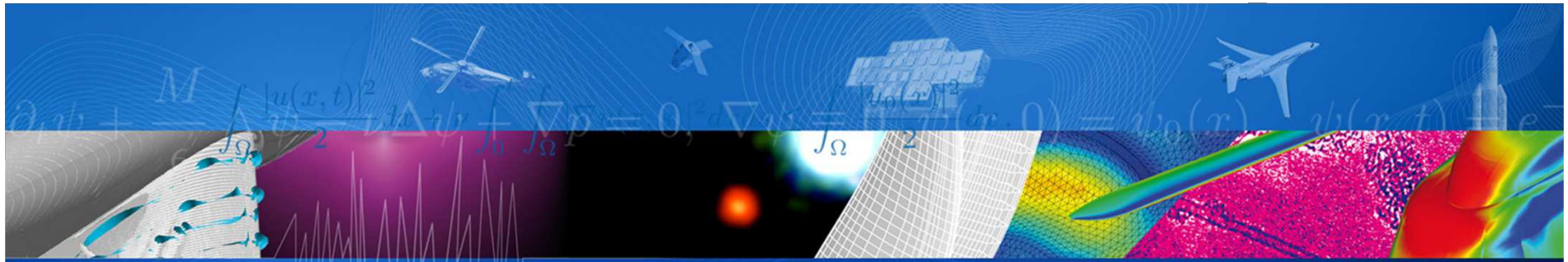


# 1st Sonic Boom Prediction Workshop
# ONERA contribution

SCITECH 2014

***52nd Aerospace Sciences Meeting***
***Saturday, January 11, 2014***

***I. Salah El Din , Andrea Minelli, Richard Grenon, Gerald Carrier***
***Onera, The French Aerospace Lab, France***

ONERA
THE FRENCH AEROSPACE LAB

return on innovation

# ONERA and supersonic aircrafts

## Supersonic aircraft design @ onera

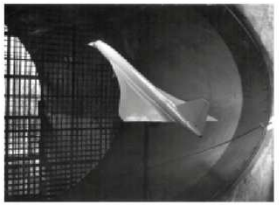
Design of Concorde
-Contribution to engine intake performance
-Wing-body model wind tunnel tests
-Low speed, flutter, icing, sonic boom assessment

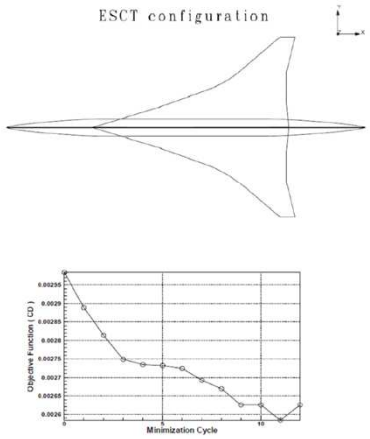
Supersonic aircraft aerodynamic numerical optimization (ESCT)

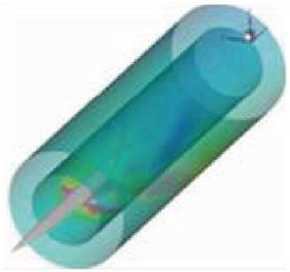
Development of CFD-based sonic boom prediction capabilities

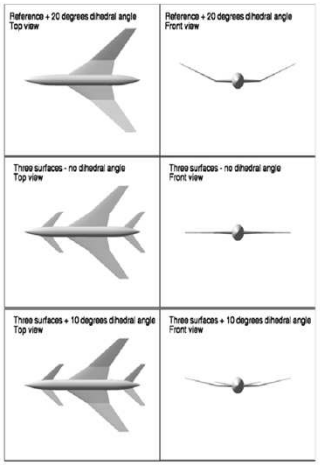
-Low-Boom / Low-Drag design
-Improvement of CFD-based sonic boom prediction capabilities

