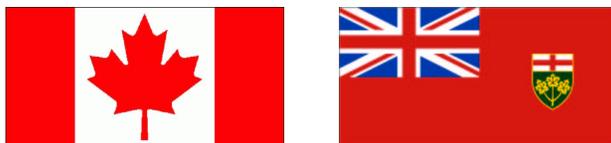


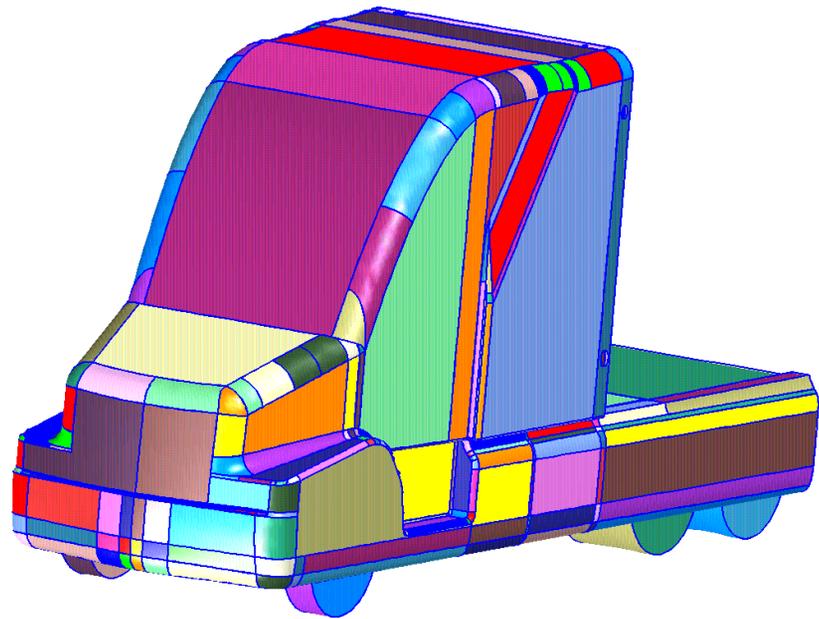
Overture: A Framework for Solving PDE's on Overlapping Grids

Bill Henshaw

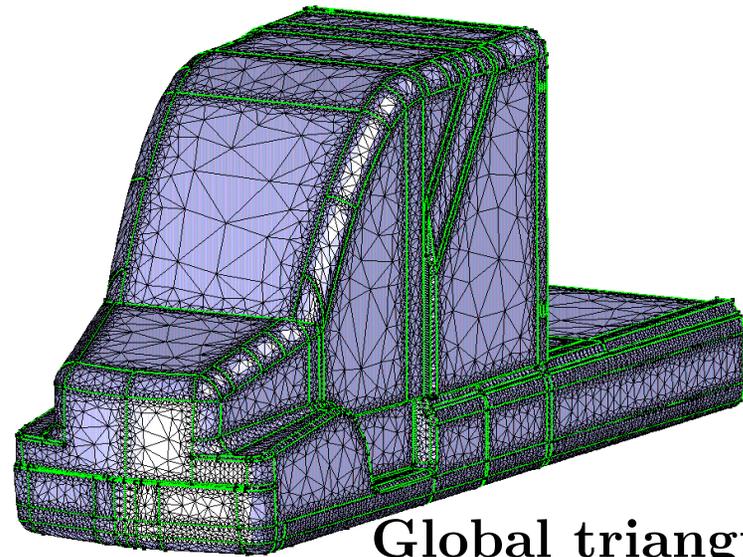


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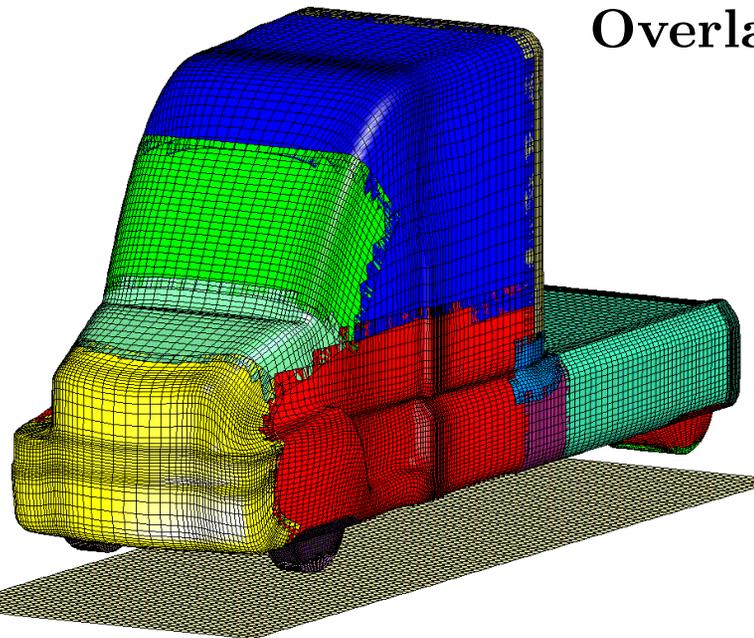
www.llnl.gov/casc/Overture



