Sonic Boom Calculations for the N+2 Configuration

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- Requirements for Sonic Boom Calculations
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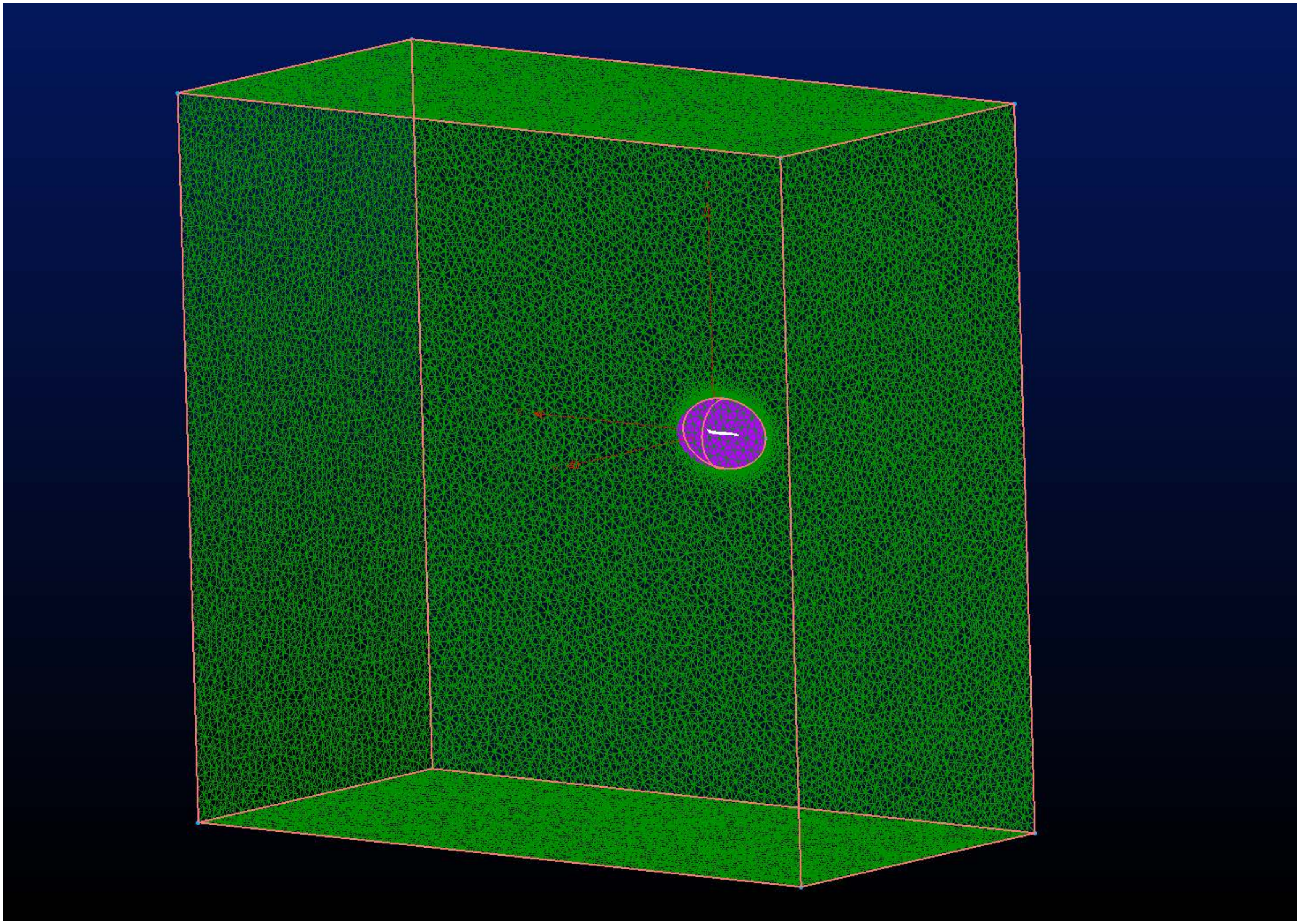
Introduction

- Low sonic boom flight a major requirement for N+2 Program
- Extensive work done to optimize sonic boom signature
- Optimization done on a rigid structure
- Structure will deflect aeroelastically under aerodynamic loads
- How will static aeroelastic deflections change the sonic boom signature?

