1st AIAA Sonic Boom Prediction Workshop (Stanford-ONERA-INRIA contribution)

AIAA Science and Technology Forum and Exposition (SciTech2014)

National Harbor, Maryland

January 13th-17th, 2014

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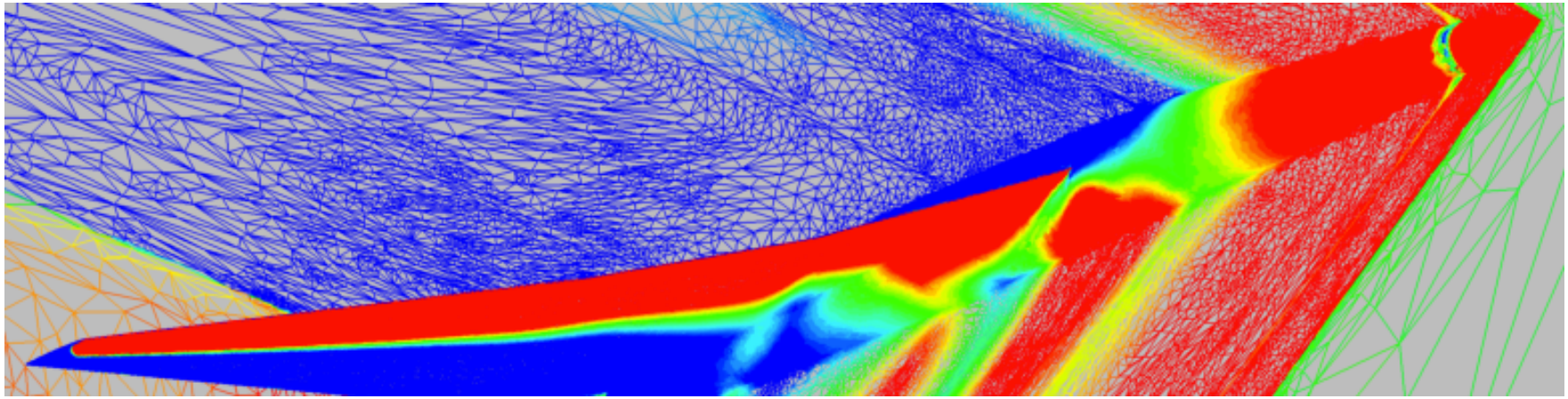
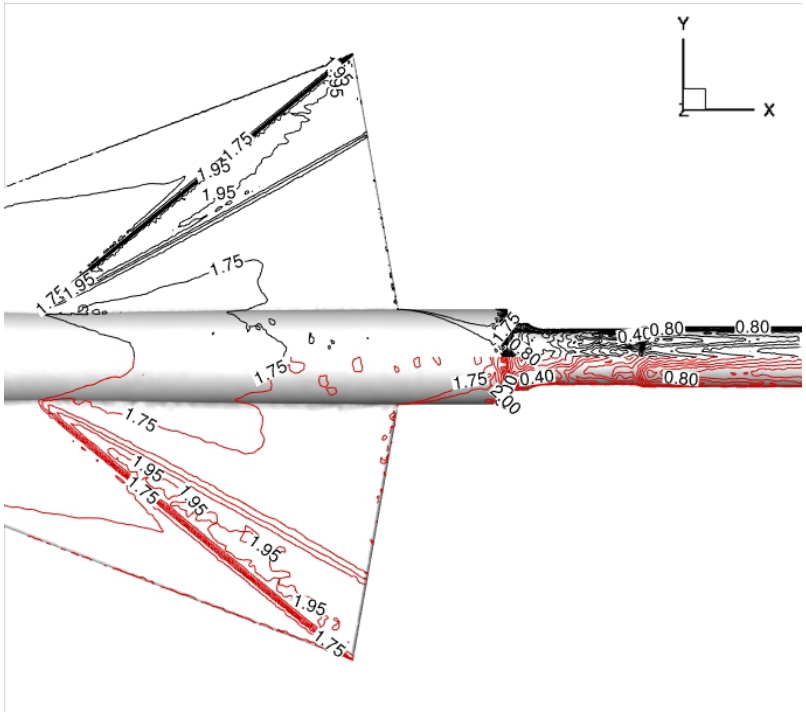
INRIA GAMMA3



Introduction / Outline

- Summary of cases and CFD solver.
- Grid description and convergence.
- Results.
- Conclusions.



Summary of cases analyzed

- 69-Degree Delta Wing Body
  - Euler, Mach 1.7, zero degrees angle of attack and sideslip
  - Mixed grid (Tetrahedra, and Hexahedra)
  - Grids provided by the workshop, and adapted using adjoint and hessian criteria.

- SEEB-ALR Body of Revolution
  - Euler, Mach 1.6, zero degrees angle of attack and sideslip.
  - Mixed grid (Tetrahedra, and Hexahedra).
  - Grids provided by the workshop.

- Focus on spatial discretization (numerical method -JST- and grid -anisotropic adaptation-).

CFD solver

The Stanford University Unstructured (SU^2). http://su2.stanford.edu/

SU^2 is under development at Stanford University in the Aerospace Design Lab (ADL) of the Department of Aeronautics and Astronautics.