1960's | 1990's | 2000's | 2005-2010





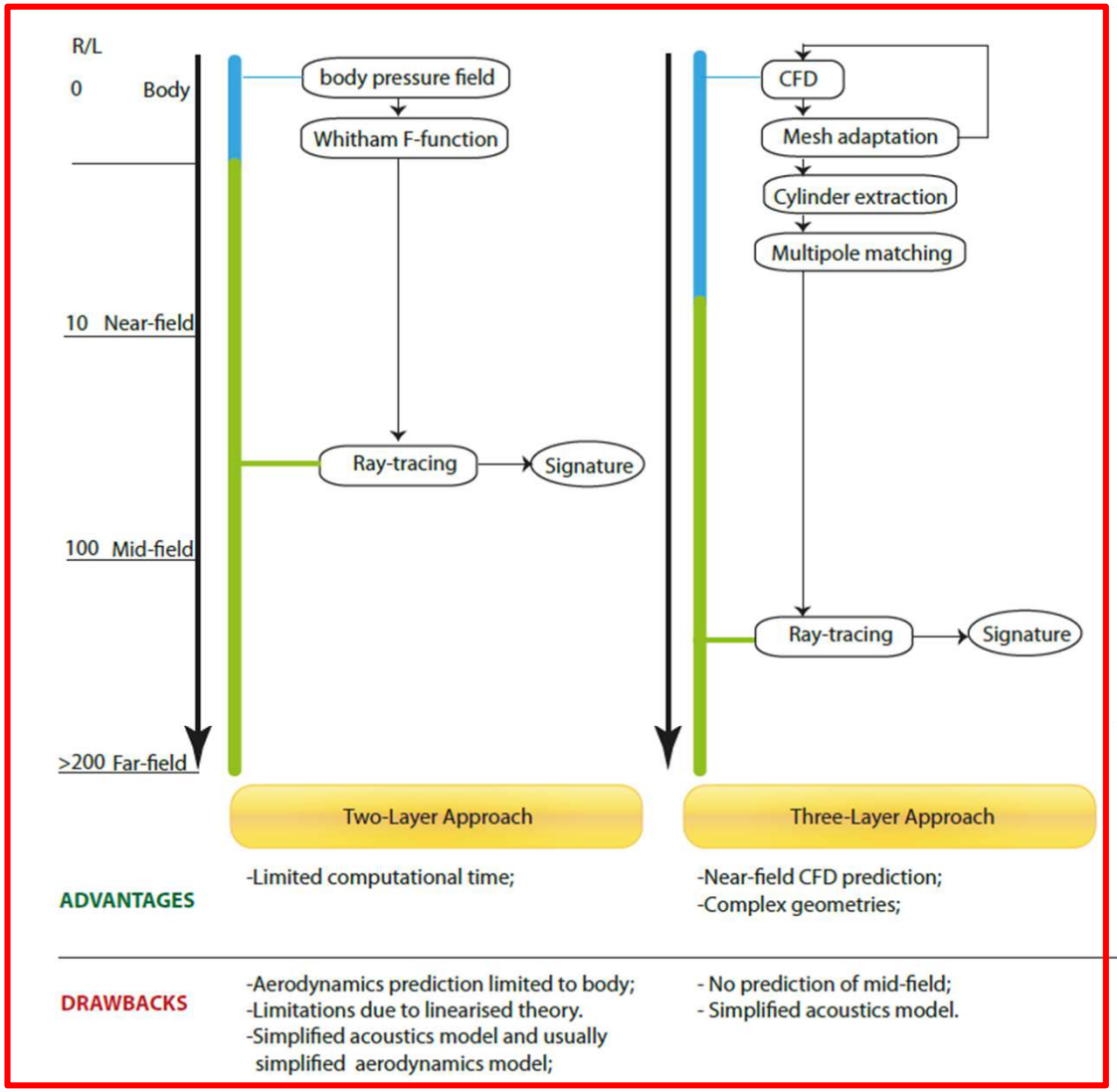






Aerodynamic design | Aerodynamic optimization | Sonic boom prediction | Aero-boom design

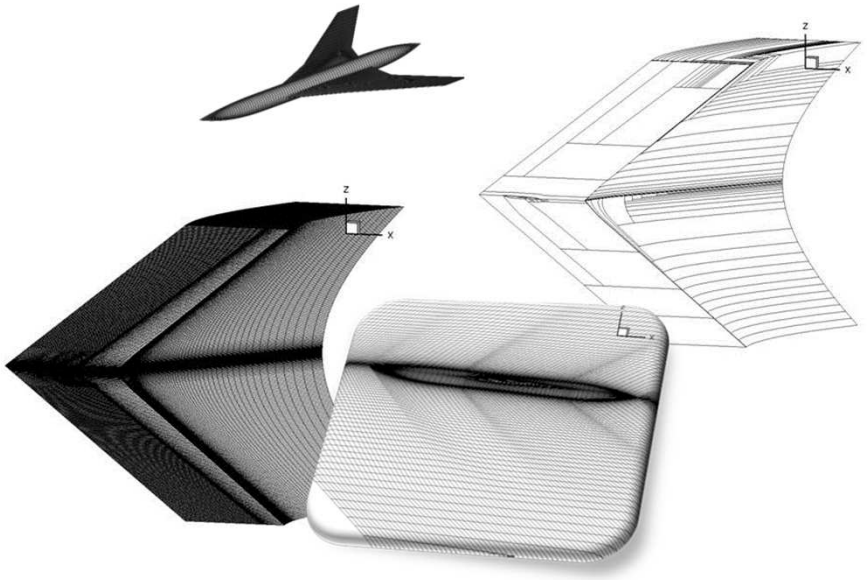
# Numerical approaches

## Prediction – Multi-zone approaches



# Numerical approaches

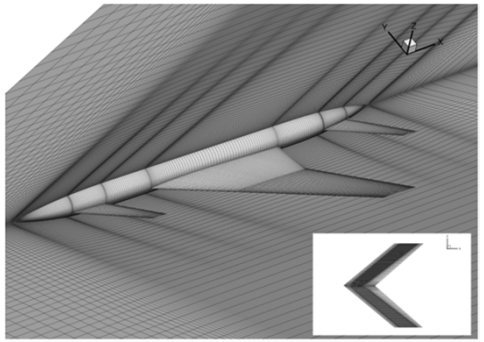
## Near field prediction – Sonic boom oriented meshing

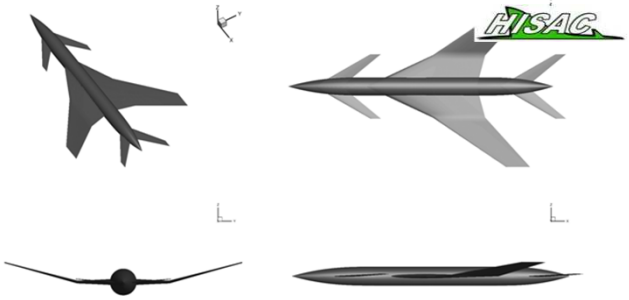


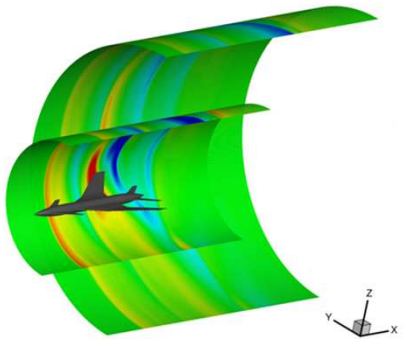
### MESH

- Provided
- In house Fortran analytical surface and volume structured multiblock mesh generator.
- ICEM/HEXA mesher

- *The volume mesh is usually aligned and refined along the shock patterns*.