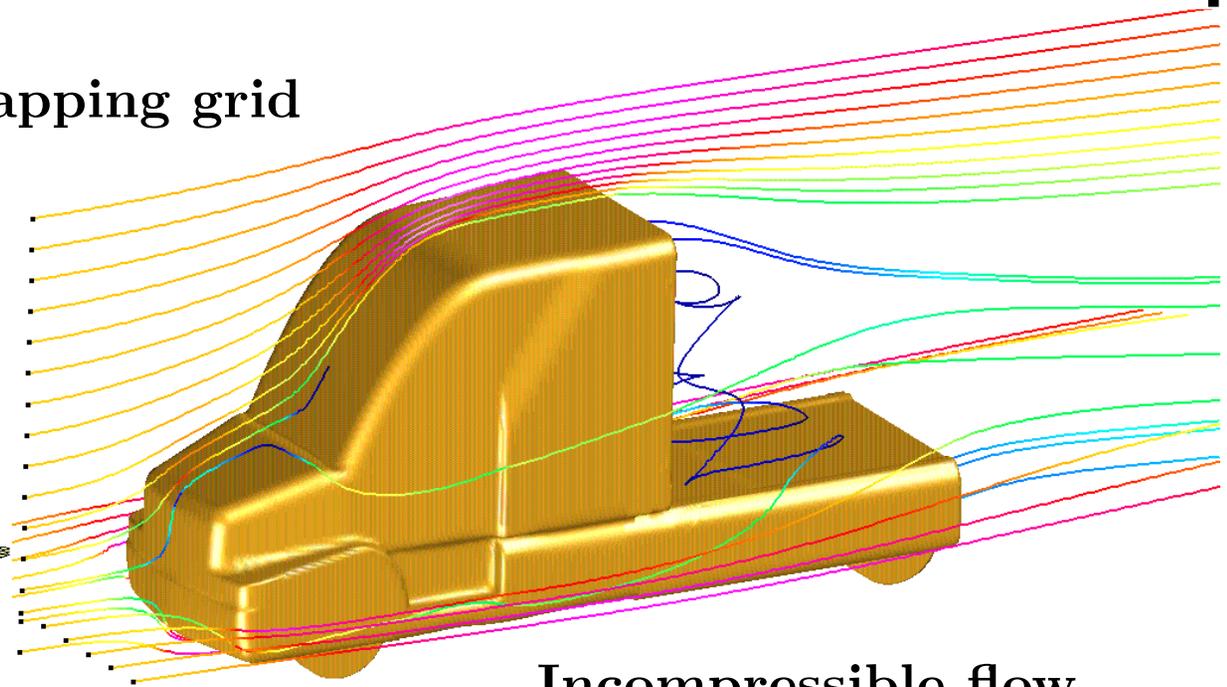
Cad geometry



Global triangulation



Overlapping grid



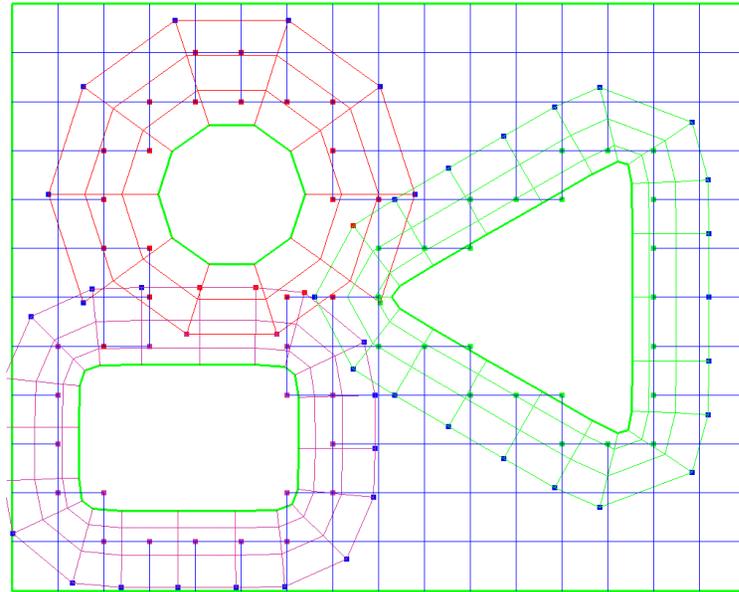
