Simulations of high Reynolds number flow past arrays of circular cylinders undergoing vortex-induced vibrations

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Motivation

- Long cylindrical marine risers of circular cross-section are used for deep water extraction of petroleum and natural gas.
- The flow of seawater around these long cylinders is subject to vortex shedding (massive unsteady flow separation).
- If the vortex shedding frequency “locks-in” to one of the natural frequencies of the riser, the cylinder may undergo severe vortex-induced vibrations (VIV) leading to structural fatigue or failure.
- Current ability to predict stress levels and fatigue rates is inadequate, relying in simplified models.
- Reliable computational fluid dynamics tools are required to analyze the VIV phenomenon.
Numerical solution procedure/capabilities


• implemented alongside the capability to treat non-matching and embedded structured grid blocks (overset grids), allowing for relative grid motions

• individual or groups of structured grid blocks are distributed among different processors

• computations are performed in TAMU SGI Altix, using up to 16 processors in parallel
Numerical solution capabilities

Overset (Chimera) grids
Simulations

Flow past a fixed circular cylinder

Vorticity and Drag history, Re = 10^5

time = 250.0
Simulations

Flow past a fixed circular cylinder

Drag vs. Reynolds number curve
Simulations

Isolated cylinder undergoing VIV
“Figure of eight” pattern of body motion

Re = 10^5, m* = 1.0, m* ζ* = 0.05, U* = 6.055
Simulations

Cylinders in side-by-side arrangement undergoing VIV

Re = $10^5$, $m^* = 1.0$, $m^* \zeta^* = 0.05$, $U^* = 6.055$, $S_0 / D = 5.5$
Cylinders in a square array undergoing VIV

Re = $10^5$, $m^* = 1.0$, $m^* \zeta^* = 0.05$, $U^* = 6.055$, $L_0 / D = 5.5$, $\alpha = 0$ deg.