Marine Hydrodynamics

Overview of Marine Hydrodynamics

People:

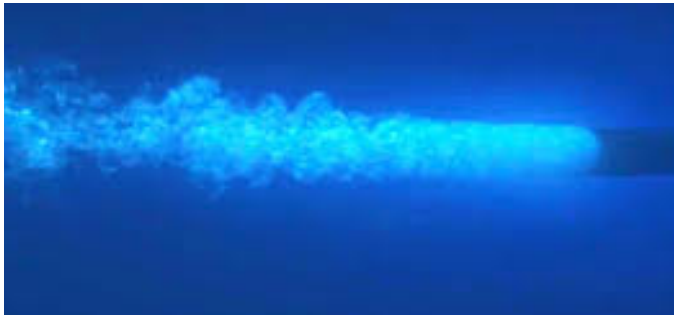
- **Stephan Grilli**, *Distinguished Professor and Chair*, Ocean Engineering, URI, Lead
- **Jason Dahl**, *Associate Professor*, Ocean Engineering, URI
- **Annette Grilli**, Associate Research Professor, Ocean Engineering, URI
- **Reza Hashemi**, *Assistant Professor*, Ocean Engineering, URI
- **James (Sau-Lon) Hu**, *Professor*, Ocean Engineering, URI
- **Stephen Licht**, *Assistant Professor*, Ocean Engineering, URI
- **Harold (Bud) Vincent**, *Associate Research Professor*, Ocean Engineering, URI
- **Chengzhi Yuan**, *Assistant Professor*, Mechanical, Industrial, and Systems Enging., URI

Capabilities

- Computational fluid dynamics (CFD) modeling
- Experimental scale model testing
- Underwater autonomous vehicles
- Quantitative flow visualization
- Dynamic fluid-structure interactions (waves, seakeeping)
- Ocean signal processing
- Coastal modeling (metocean, storm surge, wind waves, tsunamis, coastal hazard)
- Nonlinear ocean wave mechanics
- Ocean systems design

Undersea vehicle Technology Applications

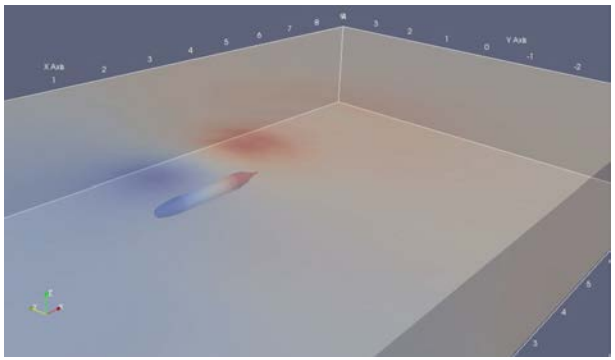
- Shape optimization to minimize propulsion requirements
- Resistance calculation (under and over the water) to design propulsion system power requirements
- Simulation of maneuvering
- Seakeeping simulations when cruising over the water
- Design of control surfaces and appendices
- Wake/breaking wave simulations



New high-fidelity low cost CFD models

Development of new Computational Fluid Dynamics (CFD) models that:

- Can simulate flow around and interaction with a variety of Navy vehicles (see figure), cruising or maneuvering under or over the sea surface, in design or operational conditions
- Are based on new efficient methods (e.g., particle Lattice-Boltzmann methods) allowing for realtime simulations on desktop workstations (with GPGPU co-processors)



Hybrid potential/Navier-Stokes fully nonlinear simulation of advancing Suboff submarine just below the free surface (pressure, wave, and drag resistance; surface wave generation). (URI)

GPGPU co-processor: over 4,000 cores and 12Mb per unit (order $2,000).