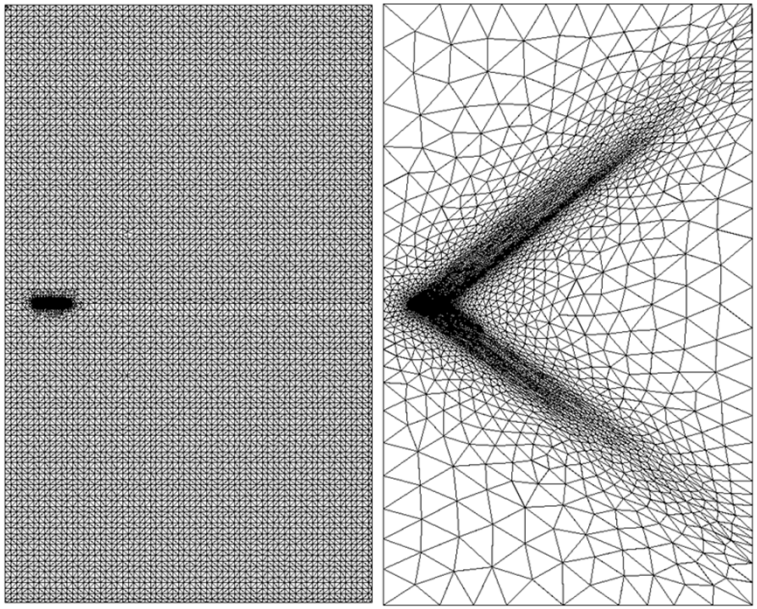



### SOFTWARE

- ***elsA*** ONERA multiblock parallel structured-based mesh solver dedicated to Euler, RANS, URANS, DES, LES computations for mono-species perfect gas (discrete adjoint available for aerodynamic objective functions)

# Numerical approaches

## Near field prediction – Sonic boom oriented meshing



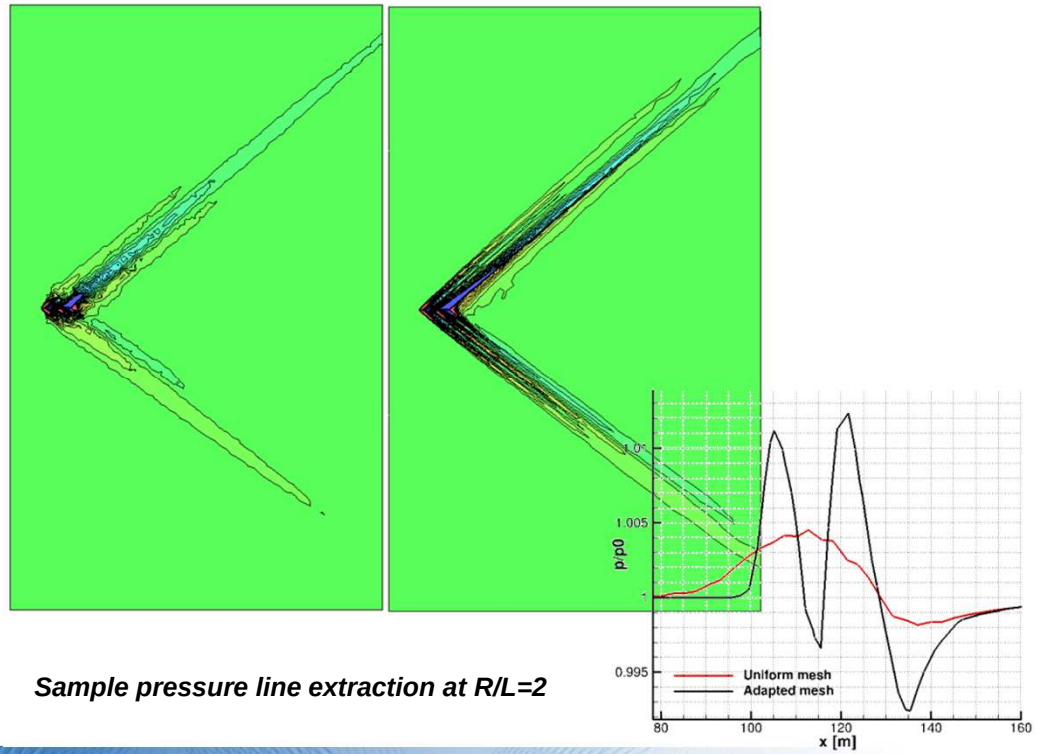
### *MESH*

- Provided
- Generated with ICEM or Pointwise

- Unstructured mesh capabilities development with adaptation to increase the near CFD field domain extent
- Mesh adaptation performed in collaboration with INRIA / GAMMA Project team

### *SOFTWARE*

- ***CEDRE*** ONERA multiblock multi-physics polyhedric parallel unstructured-based mesh solver




***Sample pressure line extraction at R/L=2***

# Results

## Processed cases

**M=1.6**

**Euler**

**M=1.7**

**Euler**

### SEEB-ALR

***Unstructured meshes***

- seeb-inches-000a-160m-100s-tet
- seeb-inches-000a-160m-156s-tet
- seeb-inches-000a-160m-200s-tet