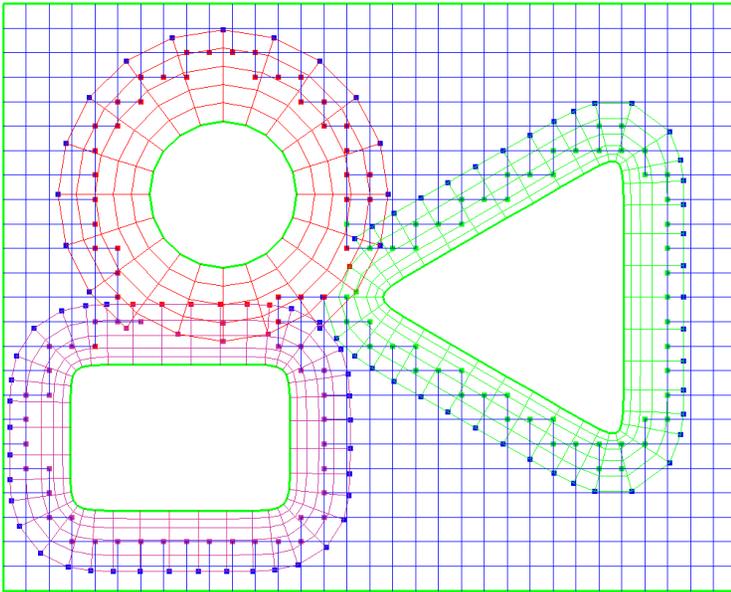
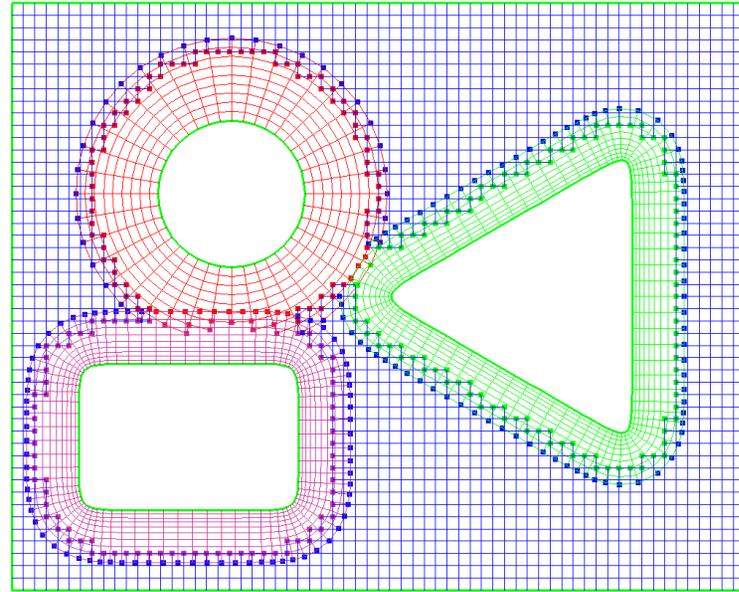
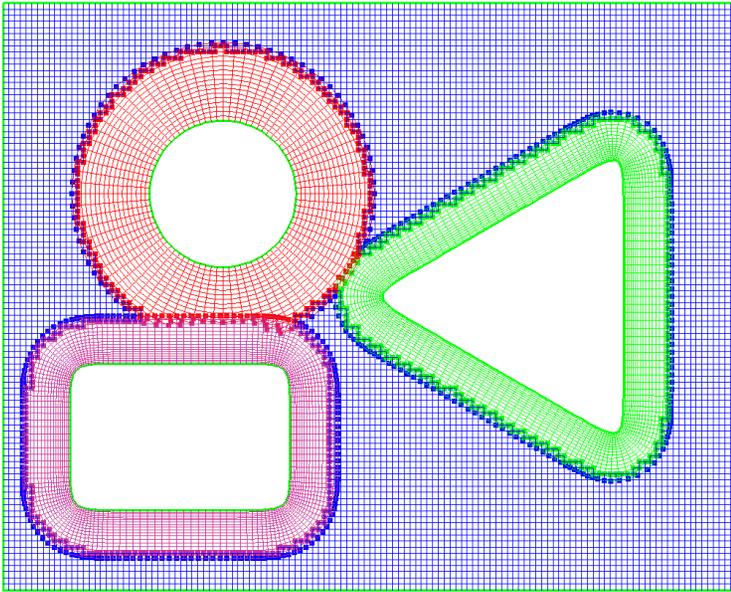
Incompressible flow.