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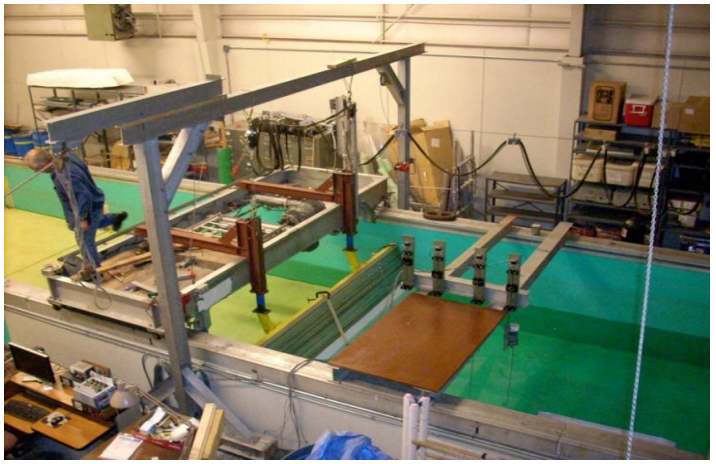
Available Facilities at URI

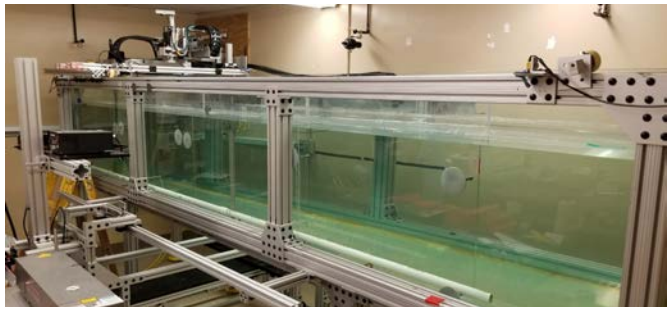
- URI has a 14 ft deep Acoustic tank, a 100 ft long wave/towing tank for vehicle staging/testing, and a 13 ft long visualization towing tank.
- URI has Allen Harbor facility and Bay Campus dock access for field testing in Narragansett Bay with R/V Shanna Rose

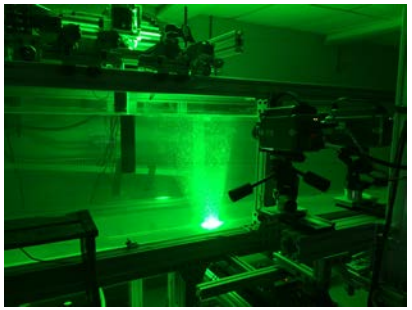


URI Wave/ Towing tank

URI Allen Harbor water access

URI Acoustic Tank





Flow visualization towing tank (4.3 m x 0.9 m x 0.9 m), stereo particle image velocimetry system: LaVision DaVis processing software, 2 Phantom V10 high-speed cameras (4 MP @ 480 fps)

Quantronix high-speed pulsed laser, and 3-D printers for model prototyping

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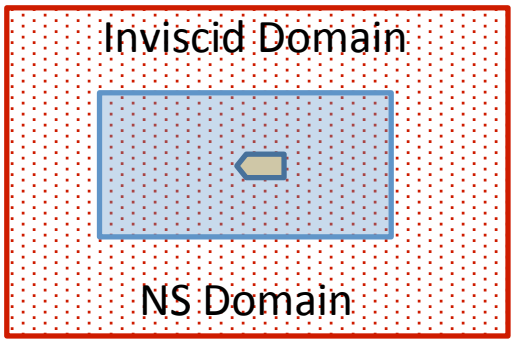
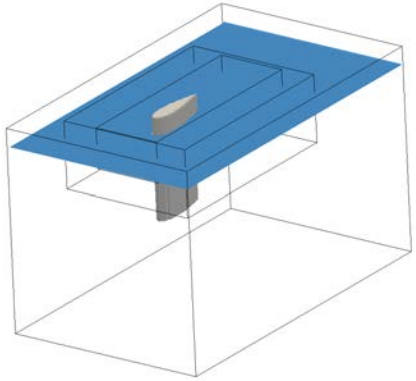
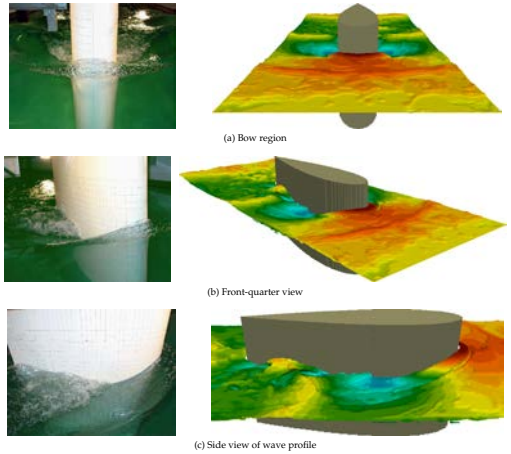
Active research project: Development and validation of an efficient hybrid-CFD method for fluid-structure interaction problems (Grant N00014-16-12970, ONR Code 333; 2016-19). PIs: S. Grilli and J. Dahl (URI)