### DELTA-69

***Unstructured meshes***

- delta-split-tet-000a-170m-100s
- delta-split-tet-000a-170m-200s

***Structured mesh***

- delta-meter-v314.cgns

**CEDRE**

- Flux AUSM+
- Jacobian: roe
- Quasi-Newton GMRES Implicit resoltution

Fixed number of iterations: 2000

**ELSA**

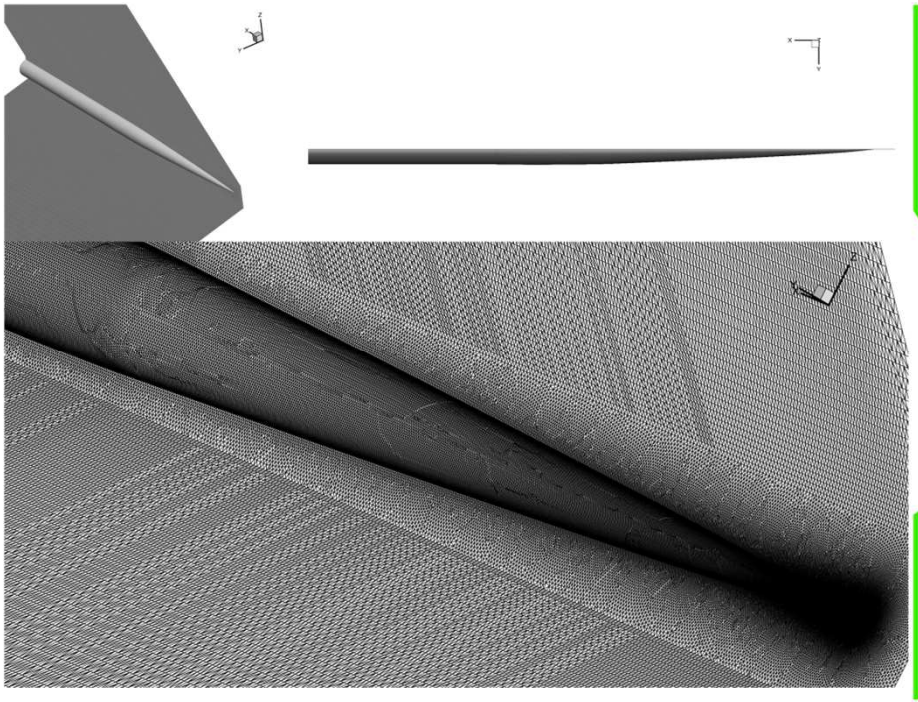
- Flux : Jameson/Roe
- Backward-Euler time stepping LUSSOR resolution
- Fixed number of iterations: 3000/7000

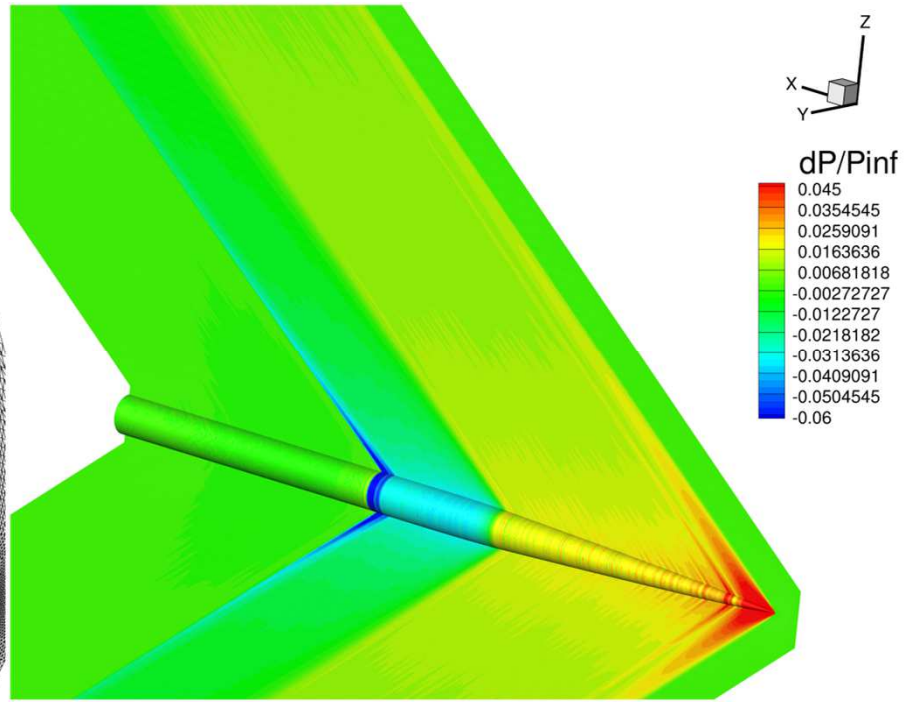
### Data formats

- ***Unstructured meshes: converted by INRIA in a CEDRE complyant format (.mesh)***
- ***Structured mesh: cgns file provided by NASA***