The Open-Source CFD Code

SU^2 v3.0 (eagle) will be released during the SciTech2014 conference (Jan 15th, 2014)

Unstructured based solver using dual grid.

JST scheme, implicit solver (CFL 5.0), Multigrid 3V.

Distributed memory (MPI), small cluster 24-48 processors.

FD-11 Solver Technology for turbulent flows.
SU2, Analysis and Design Tech. for Turb. Flows.
5:00pm 5:30pm
Conference Room 3

Grid description

- Workshop provided grids.
  - delta-split-mixed-000a-170m-___s.cgns (5.36MPts, 2.74MPts, 1.41MPts, 0.69MPts).
  - seeb-inches-000a-160m-___s-mixed.cgns (10.15MPts, 5.25MPts, 1.16MPts, 0.67MPts).

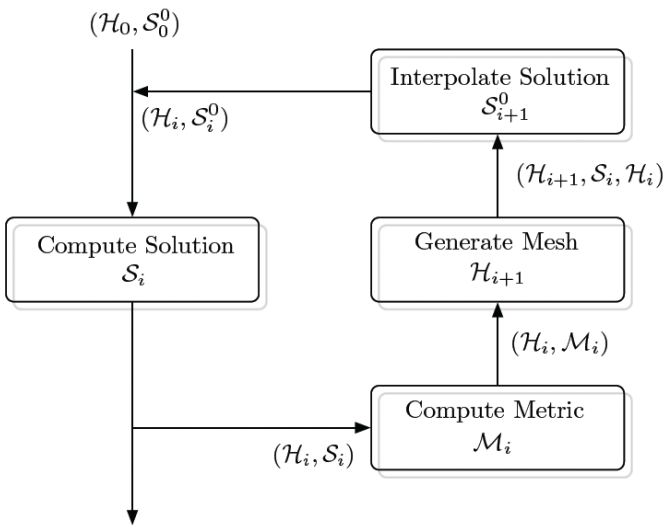
- Adapted grid (using FEFLOA -INRIA-).
  - Anisotropic grid adaptation using Hessian criteria. 1.19MPts
  - Anisotropic grid adaptation using Adjoint criteria 0.23MPts

Anisotropic mesh adaptation (INRIA code FEFLOA)

Method description

Main features:

1. Surface and volume remeshing
2. CAD repositionning
3. Simple local operators: edge bisection and edge collapse
4. Use of the riemannian metric fields as the anisotropic prescription [Frey et George, 2008]