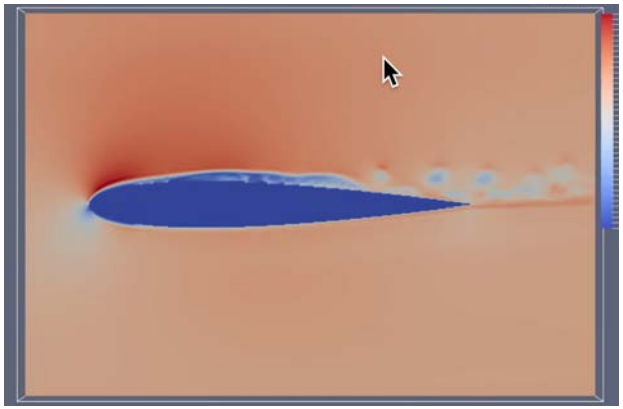


Overlapping potential and NS domains in hybrid model

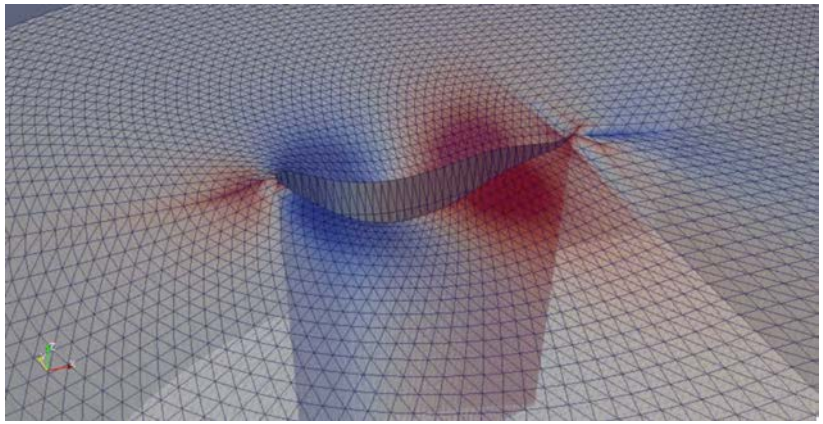


Advancing surface piercing NACA 0024 foil





High Re turbulent flow around NACA 0012 foil at 4 deg. incidence, in hybrid LBM-LES



Advancing surface piercing NACA 0024 foil (Fr = 0.37)