Wave equation solver:

Fast and memory efficient solvers can be created that take advantage of cartesian component grids.

problem	grid points	cpu/step	Memory	real/grid-pt
twoCircles (2D)	6.3 million	1.3	220 M	4.5
sphere in a box (3D)	8.4 million	5.7	580 M	8.8
two spheres (3D)	9.6 million	9.6	950 M	12.7

Table 1: Performance results for the wave equation solver on a 2.2 GigaHertz Pentium workstation. Fourth-order accurate in space.



An overlapping grid for some shapes, 4 multigrid levels.

Ogmg: multigrid solver for overlapping grids

					CPU time (s)			storage
Solver	grid	pts	its	$\ res\ _\infty$	total	setup	solve	reals/pt
Ogmg V[1,1] FMG	cic	1.1e6	7	5.7e-10	3.3	.54	2.8	4.6
biCG-stab, ILU(5)	cic	1.1e6	144	8.9e-9	152	35.	117	53.5
gmres ILU(5)	cic	1.1e6	435	1.0e-8	271	35	236	65.0
biCG-stab, ILU(0)	cic	1.1e6	554	8.6e-9	342	32	310	33.3
gmres ILU(0)	cic	1.1e6	2657	8.9e-9	1135	33	1102	49.0
Ogmg V[1,1] FMG	elb	2.0e6	10	3.3e-10	21.5	4.52	17.0	9.9
biCG-stab, ILU(2)	elb	2.0e6	46	4.1e-10	222.	106	116	70.3
biCG-stab, ILU(0)	elb	2.0e6	113	3.7e-10	264.	77.	187	41.6
gmres(20), ILU(0)	elb	2.0e6	218	5.2e-10	306.	70.	236	56.5

Table 2: A comparison of the multigrid solver Ogmg to some Krylov based solvers (PETSc). The cic grid is a two-dimensional circle-in-a-channel, the elb grid is ellipsoid-in-a-box.