# Results

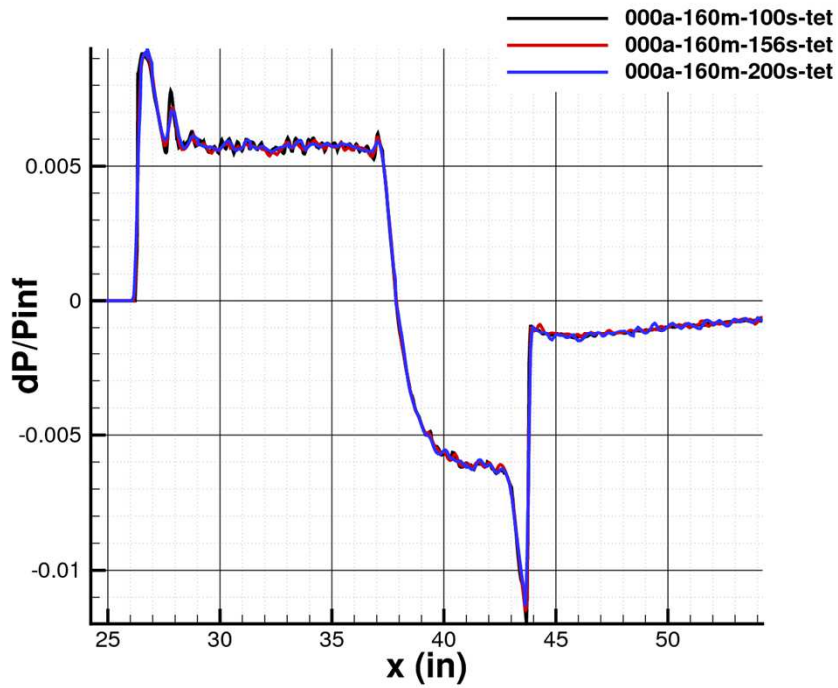
## SEEB-ALR case



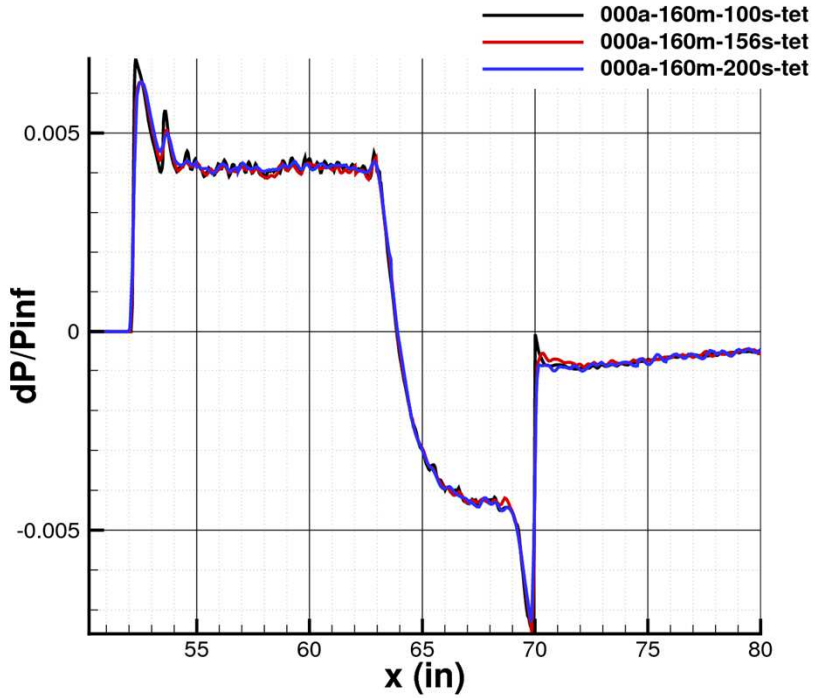


## SEEB-ALR – Pressure signature in near field – mesh convergence

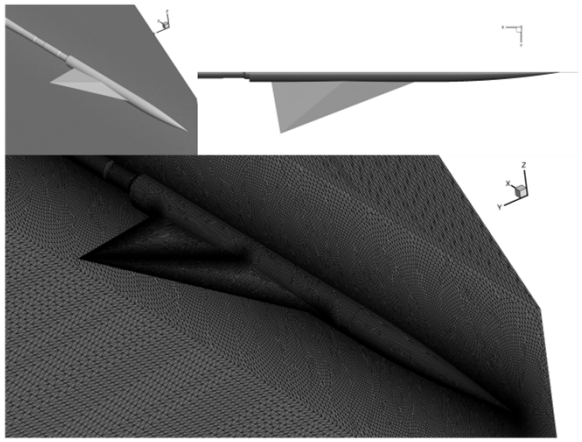
H=-21 in