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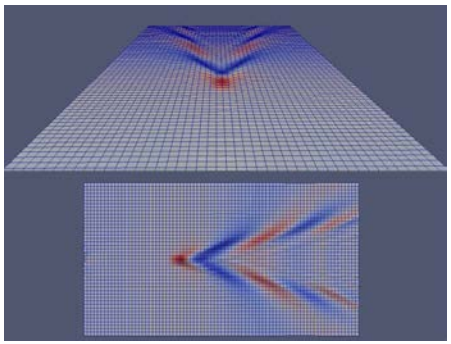
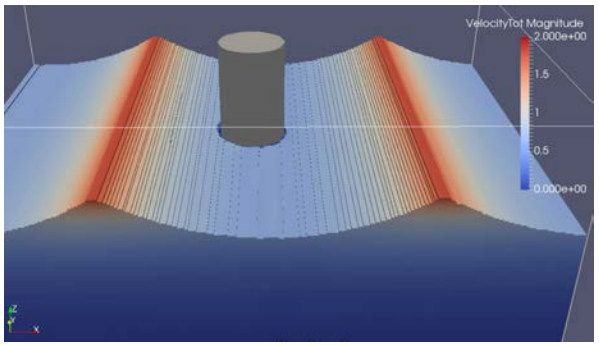
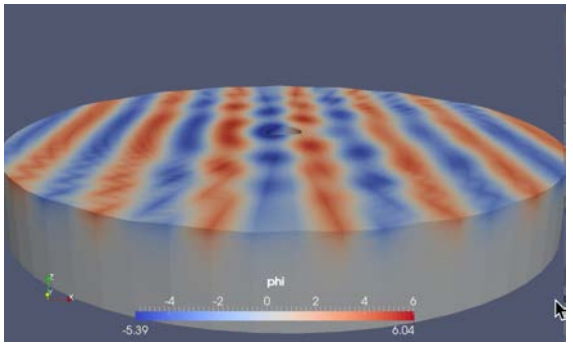


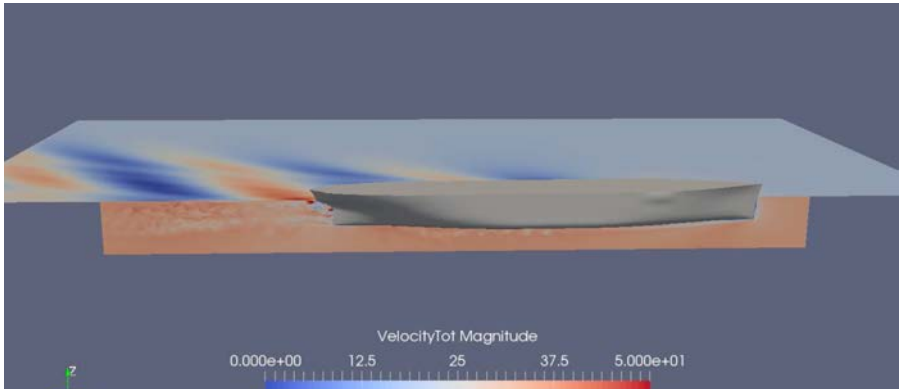
Wake generated by advancing SES



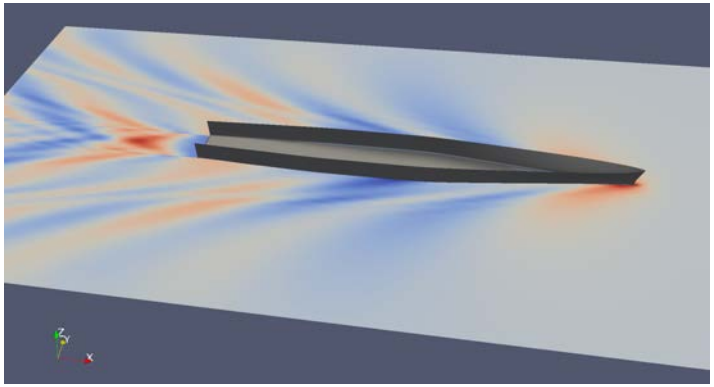
Fully nonlinear wave interacting with surface piercing cylinder in hybrid LBM-LES model



Nonlinear periodic wave diffraction around a surface piercing cylinder (potential flow model)



Hybrid potential-LBM-LES model of advancing Series 60 ship (Fr = 0.30)