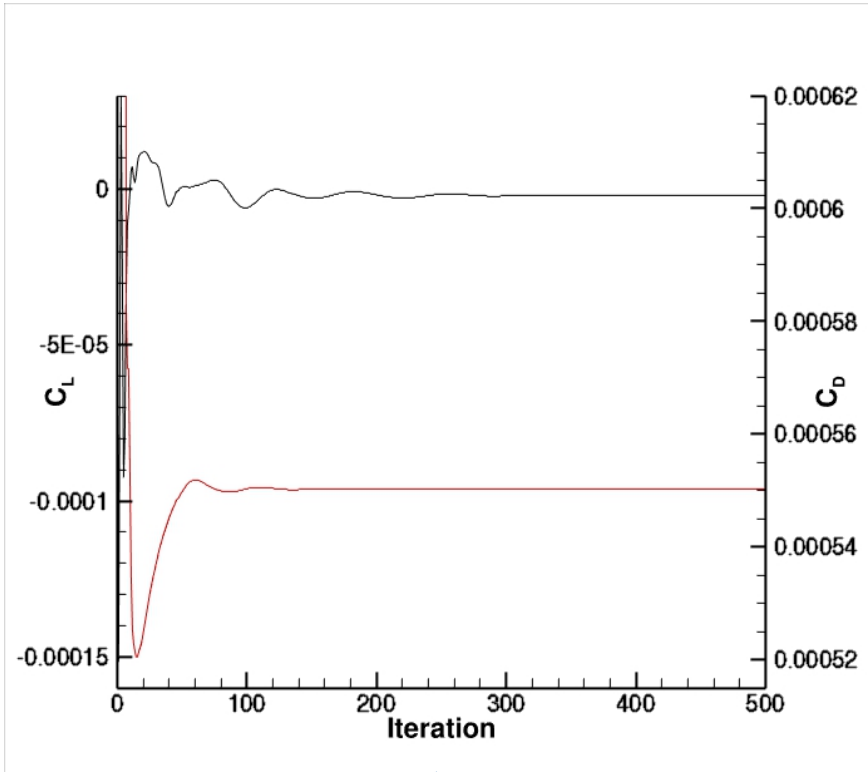


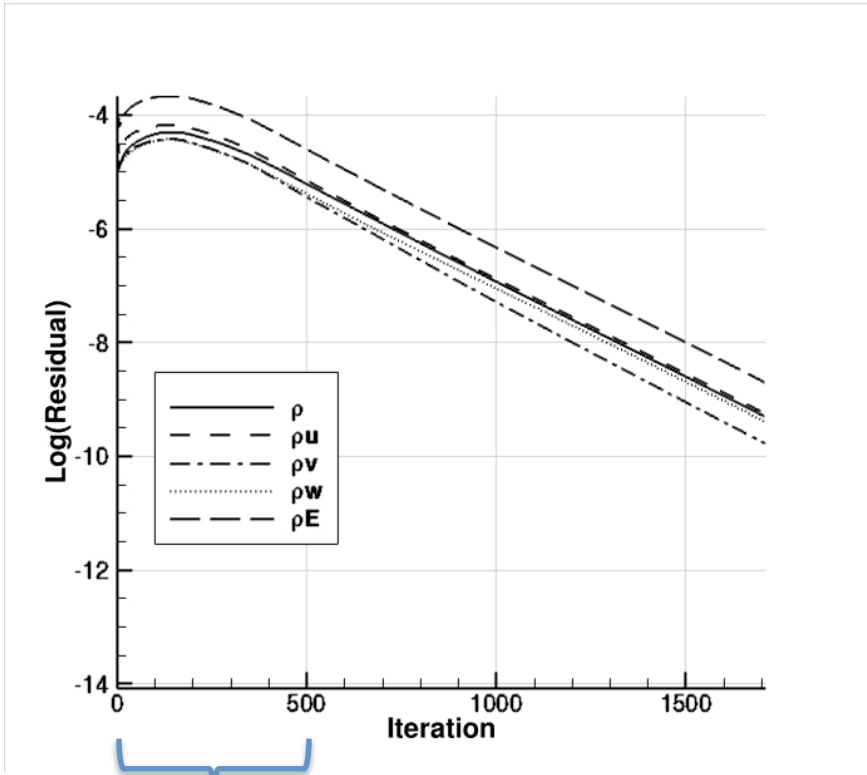
Algorithm:

1. Monitored by a metric-based quality function
2. Classic surface remeshing control (planarity, surface deviation, …)

Flow Solver convergence

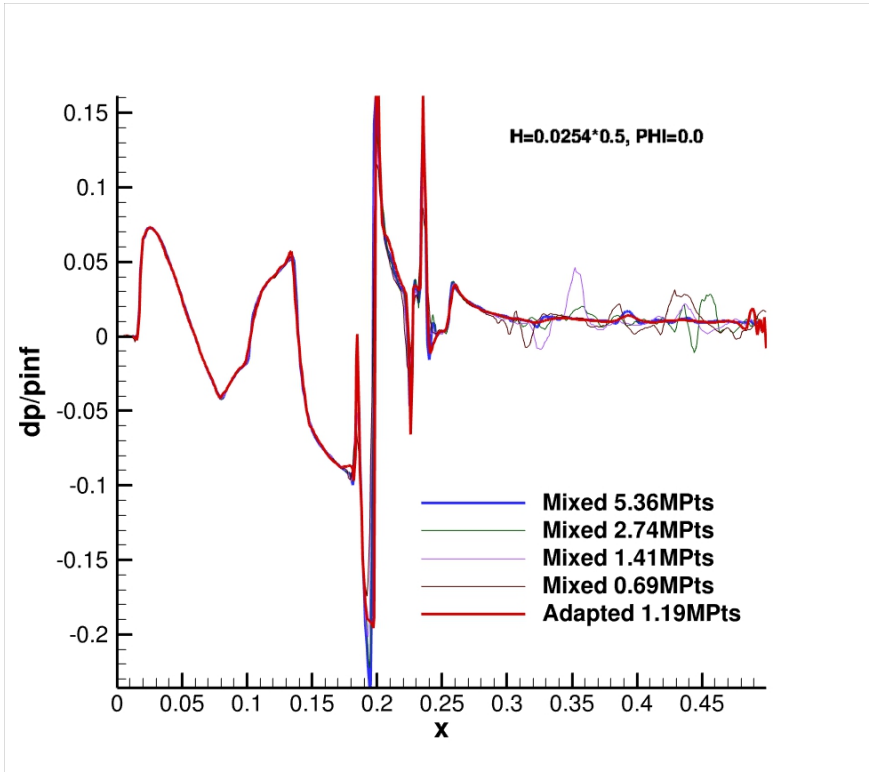
- Convergence criteria: reduction of 5 order of magnitude in density residual.
- Implicit (CFL 5.0, GMRES), MG 3V, JST scheme.