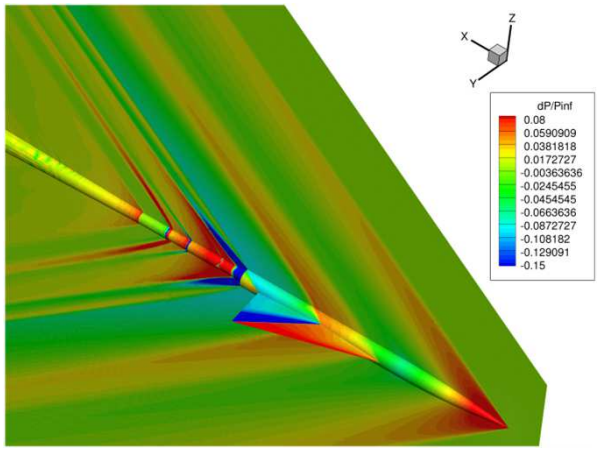



H=-42 in

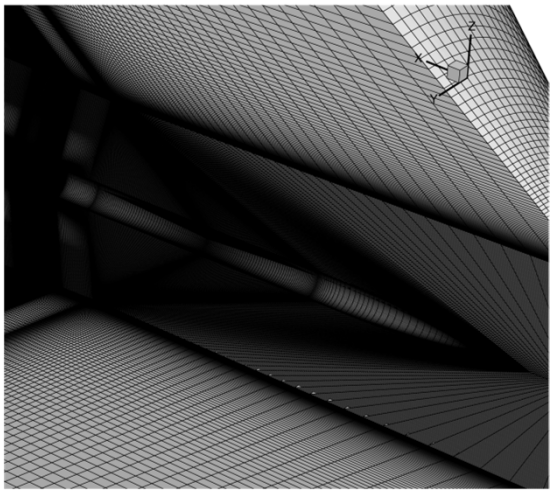


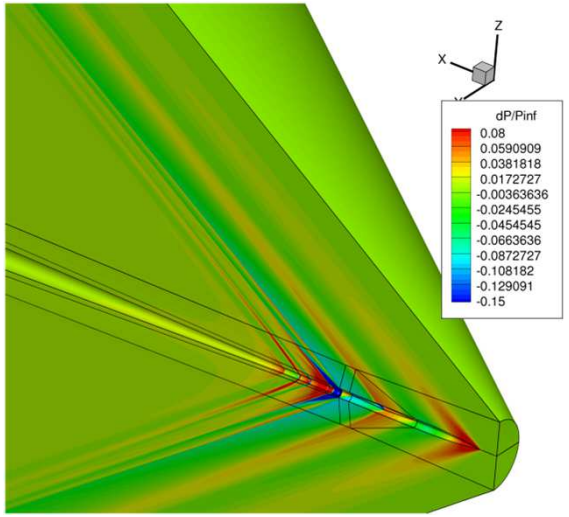
Unstructured mesh – CEDRE solver





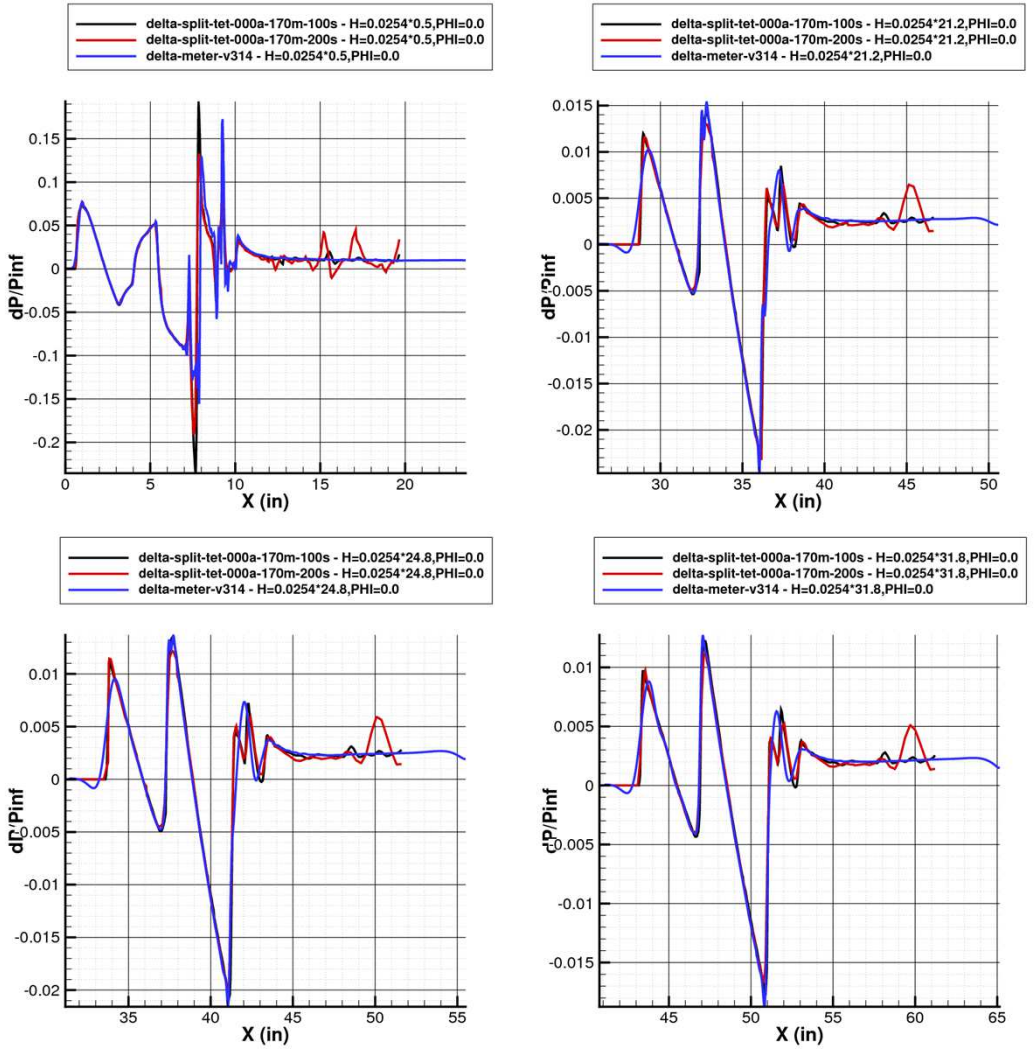

Structured mesh – elsA solver