Ogmg: multigrid solver for overlapping grids

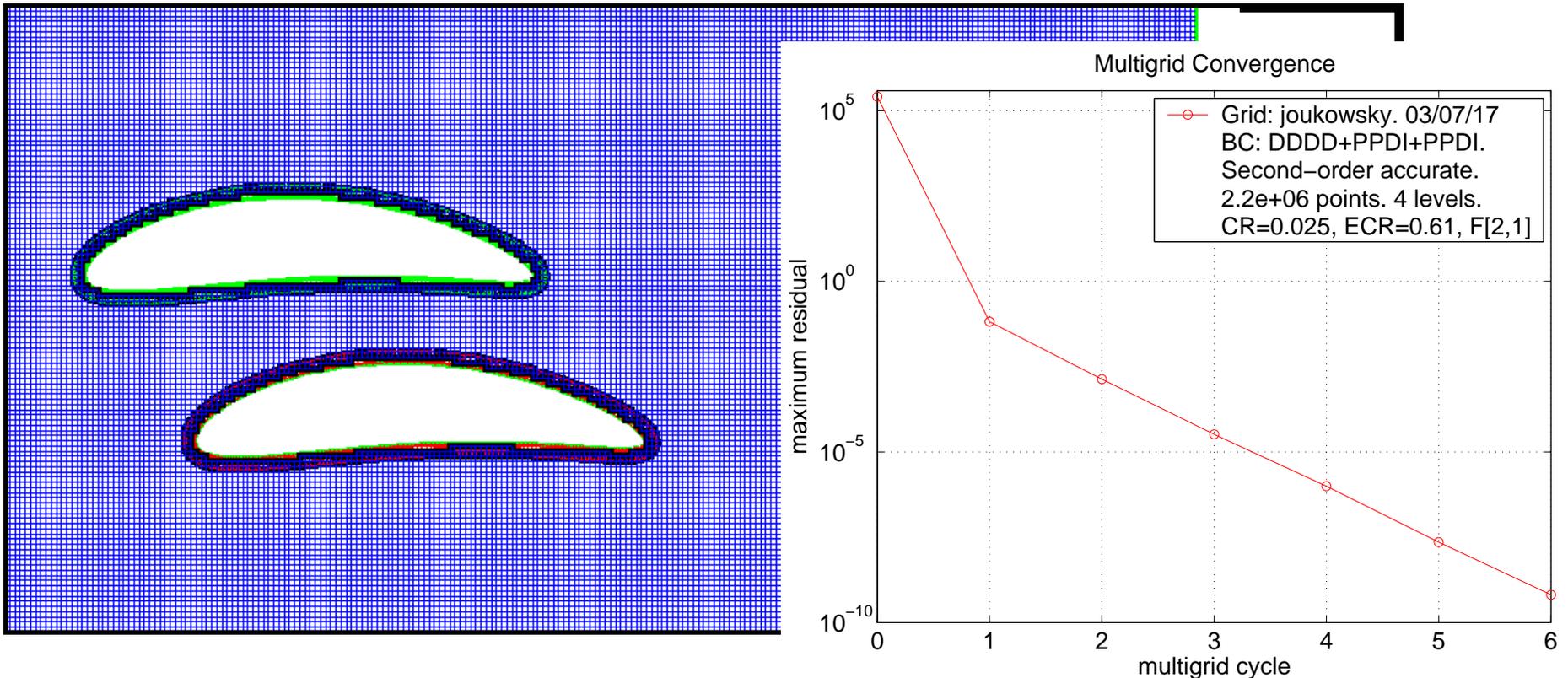


Figure 1: An overlapping grid for two airfoils in a channel (multigrid level $l = 3$). Convergence history for Poisson's equation including an initial full multigrid cycle. An alternating zebra smoother is used on the body fitted grids.