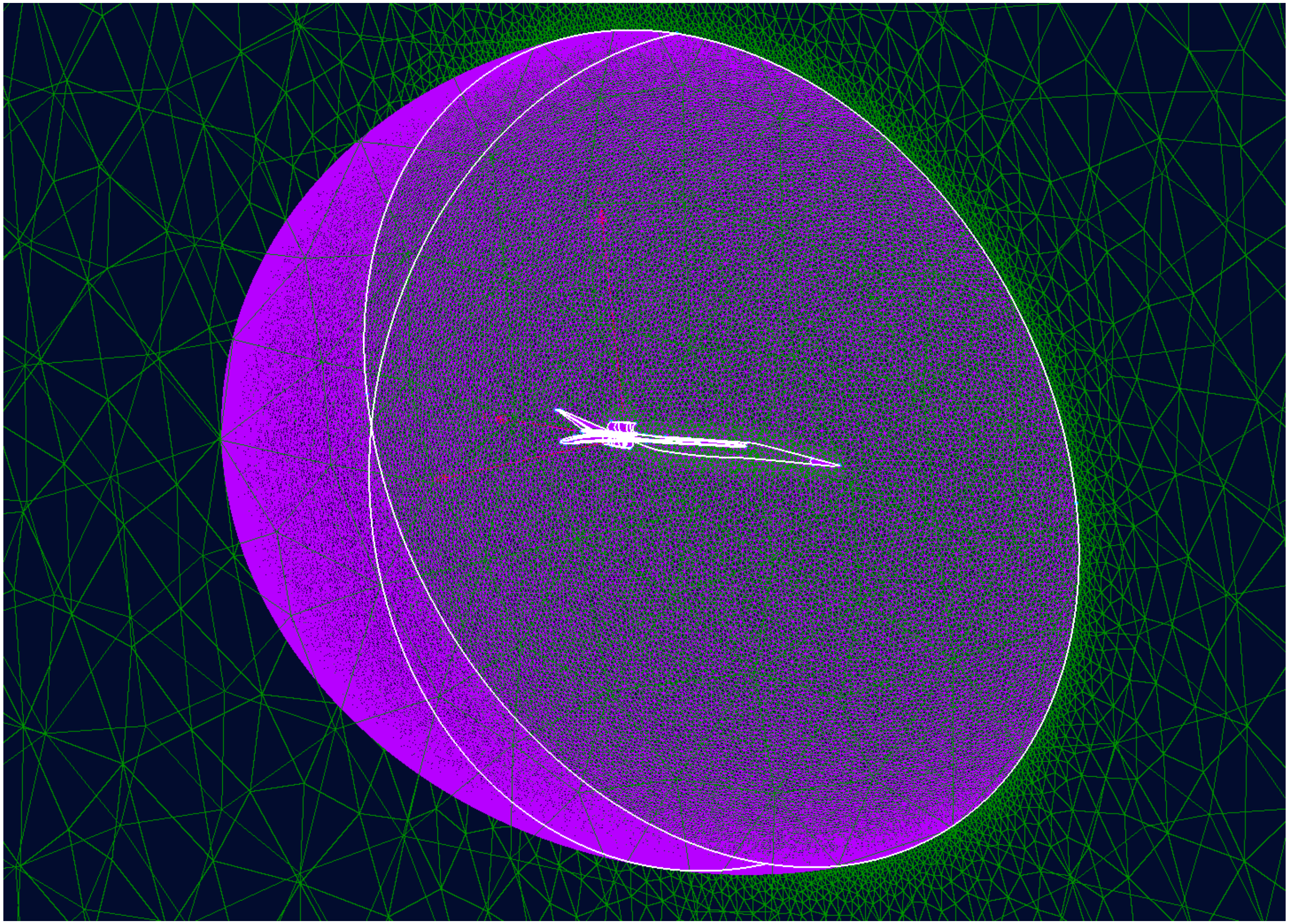
Requirements for Sonic Boom Calculations