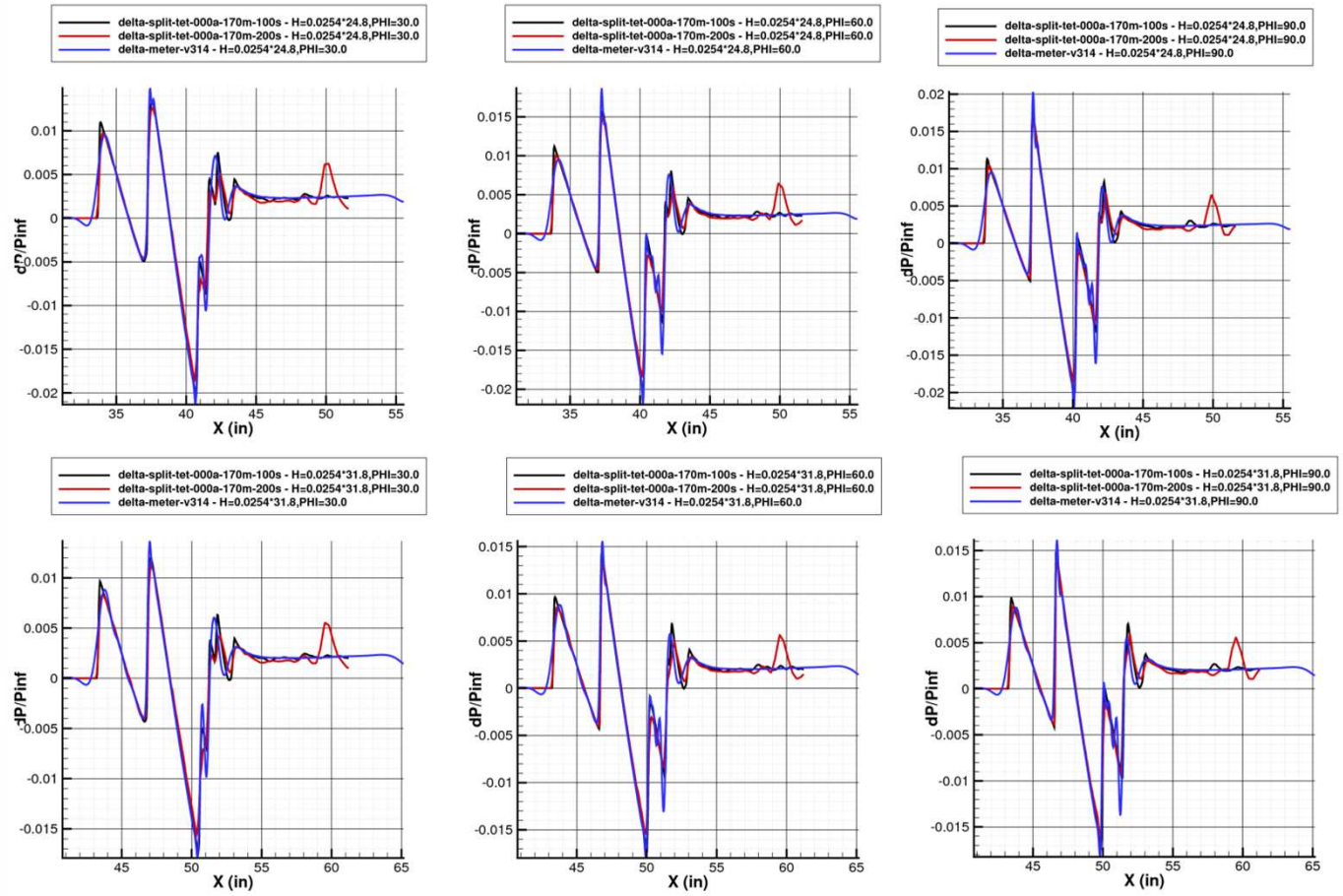
# Results

## DELTA69 – Pressure signature in near field – Uns vs Str



# Results

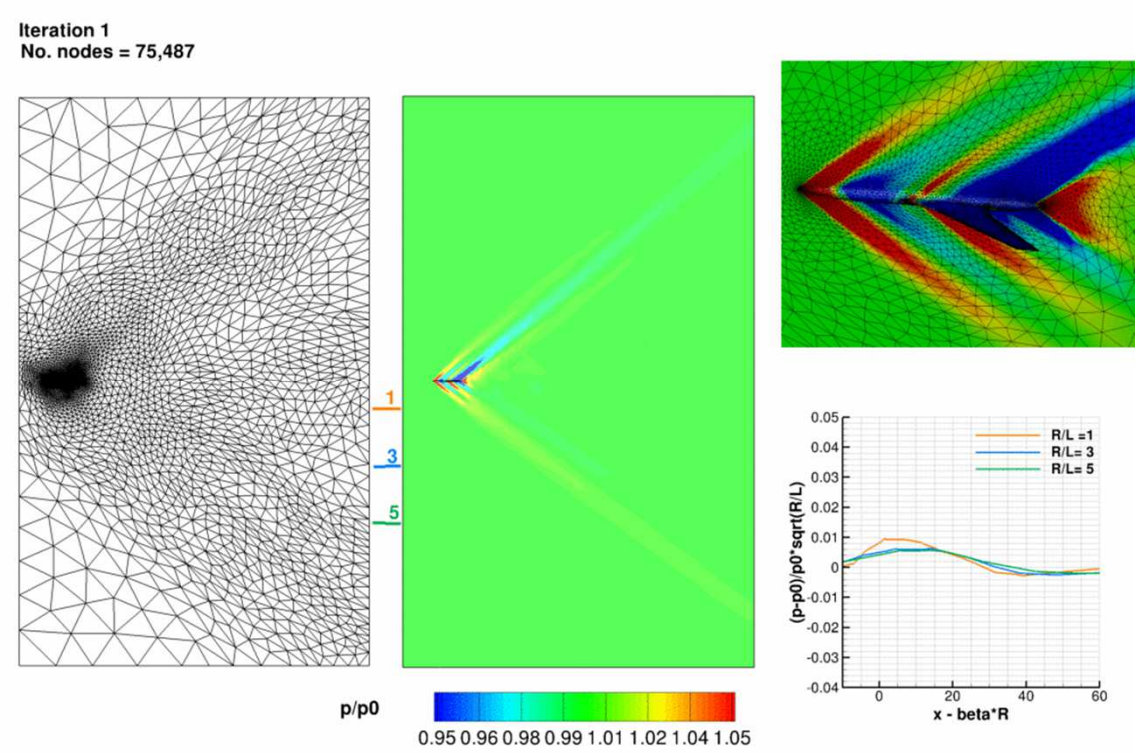
## DELTA69 – Pressure signature in near field – Uns vs Str



