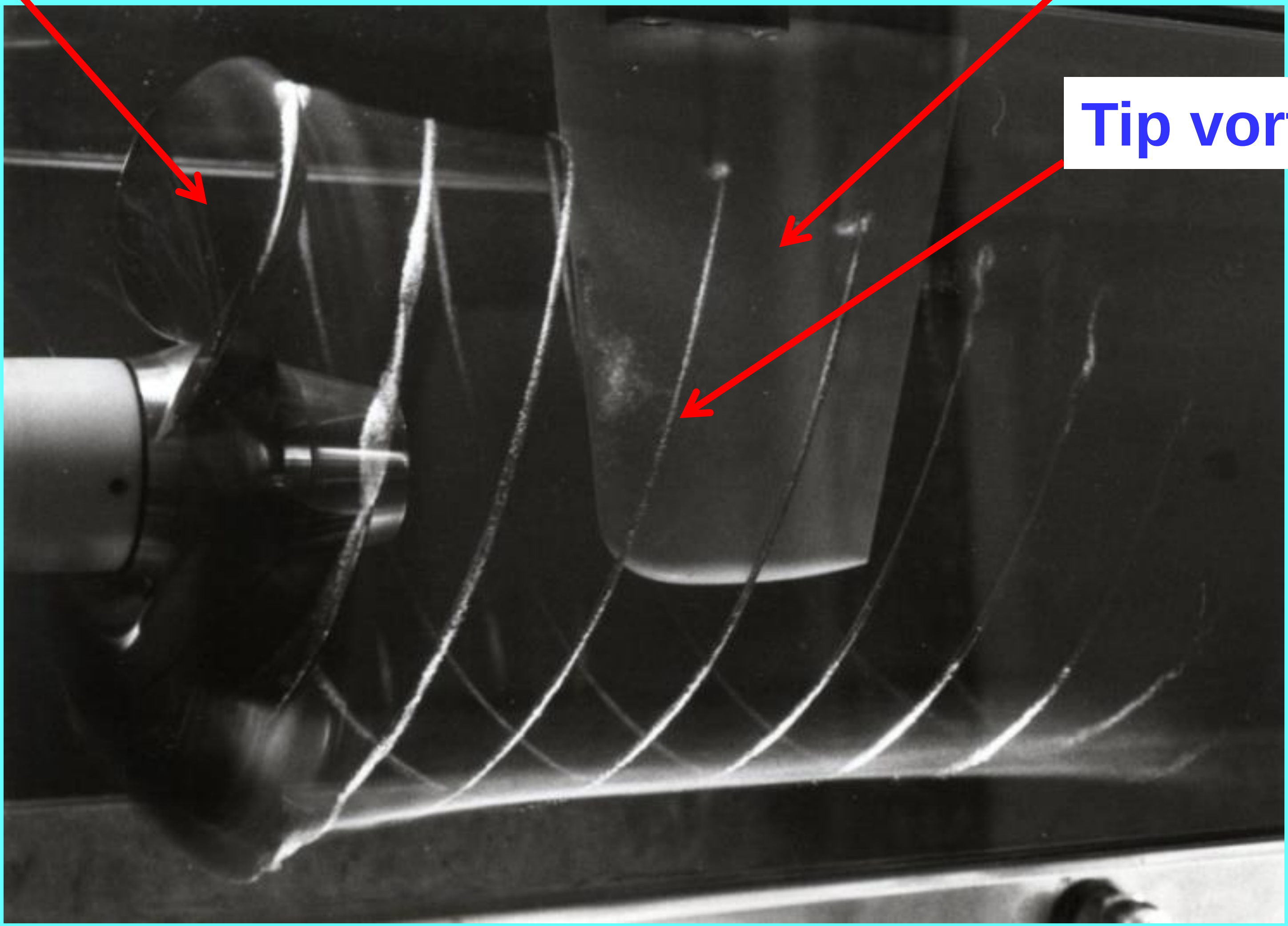


Tip vortex

- **Cavitation can accelerate erosion of blades, produce noise, or result in sudden loss of thrust**
- **However, allowing for some cavitation can increase efficiency**

Rotating components interacting with stationary ones

(propeller) (rudder)

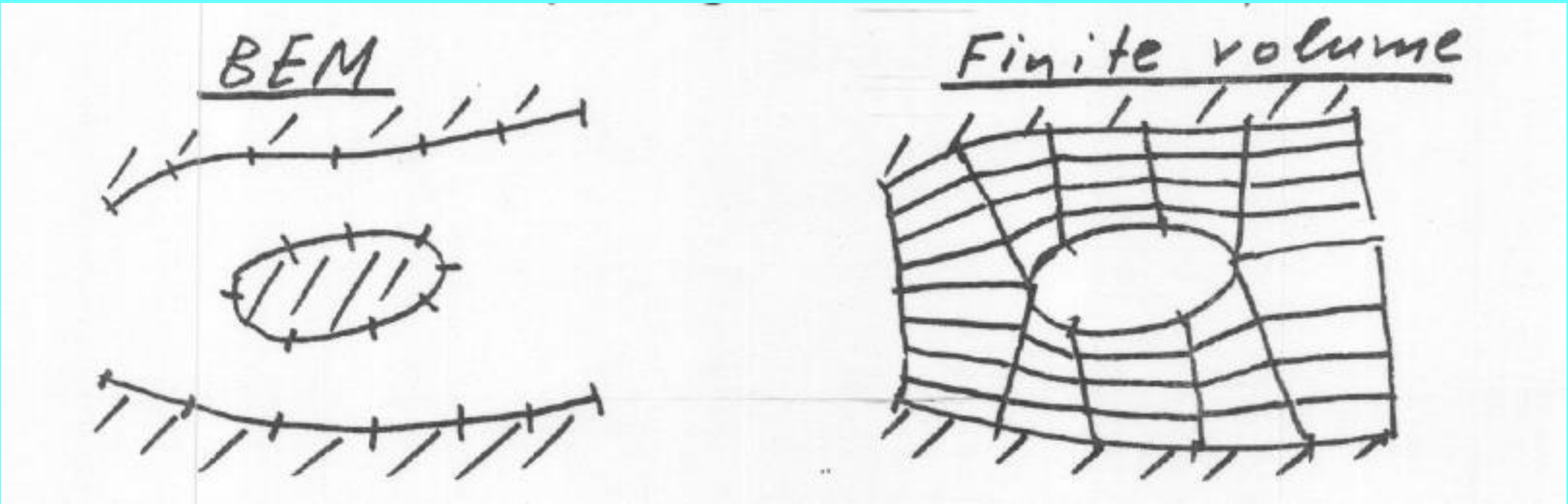


Tip vortex

Two methods to model flow

Boundary Element (or Panel) Method (addressed in CE380P.4)

Finite Volume Method (addressed in CE380T)