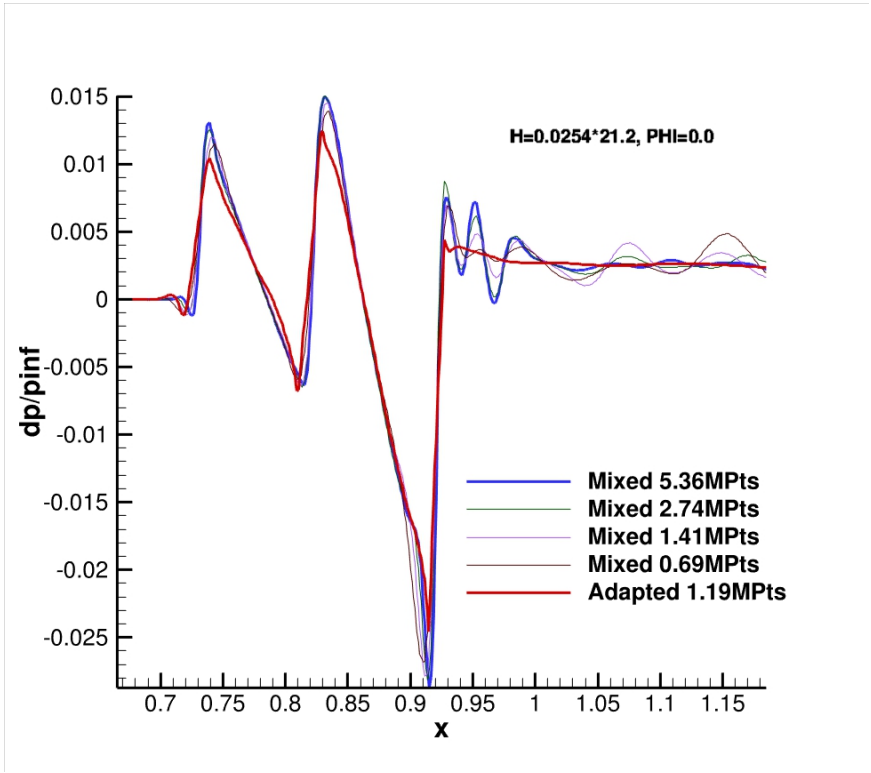




69-Degree Delta Wing Body

- Extracted near field signatures
- Signature convergence with grid resolution





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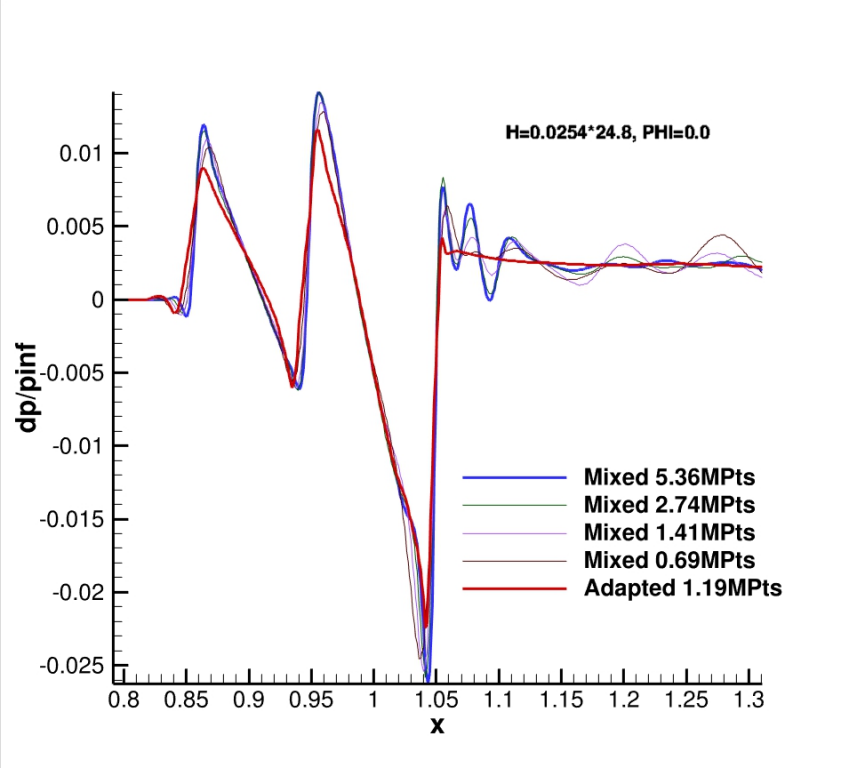
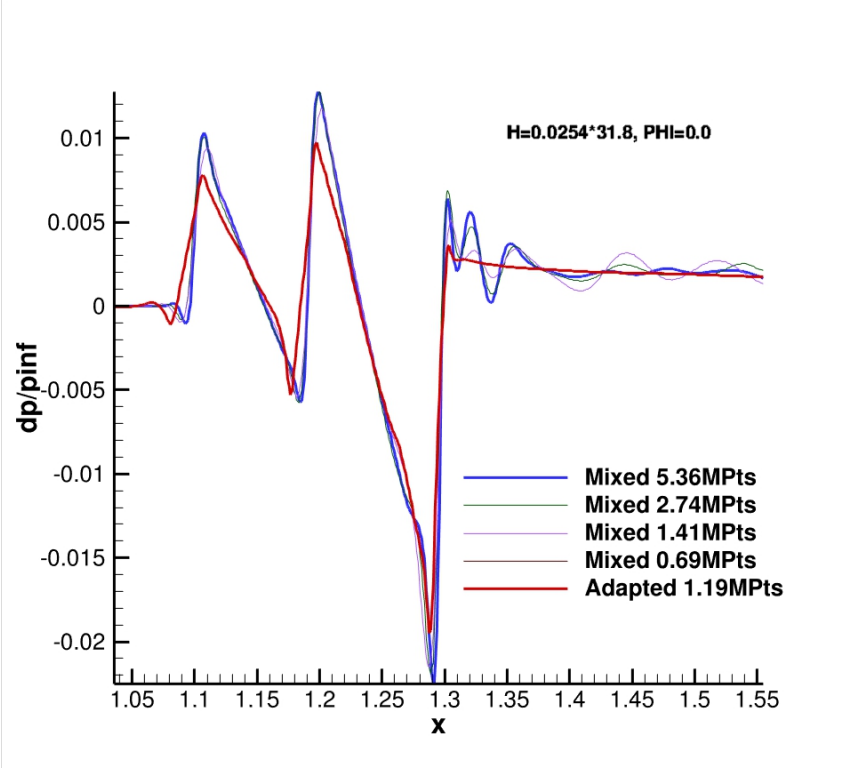
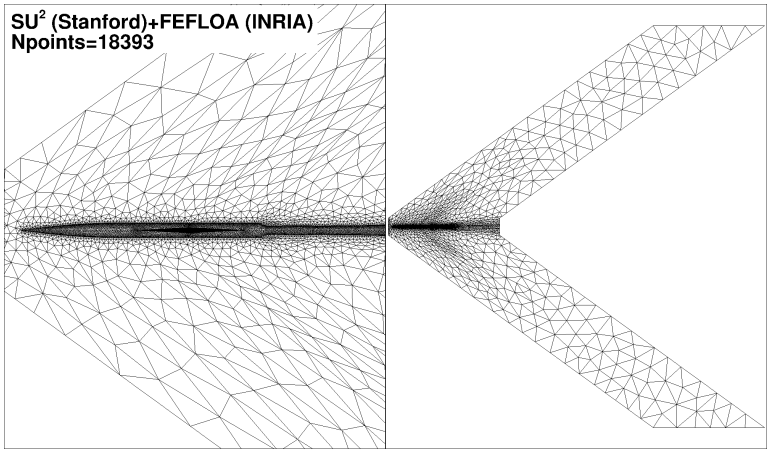