Ogmg: multigrid solver for overlapping grids

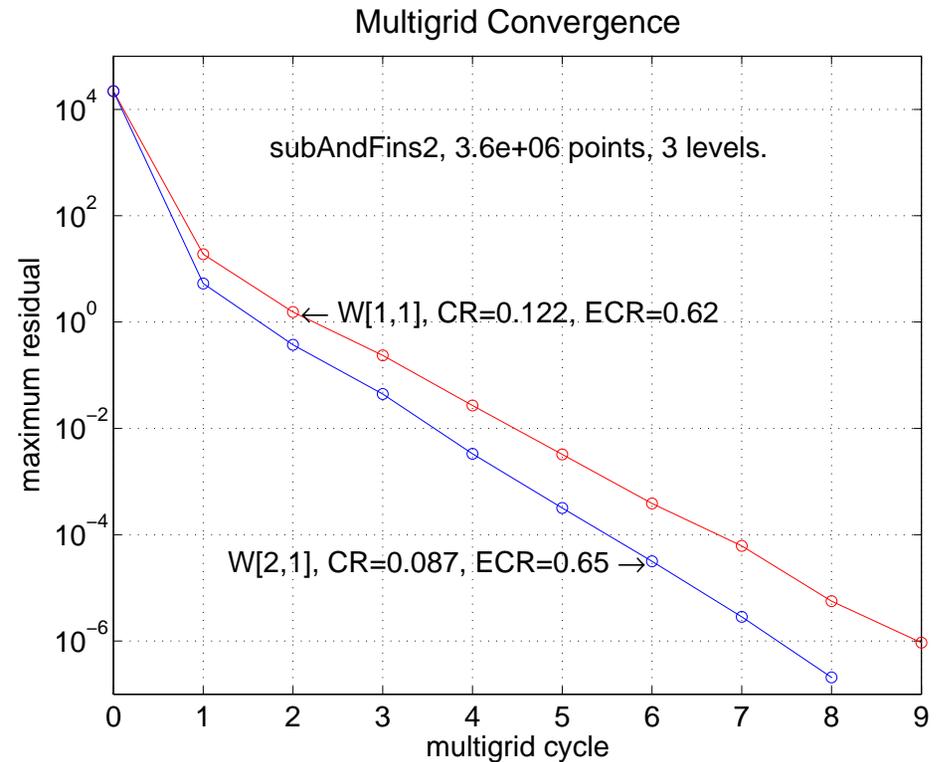