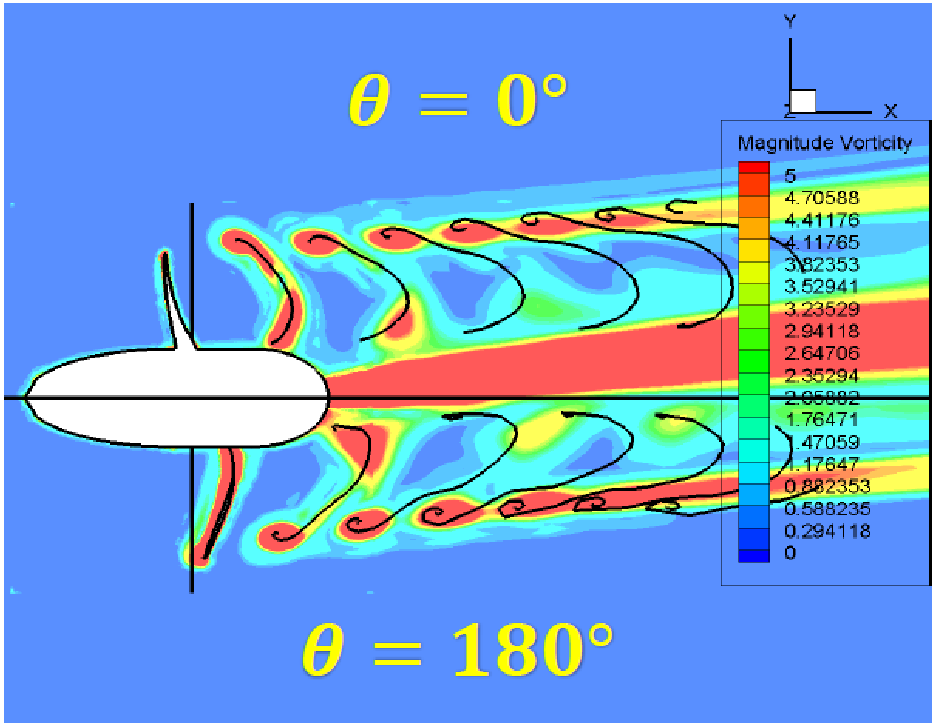


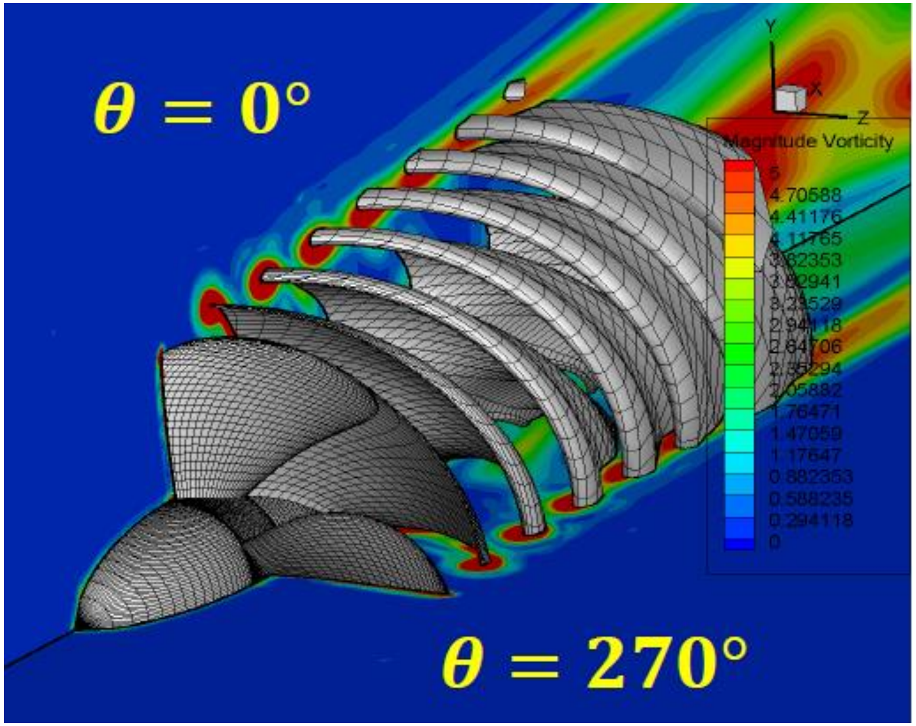
- **BEM can only handle the inviscid part of the flow (i.e. NOT very close to boundaries). The effects of viscosity are included via coupling with integral boundary layer methods**
- **FVM needs a very large number of cells to resolve the whole domain (especially the boundary layer) within acceptable accuracy**

Flow around propeller in inclined flow predicted by

a) BEM (vorticity location shown in black)

b) FVM (vorticity shown in color)



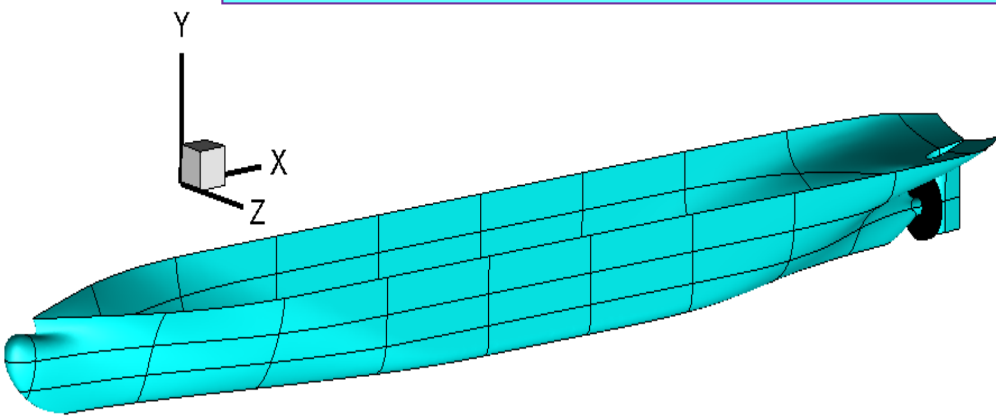


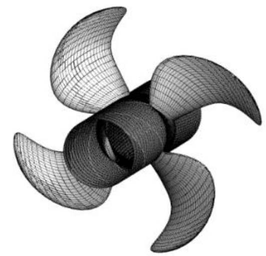
From OE MS'17 and recent work of S. Kim

Ship Hull – Propeller – Rudder Interaction

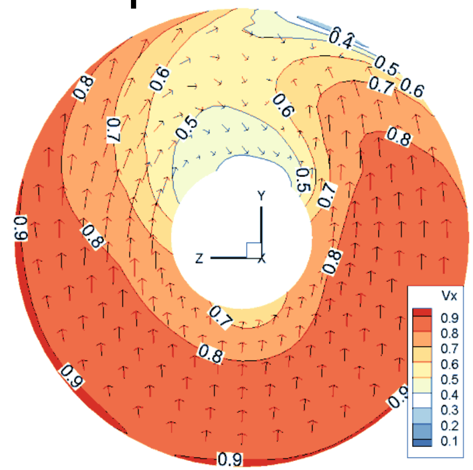
(Y. Su, OE/PhD '18 and Su & Kinnas, Journal of Ship Research, 2017)

Combination of FVM (on the ship) with BEM (on the propeller)