Hybrid potential-LBM-LES model of Series 60 ship

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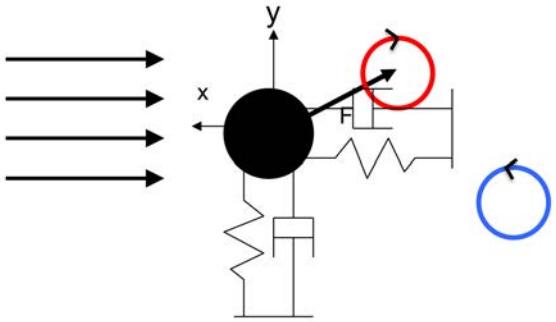
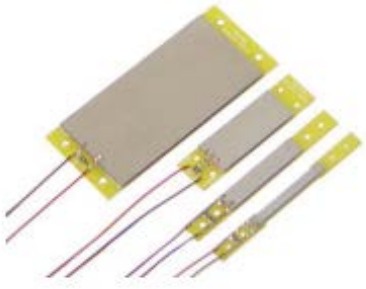
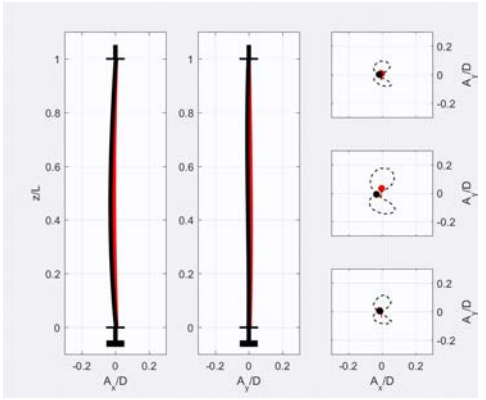
Active research project: Dynamic Interaction of Underwater Vibrations with Piezo Stimulus and Pressure-Based Feature Detection (Grant from ONR Code 333; 2016-19; PM K. Cooper). PIs: J. Dahl (URI)



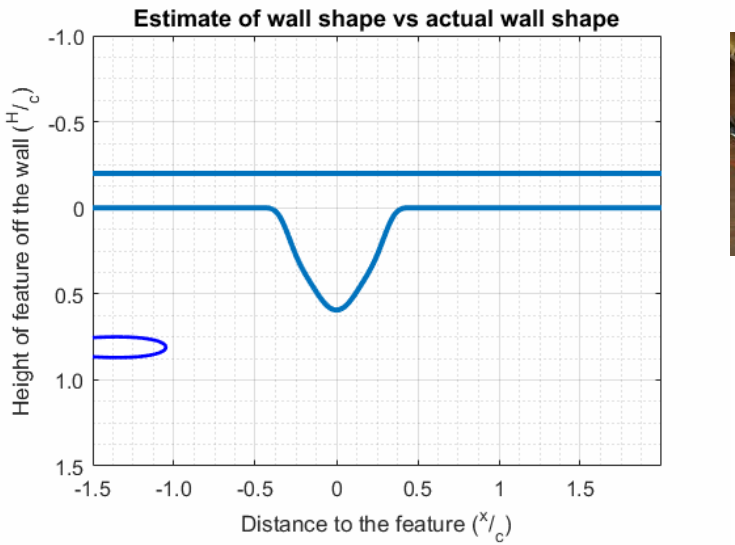
VIVs of a flexible cylinder in a free stream

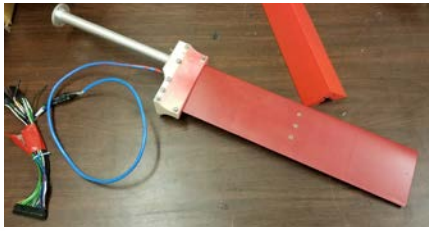


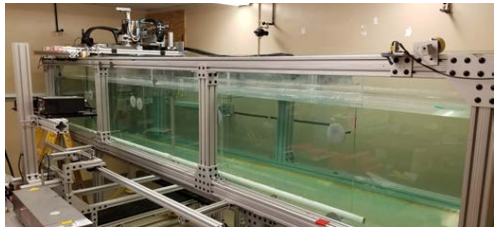
Motion control/damping by piezo actuators mounted on cylinders



Black: natural response; red: response controlled by piezo-actuators







Test of advancing fin equipped wit 3 pressure sensors in tow tank
Past various shapes. Use unscented K-filter method. Compare to CFD (Lilypad)