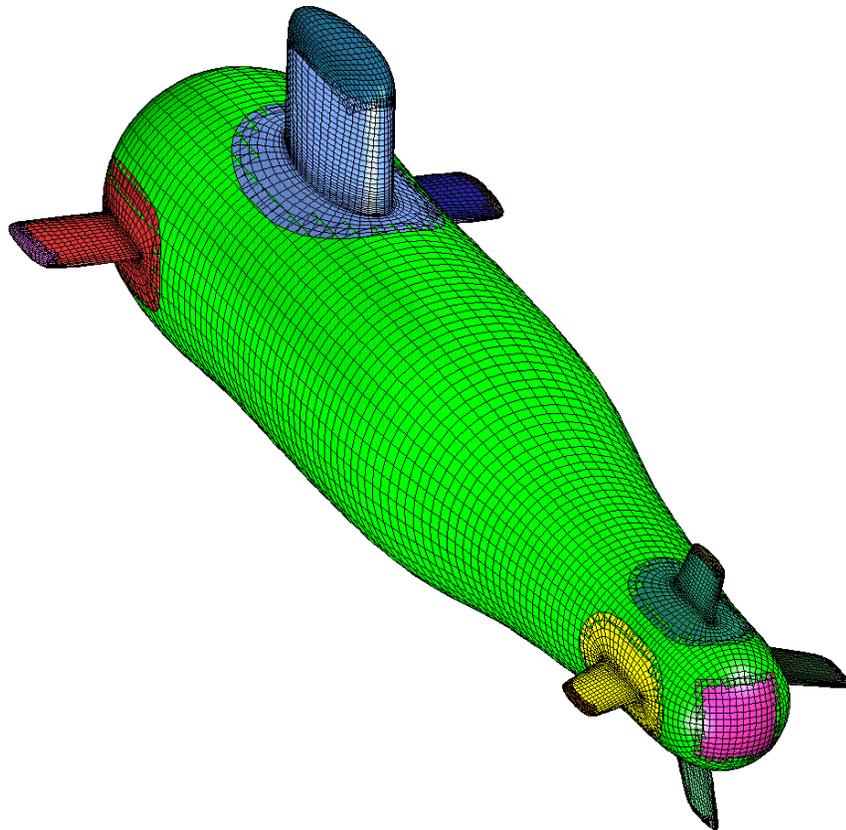
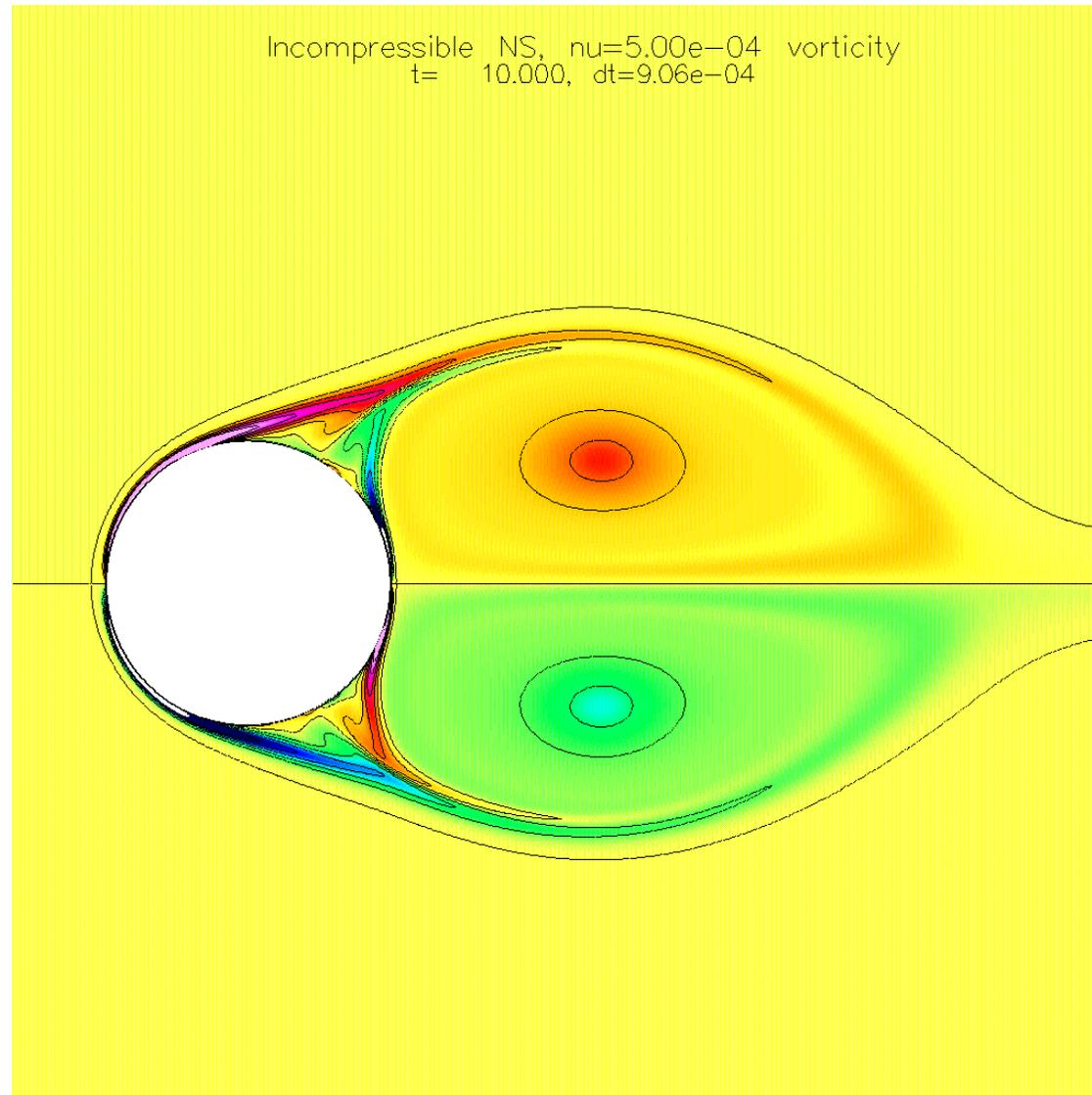
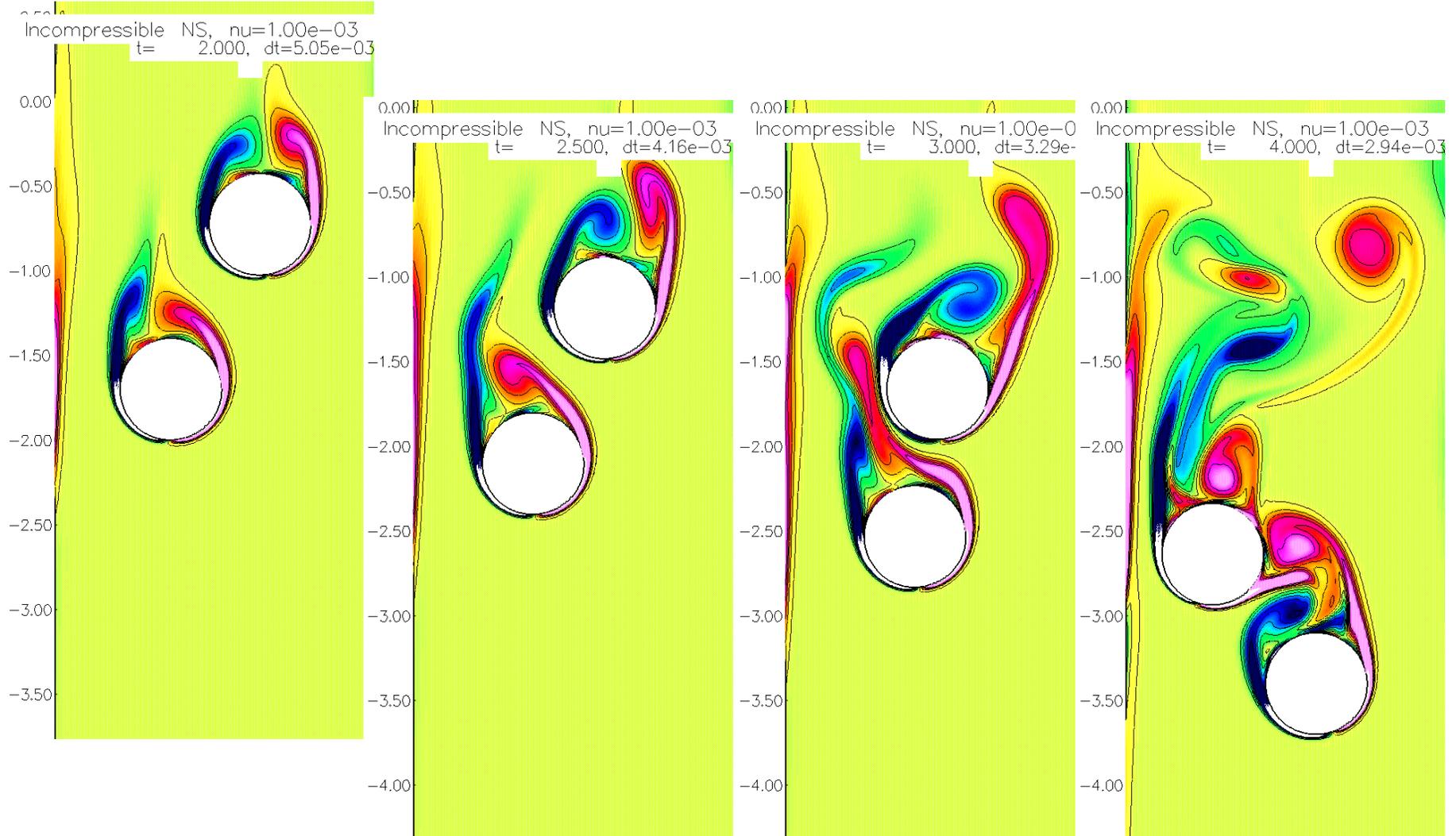