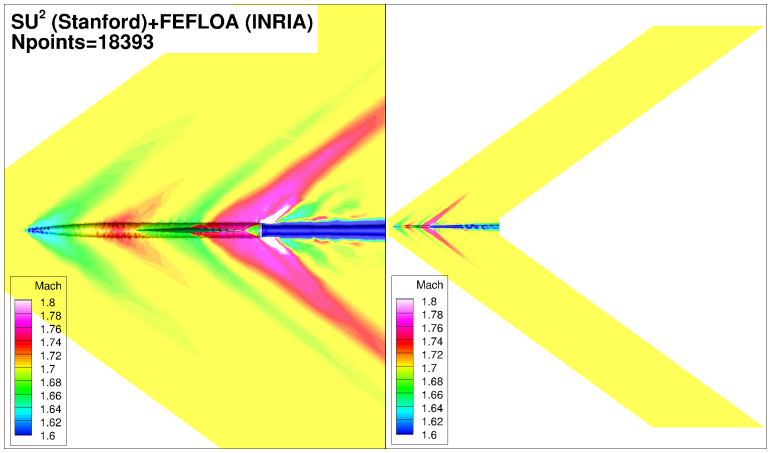


69-Degree Delta Wing Body

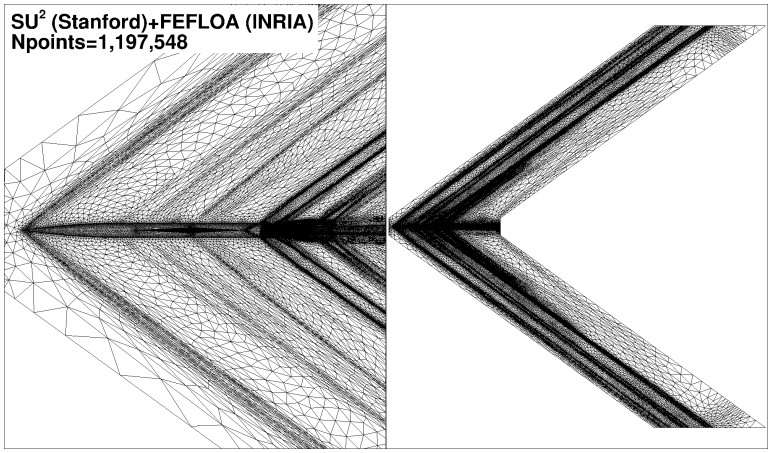
Hessian-based adaptation (Mach field)

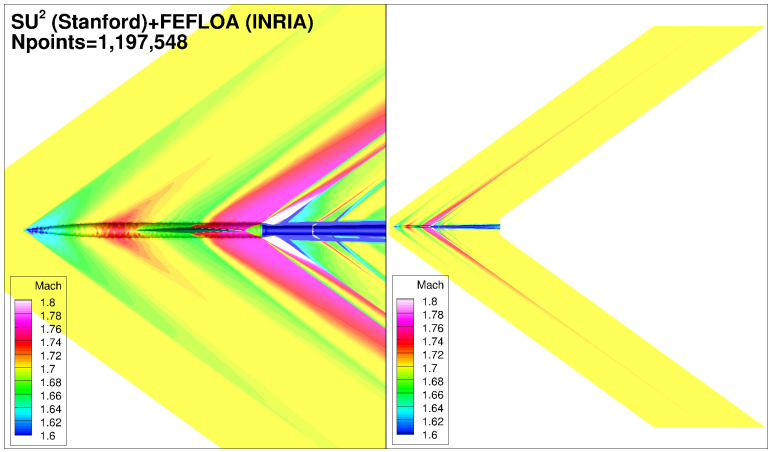
Initial mesh (very coarse)