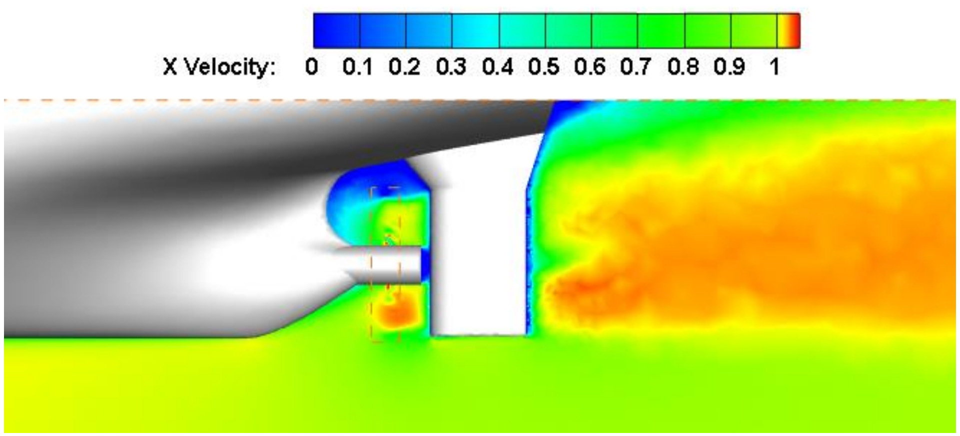


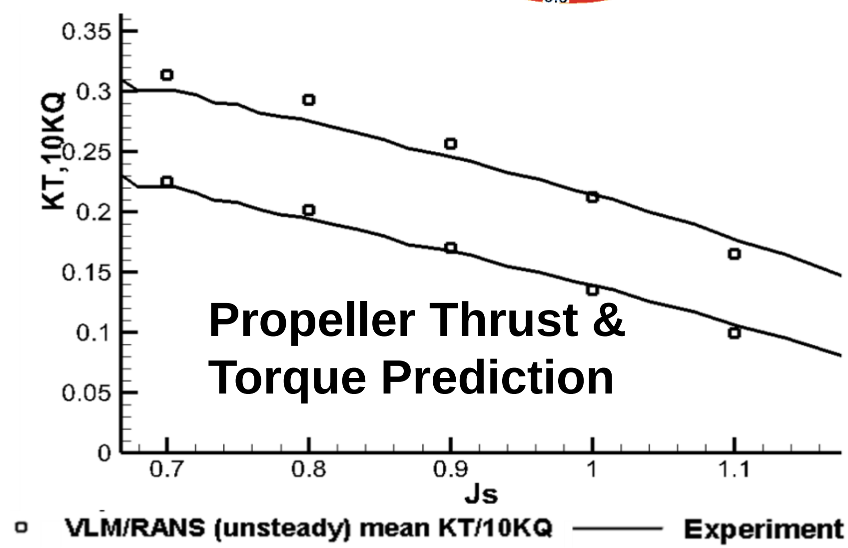


Propeller Inflow

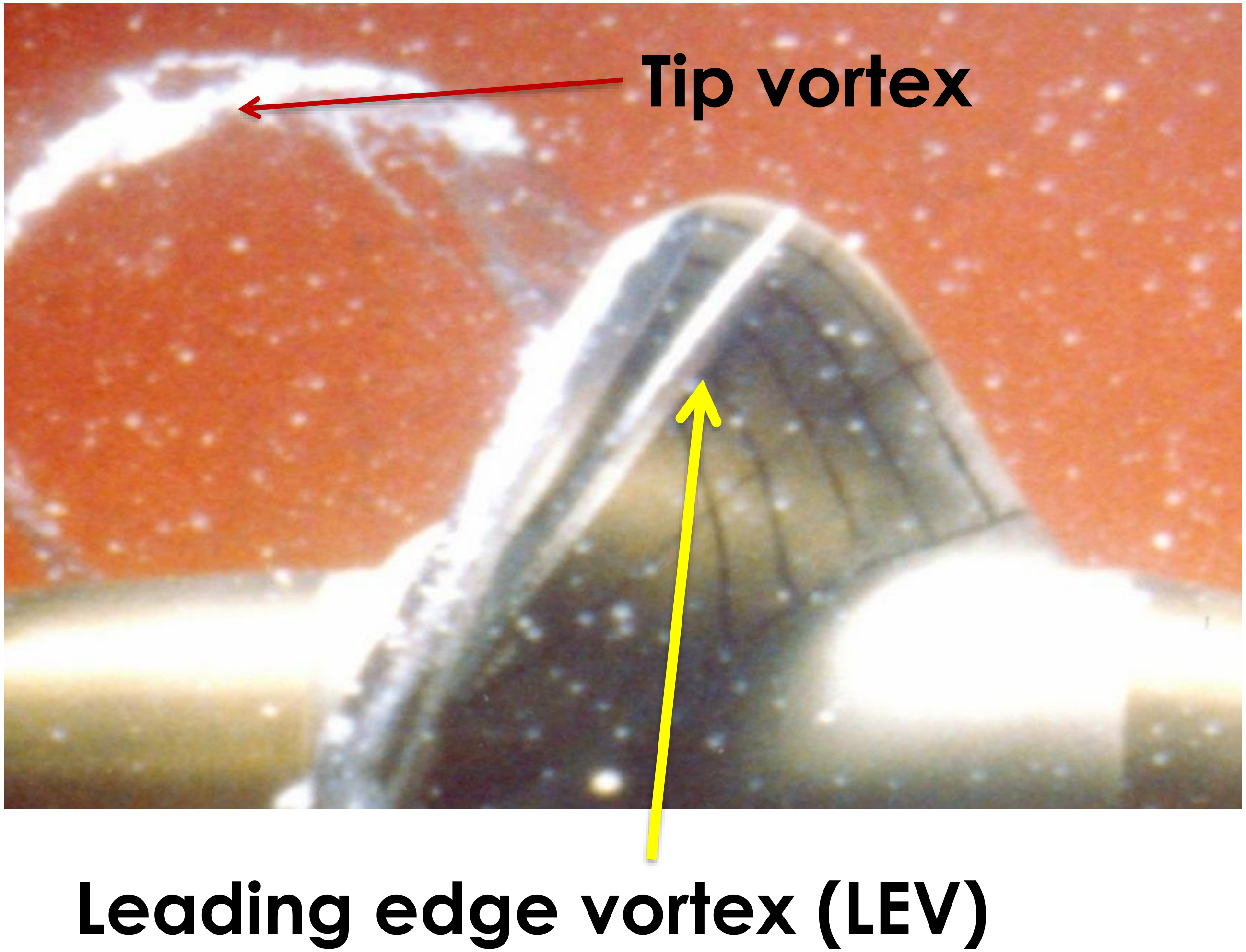


Axial Velocity/Ship Speed





A VIScous Vorticity Equation (VISVE) Model for Propeller at Off-Design with Leading Edge Vortex (LEV)