Figure 2: Left: Grid for a submarine-in-a-box, Right: convergence history for Poisson's equation.

Incompressible Navier-Stokes Equations

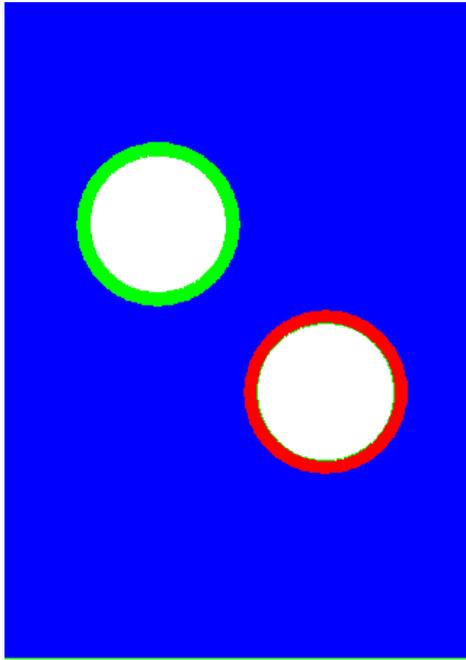


Laminar flow past a cylinder. Multigrid is used for the pressure solve and implicit time-stepping. For 1.1 million grid points, OverBlown requires 320M, 7.6 s/step.

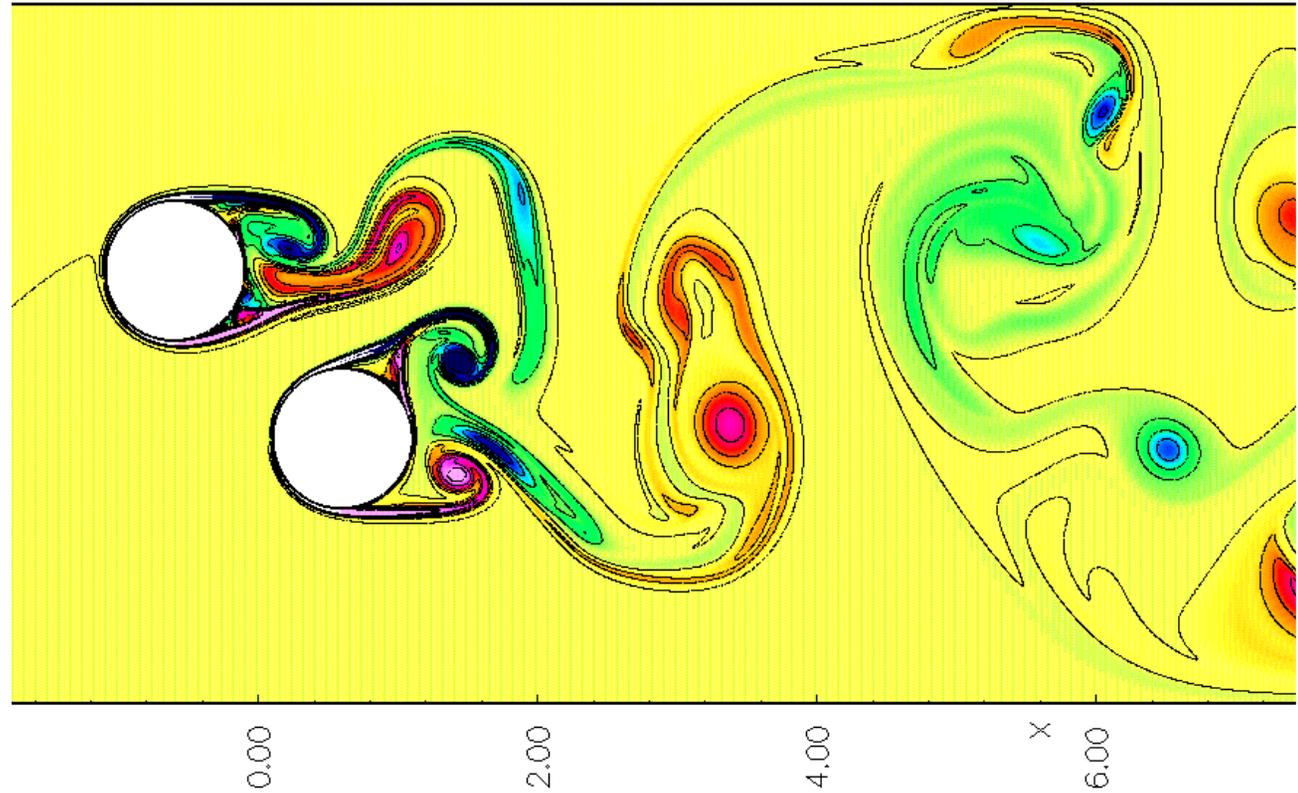


Two falling cylinders in an incompressible flow.

- ◇ overlapping grids are recomputed at each time step,
- ◇ GMRES solution of the pressure equation.



Grid



Flow past two cylinders, vorticity. $Re_D=2000$.

- ◇ multigrid solution of the pressure and implicit time-stepping equations,
- ◇ 1.3 million grid points,
- ◇ requires 460 MB of memory,
- ◇ $cpu = 10$ s/step,
- ◇ 2.2 GHz Xeon, 2 GB of memory