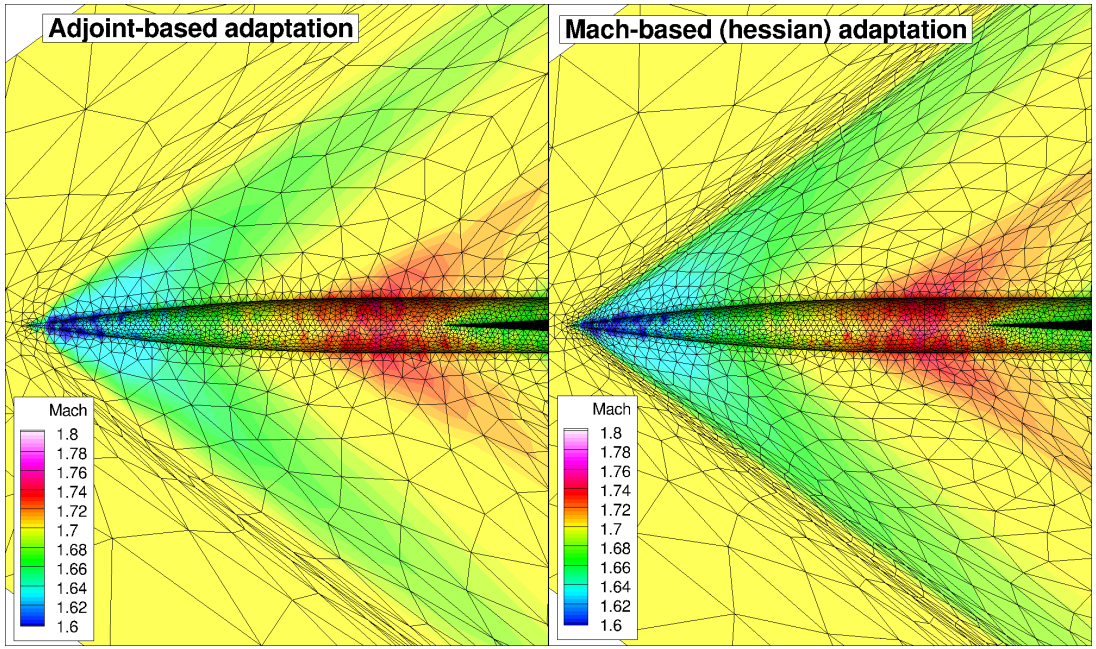
Adapted mesh (40th iter.)





69-Degree Delta Wing Body

Adjoint-based (WOLF + FEFLOA) adaptation vs. hessian adaptation.

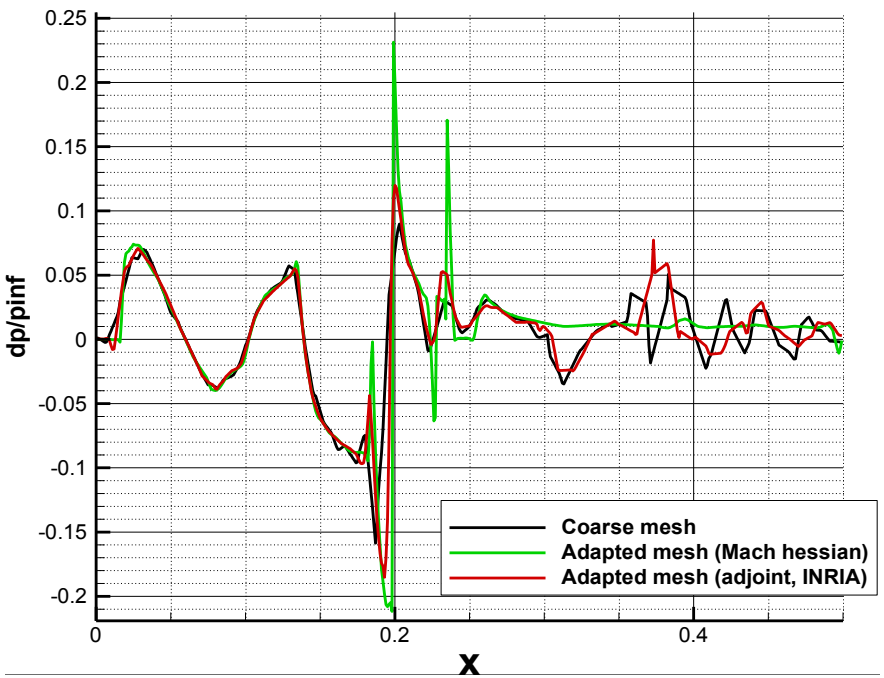


Anisotropic grid adaptation using Hessian criteria. 1.19MPts
Anisotropic grid adaptation using Adjoint criteria 0.23MPts