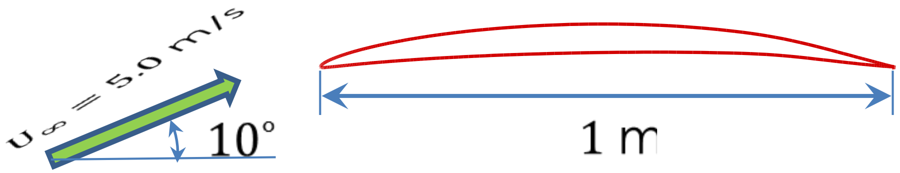


Tian, PhD OEG/UT 2014

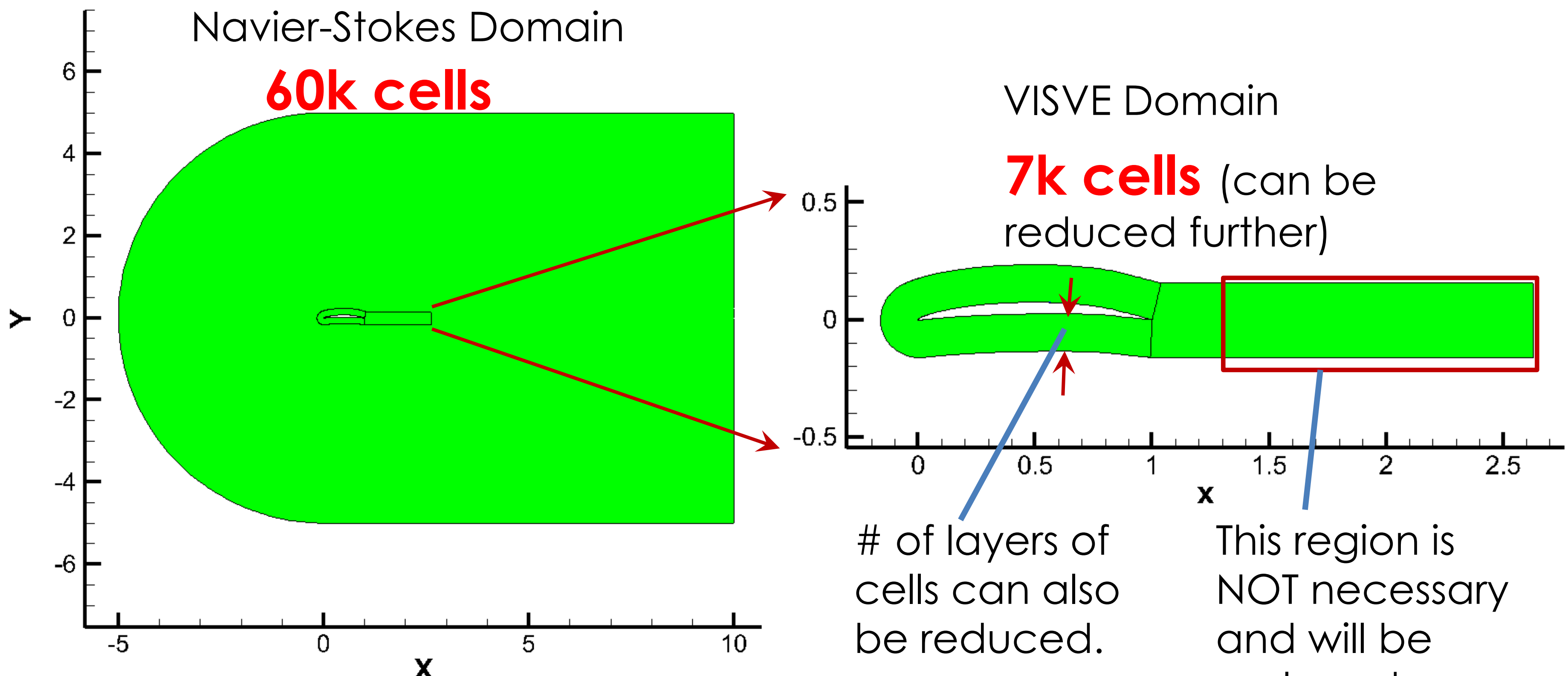
Tian & Kinnas; SMP'15

NEW METHOD FOR EVALUATION OF LE SEPARATION

- **2D hydrofoil at high angle of attack**



$Re = 5 \times 10^4$

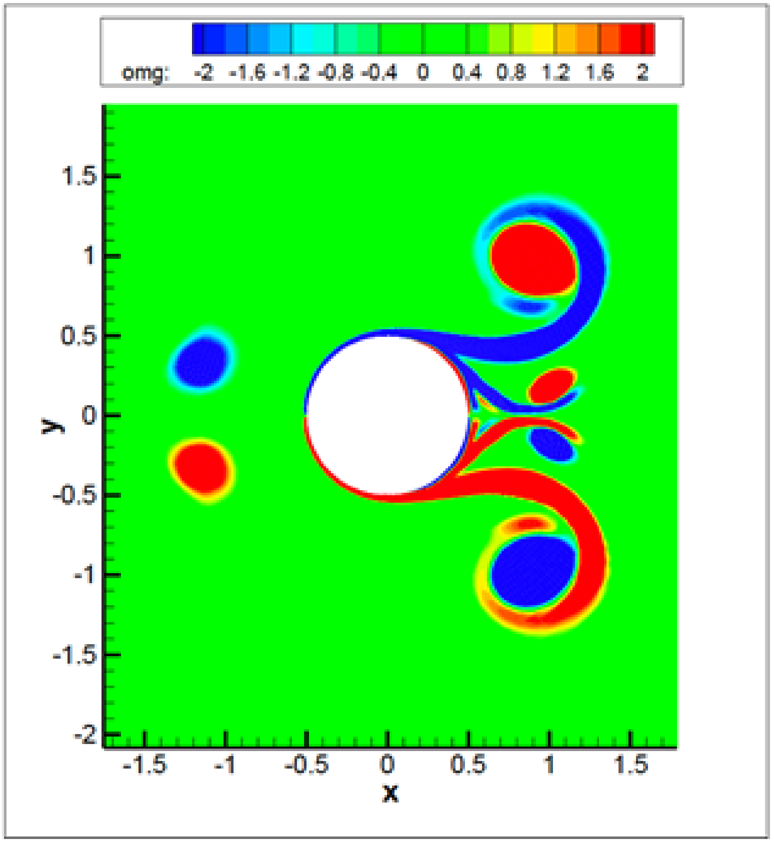


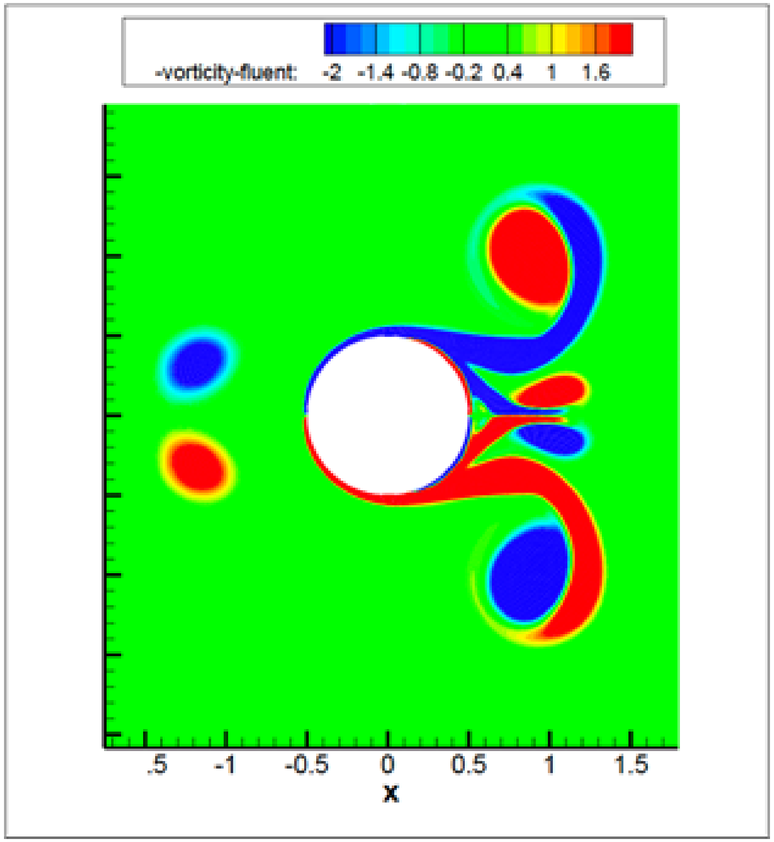
# of layers of cells can also be reduced.