# Conclusions / Prospects

## *MESH AND NEAR FIELD CFD*

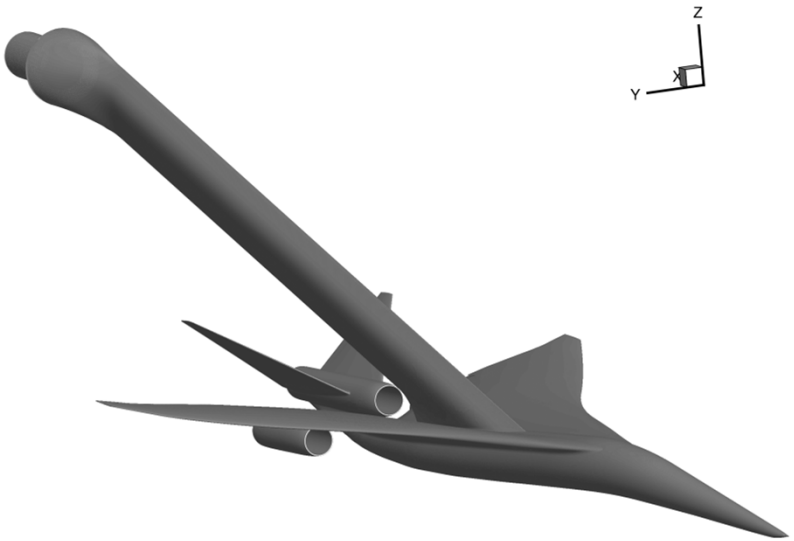
- ***Automated unstructured mesh adaptation (INRIA Feflo mesh adaptation + CEDRE) – see also ONERA-Stanford results***
- RANS vs EULER
  - Sensitivity wrt numerical parameters (flux schemes, dissipation …)
- Alternative SB source prediction (Equivalent area calculation from skin data)

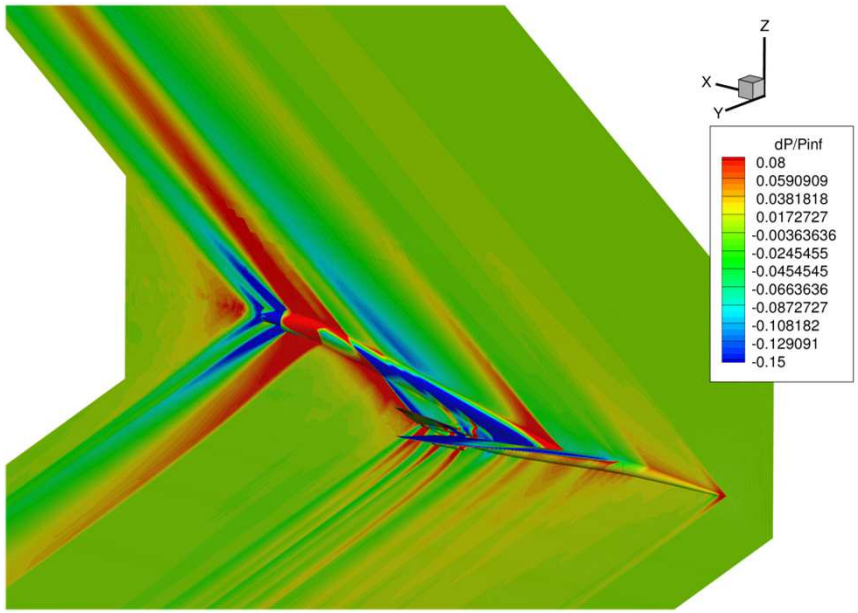


# Conclusions / Prospects

## MESH AND NEAR FIELD CFD

- Unstructured mesh adaptation
- *RANS vs EULER*
  - *Sensitivity wrt numerical parameters (flux schemes, dissipation …)*
- Alternative SB source prediction Surf cut

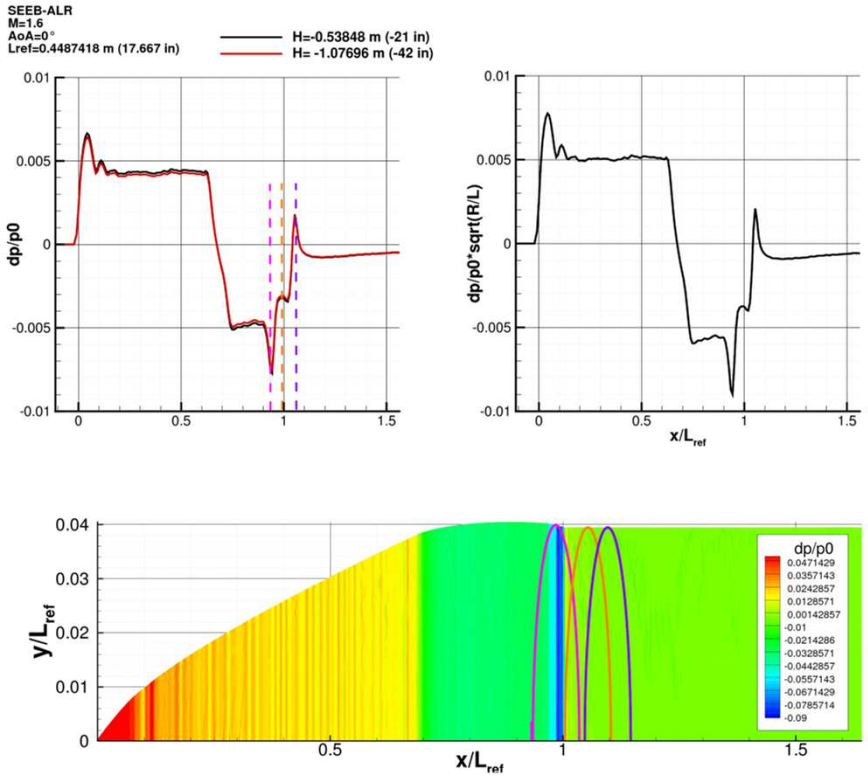


# Conclusions / Prospects

## MESH AND NEAR FIELD CFD

- Unstructured mesh adaptation
- RANS vs EULER
  - Sensitivity wrt numerical parameters (flux schemes, dissipation …)
- ***Alternative SB source prediction Surf cut***



# Conclusions / Prospects

- ***SB ASSESSMENT – PROPAGATION***
  - Use of multipole matching (MM) to match near and far field (dev @ onera since 2004)
    - R/L reduction using MM
  - Propagation solver : TRAPS & BangV ($p^{ty}$ of Airbus /Dev UPMC F. Coulouvrat)
    - Molecular relaxation
    - Cross-wind
    - Turbulence
  - PldB like metrics validation vs explicit delta p criteria