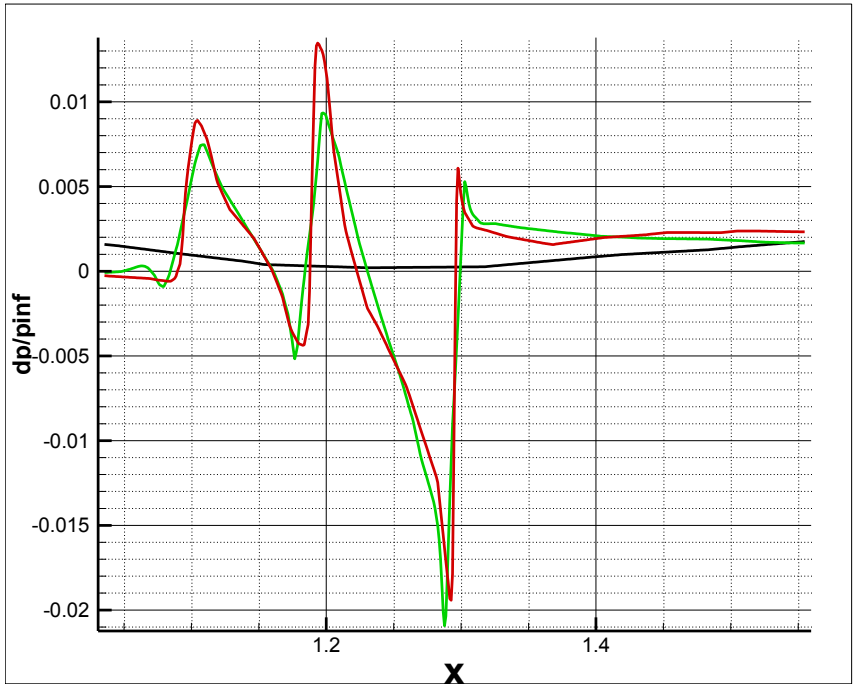
- Adjoint-based adaptation provides slightly different mesh characteristics (compared to Hessian-based adaptation)

69-Degree Delta Wing Body

Comparison of under-track pressure signature (anisotropic grid adaptation)