This region is NOT necessary and will be replaced.

Alternating Flow around cylinders by VISVE VIScous Vorticity Equation method VISVE (left) vs. RANS

OE/MS'17 Z. Li

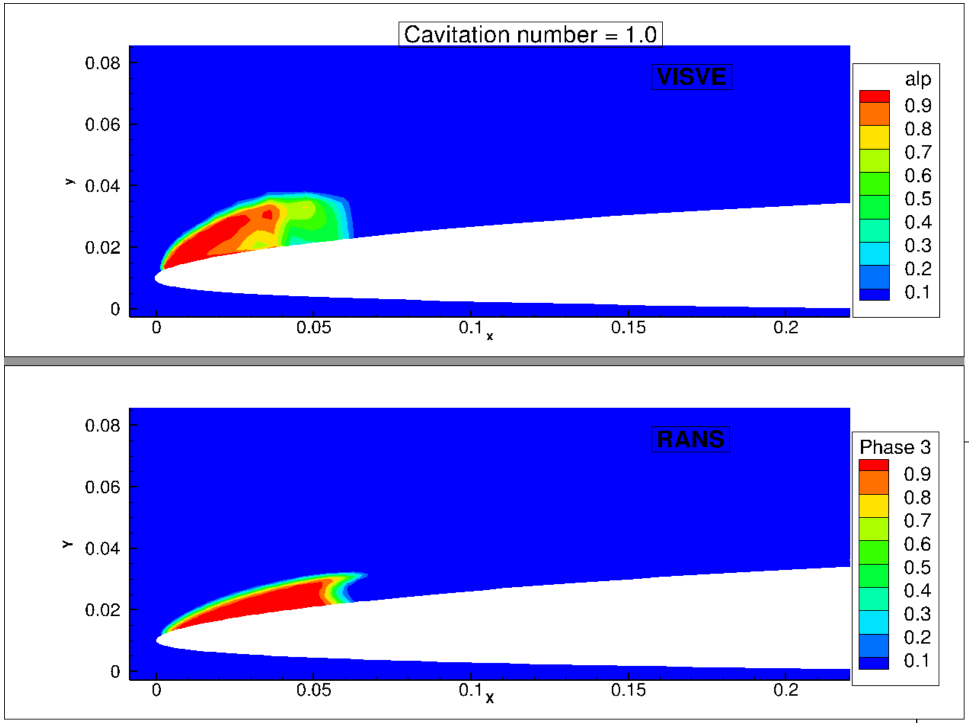


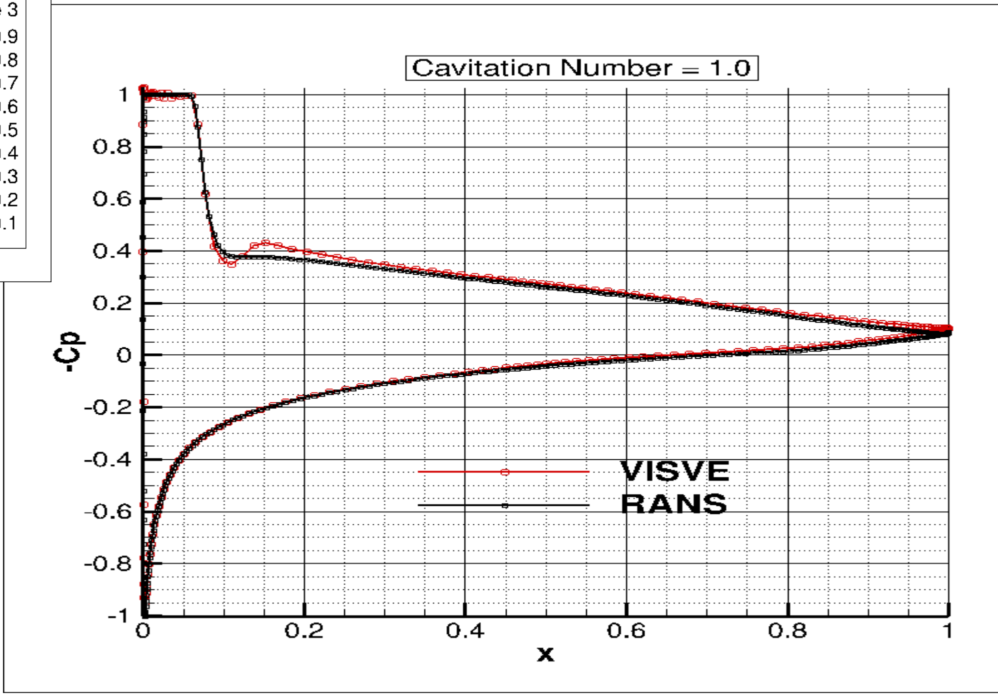


Prediction of cavitation via VISVE

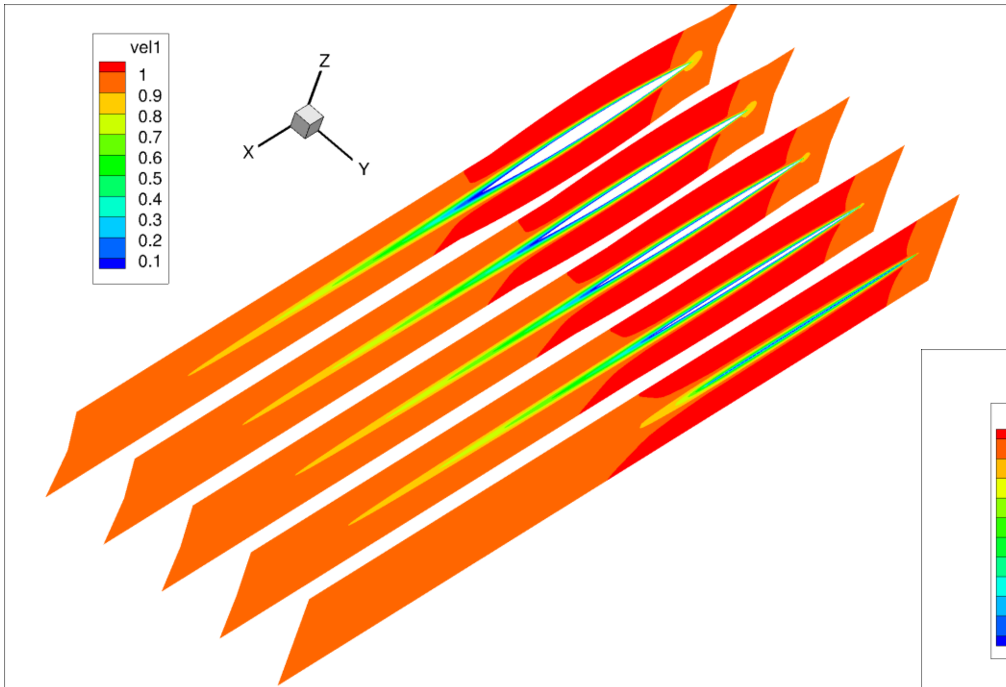
Cavitation Number = 1.0

OE/MS'18 L. Xing

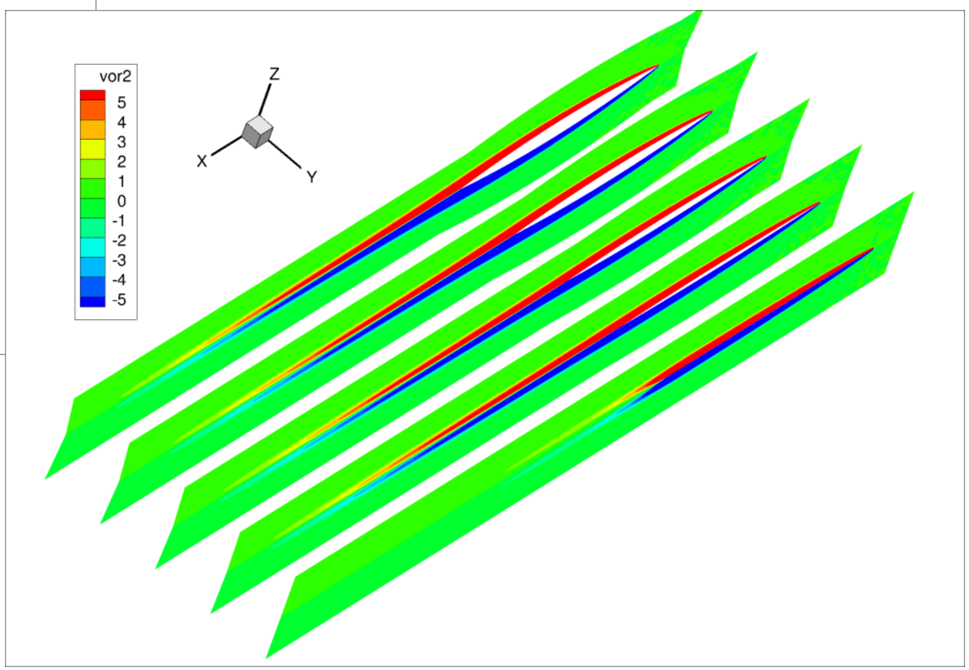




Prediction of flow around 3D hydrofoils via VISVE (slices with velocity-on the left-and vorticity shown)

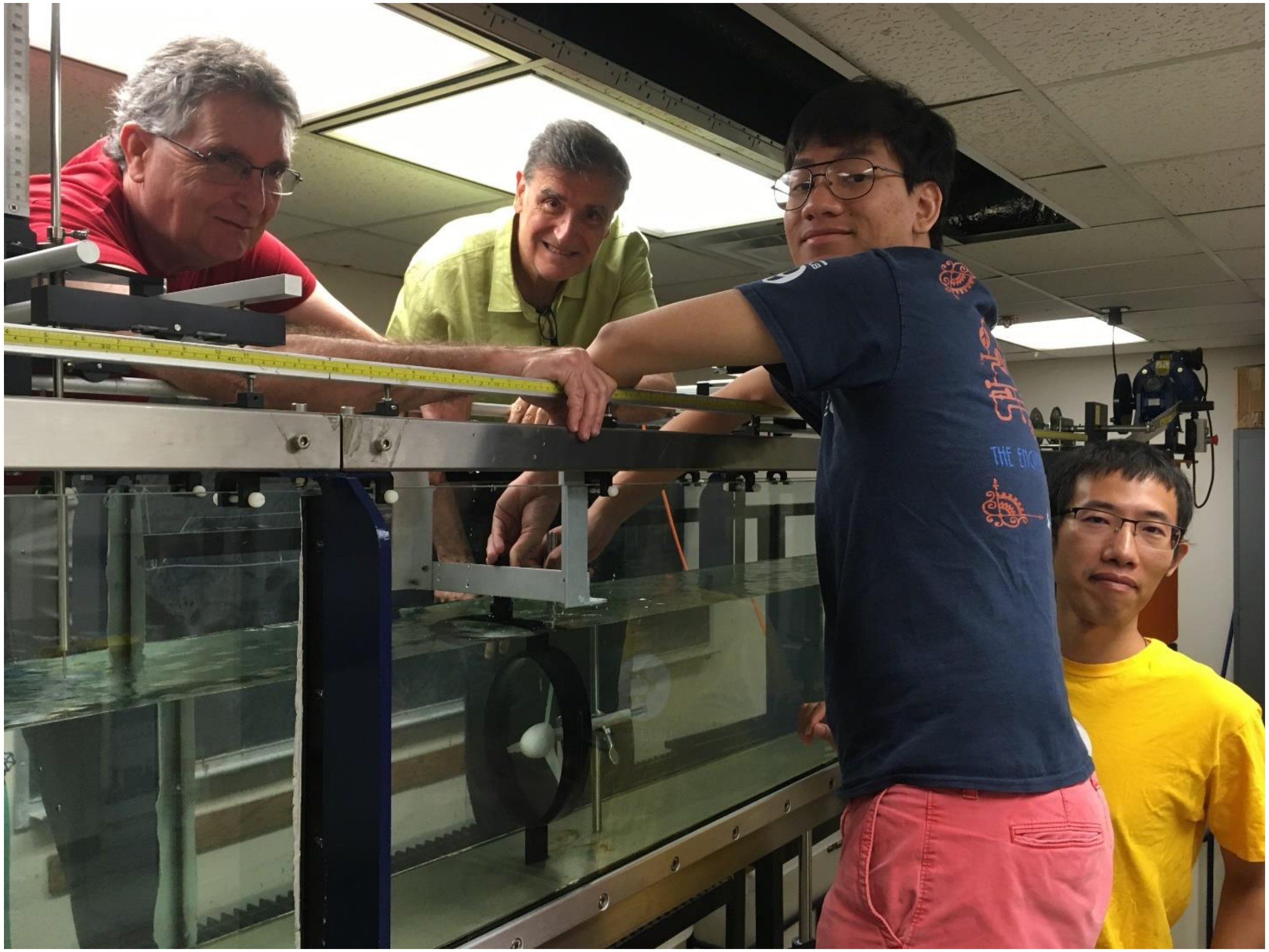


Work of C. Wu



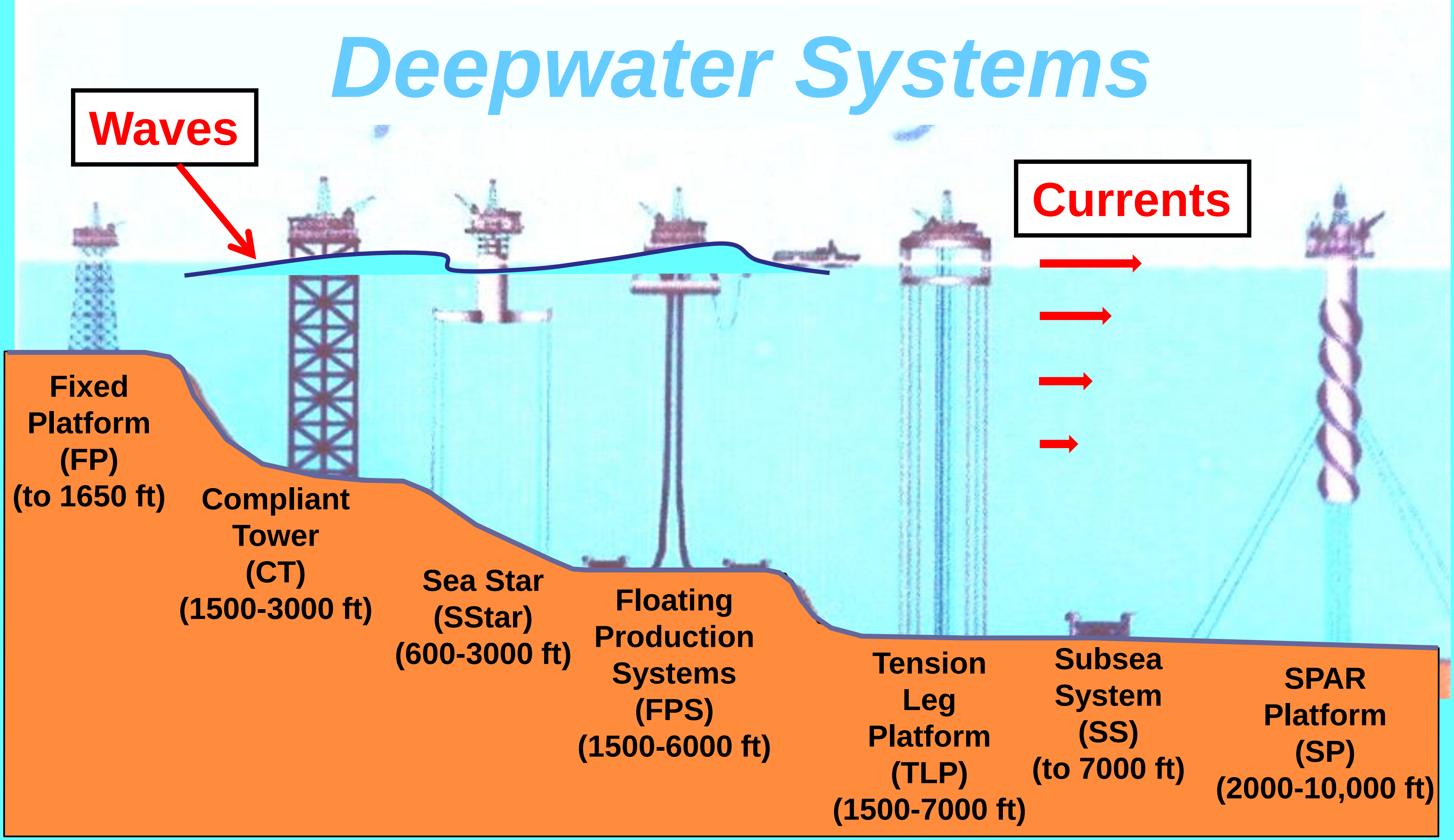
Design, 3D printing, and testing of ducted marine turbine in CAEE's flume

Work of A. Du and H. Pham



Check @SpyrosKinnas for updates

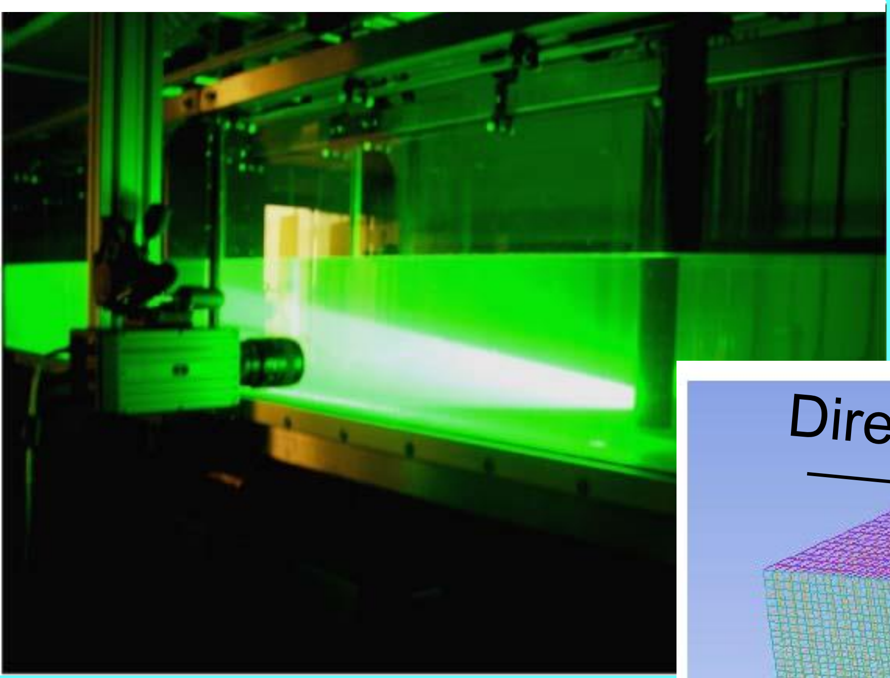
OFFSHORE PLATFORMS



Source: Bureau of Ocean Energy Management

Experiment and simulation of flow around cylinder subject to wave
(G. Wang; OE/MS '15; Wang & Kinnas, Journal of Offshore and Arctic Engineering, 2018)

UT's flume and Particle Image Velocimetry (PIV) system



Simulation of viscous flow inside flume (using ANSYS/Fluent)

- Reynolds-Averaged Navier-Stokes (RANS)
- Large Eddy Simulation (LES)