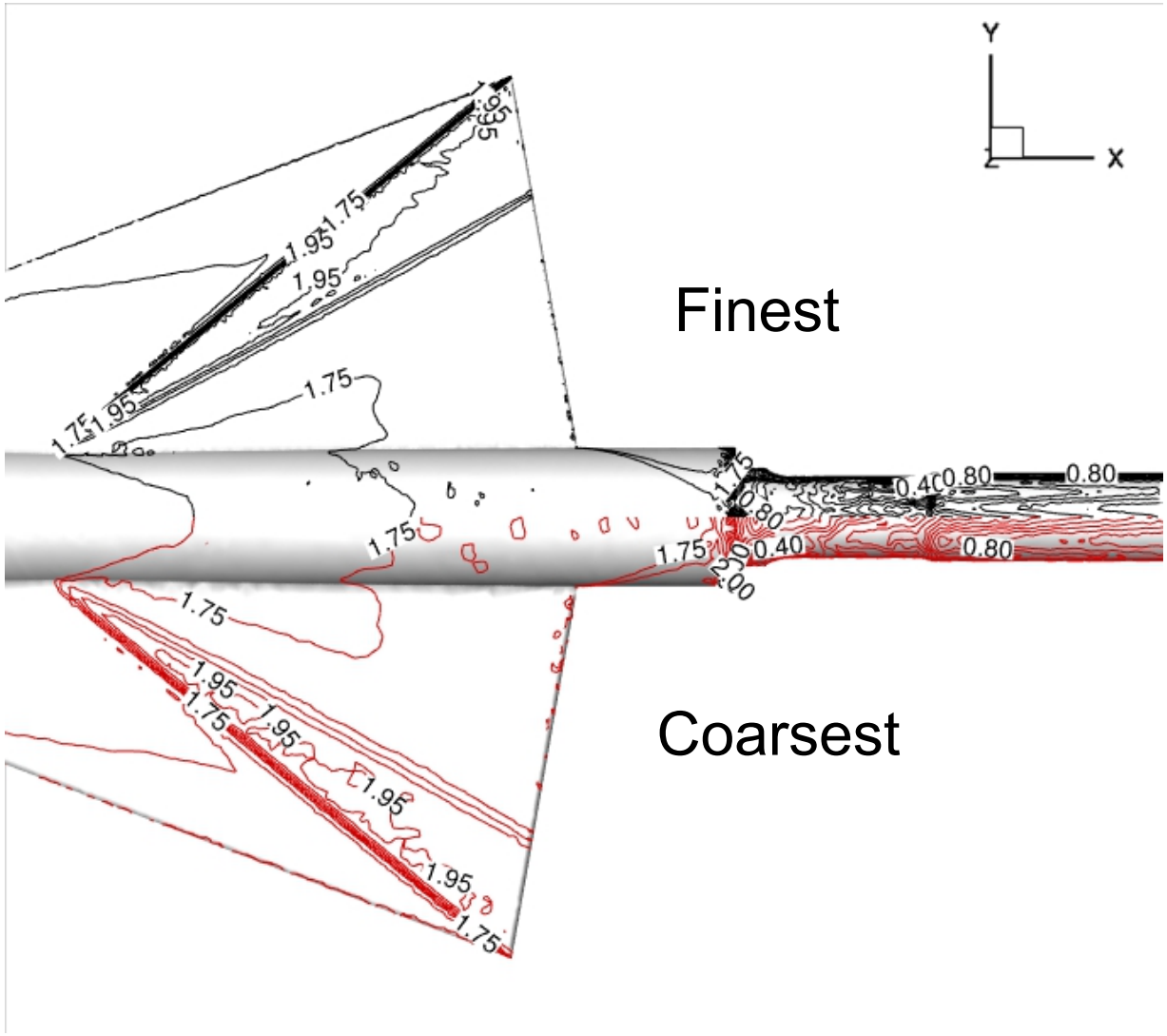


Comparison of pressure signals at R=0.5 in (Φ=0°)



Comparison of pressure signals at R=31.8 in (Φ=0°)

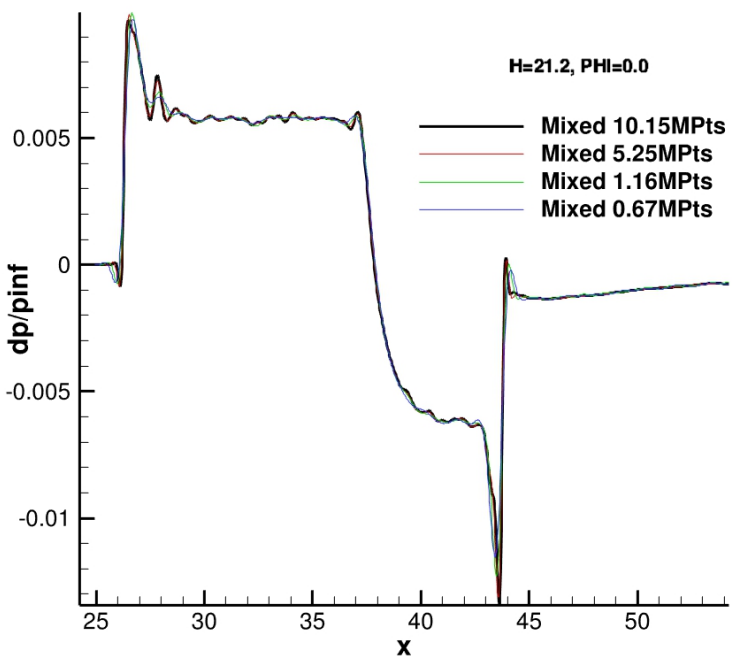
69-Degree Delta Wing Body

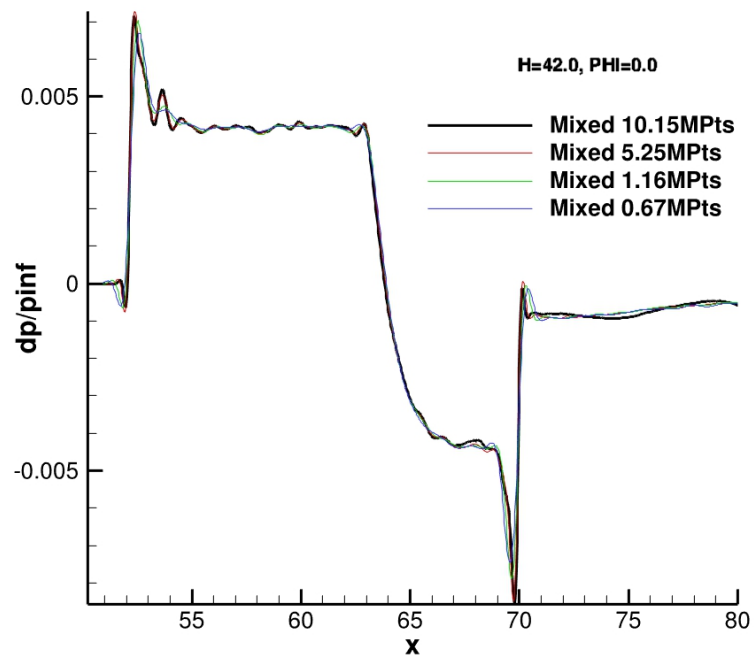


Even using the finest grid, the surface discretization produces tiny non-physical oscillations on the surface.

SEEB-ALR Body of Revolution

- Solution pressure contours
- Extracted near field signatures
- Signature convergence with grid resolution





Summary / Conclusions

- Hybrid grids provided by the workshop
  - A-priori grid adaptation meshes (hybrid) are easy to converge.
  - JST scheme do a good job (robustness, accuracy, and speed).
  - Medium size grid provides optimal results in terms of convergence and accuracy.

- Anisotropic adaptation
  - Mesh adaptation enables accurate near-field sonic-boom pressure signature starting from a coarse, un-adapted mesh. It is a very powerful tool that should be used carefully.
  - 3D-anisotropic mesh adaptation (INRIA code FEFLOA) is efficient to propagate pressure perturbations far away from the source (with meshes of fixed complexity).
  - In this application, adjoint-based adaptation provides better results than Mach Hessian-based adaptation.

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