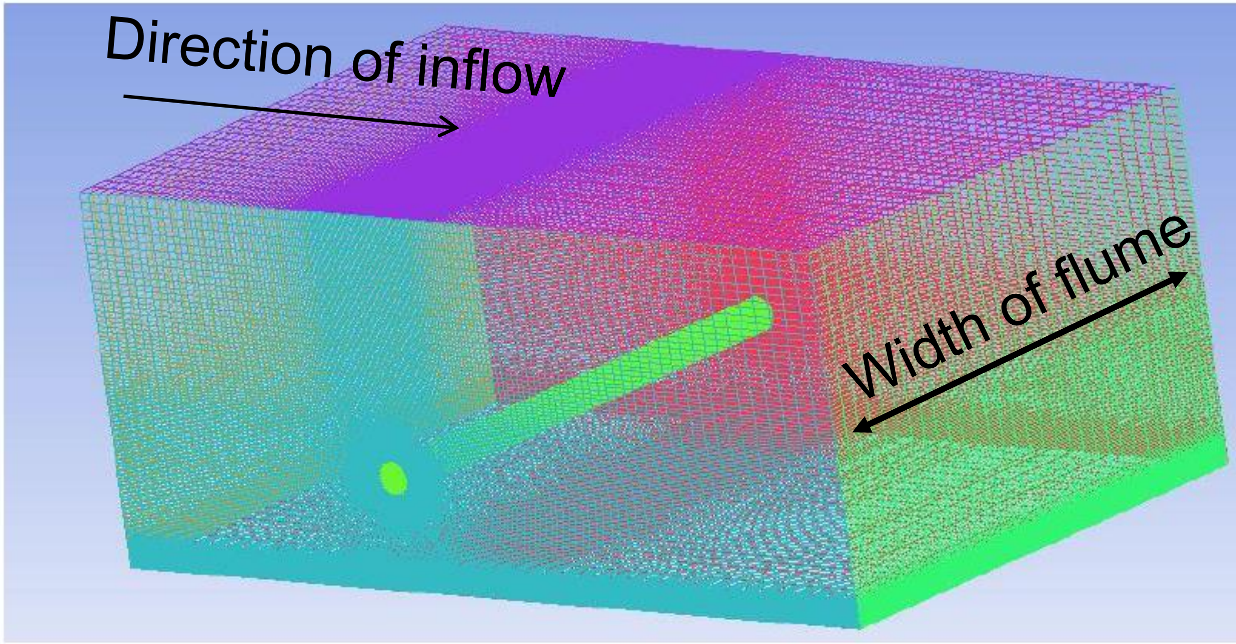


Figure 4.37 3D mesh including free surface

Measured vs. predicted velocity over time

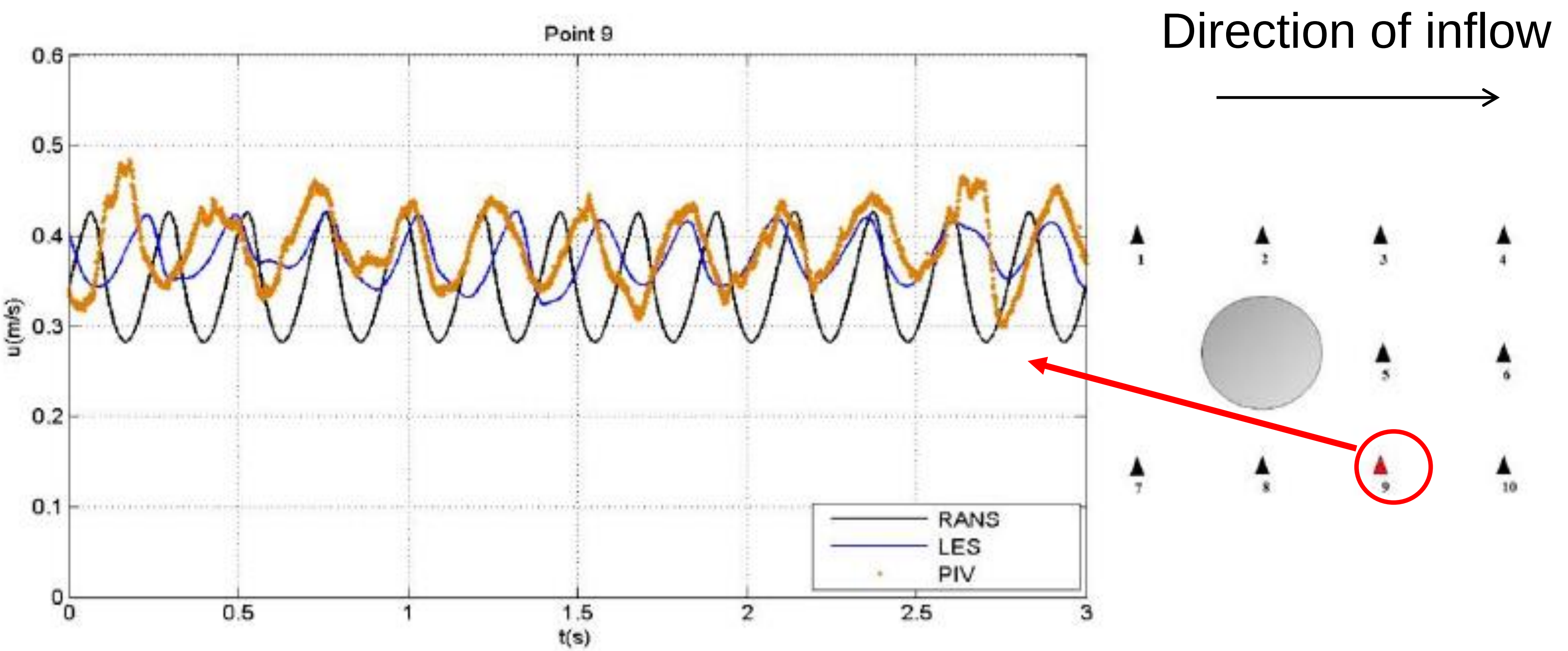


Figure 4.13 Time history of horizontal velocity of point 9

Measured vs. computed time averaged velocities (Reynolds stresses)

LES appears to do a much better job than RANS in simulating the viscous flow

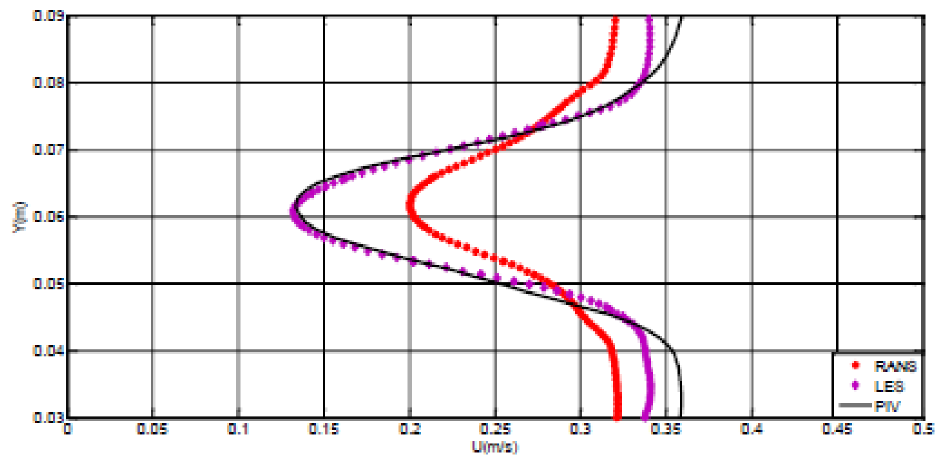


Figure 4.16 Time-averaged horizontal velocity at section 1

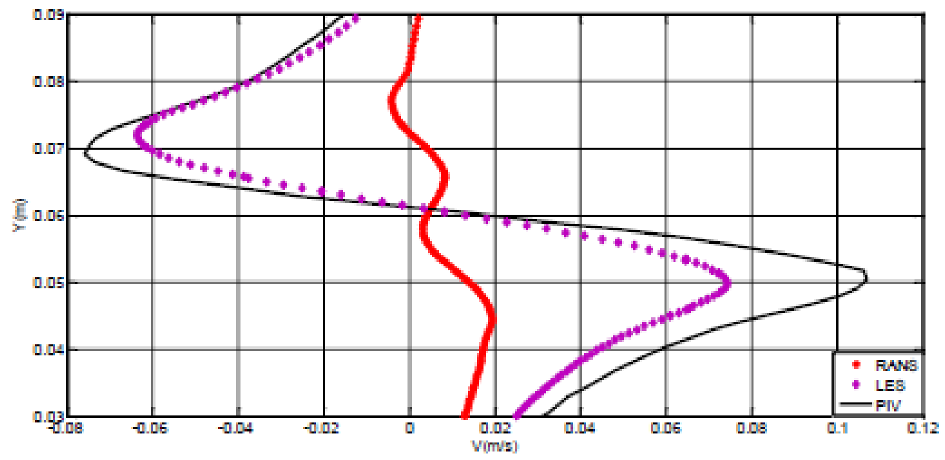


Figure 4.17 Time-averaged vertical velocity at section 1

2018-19 Opportunities in OEG:

- **MS Thesis in OE on the topics listed (unfunded) – Requires strong background in Fluid Mechanics, Advanced Calculus, and Computational Methods**