- Conventional Static Aeroelastic domain is rectangular
- Body is defined at 0^{o} angle of attack
- Same grid can be used for multiple flow conditions
- Sonic Boom domain must be shock aligned
- Conical-shaped domain with angle of cone dictated by Mach angle
- Body must be rotated to proper angle of attack
- Separate grid for each flow condition

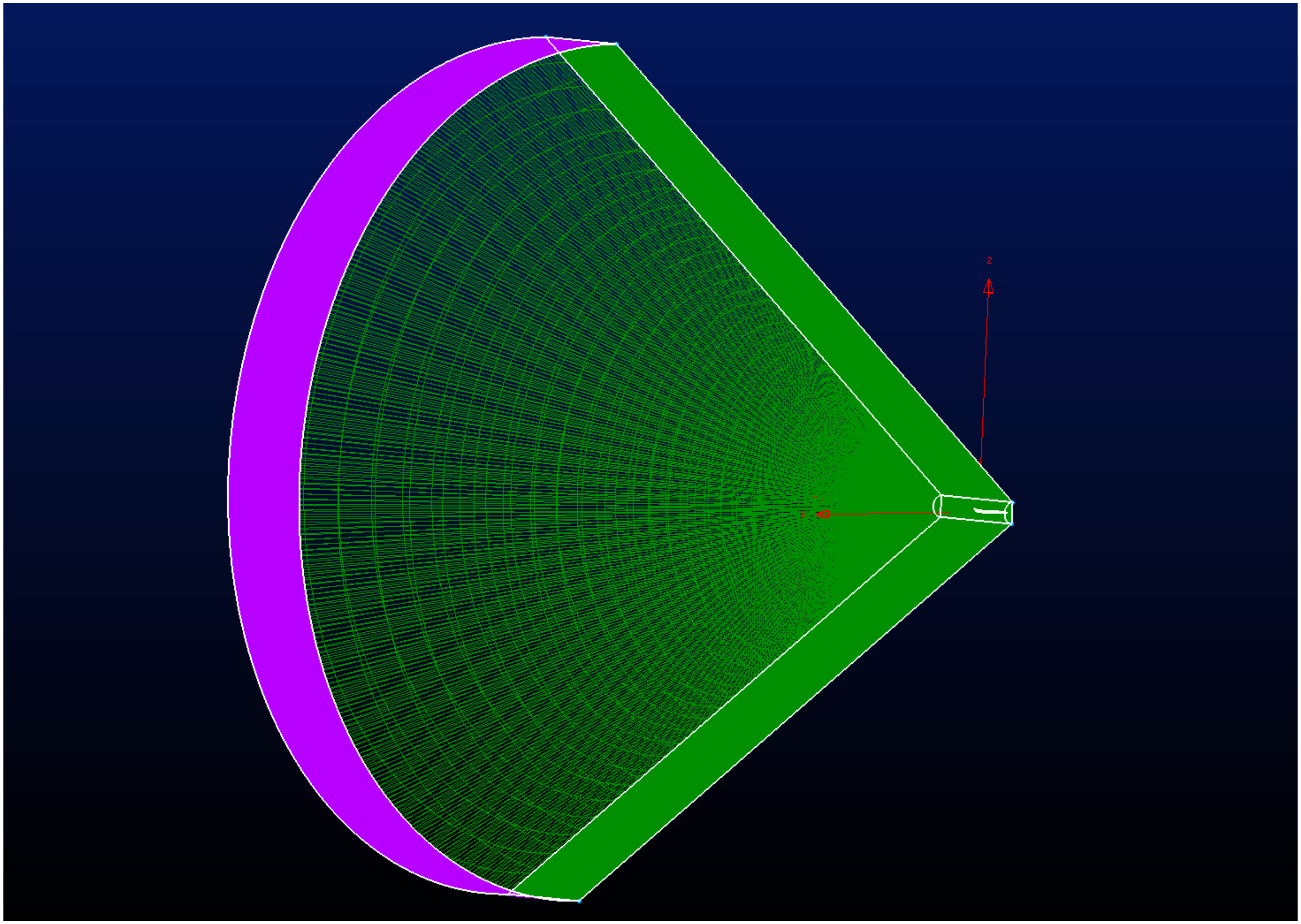
CAE Computational Domain



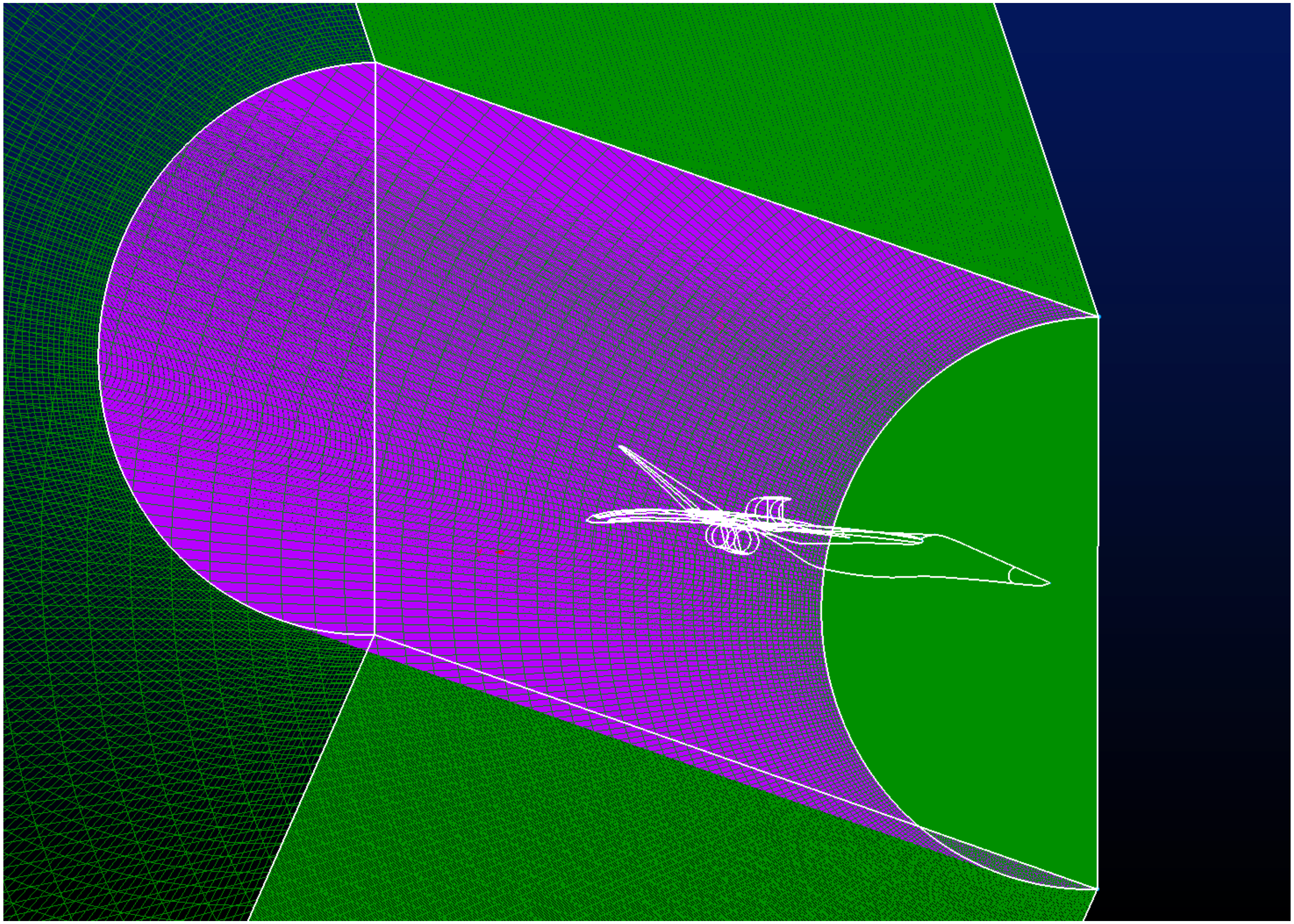
CAE Computational Domain Detail



Sonic Boom Computational Domain



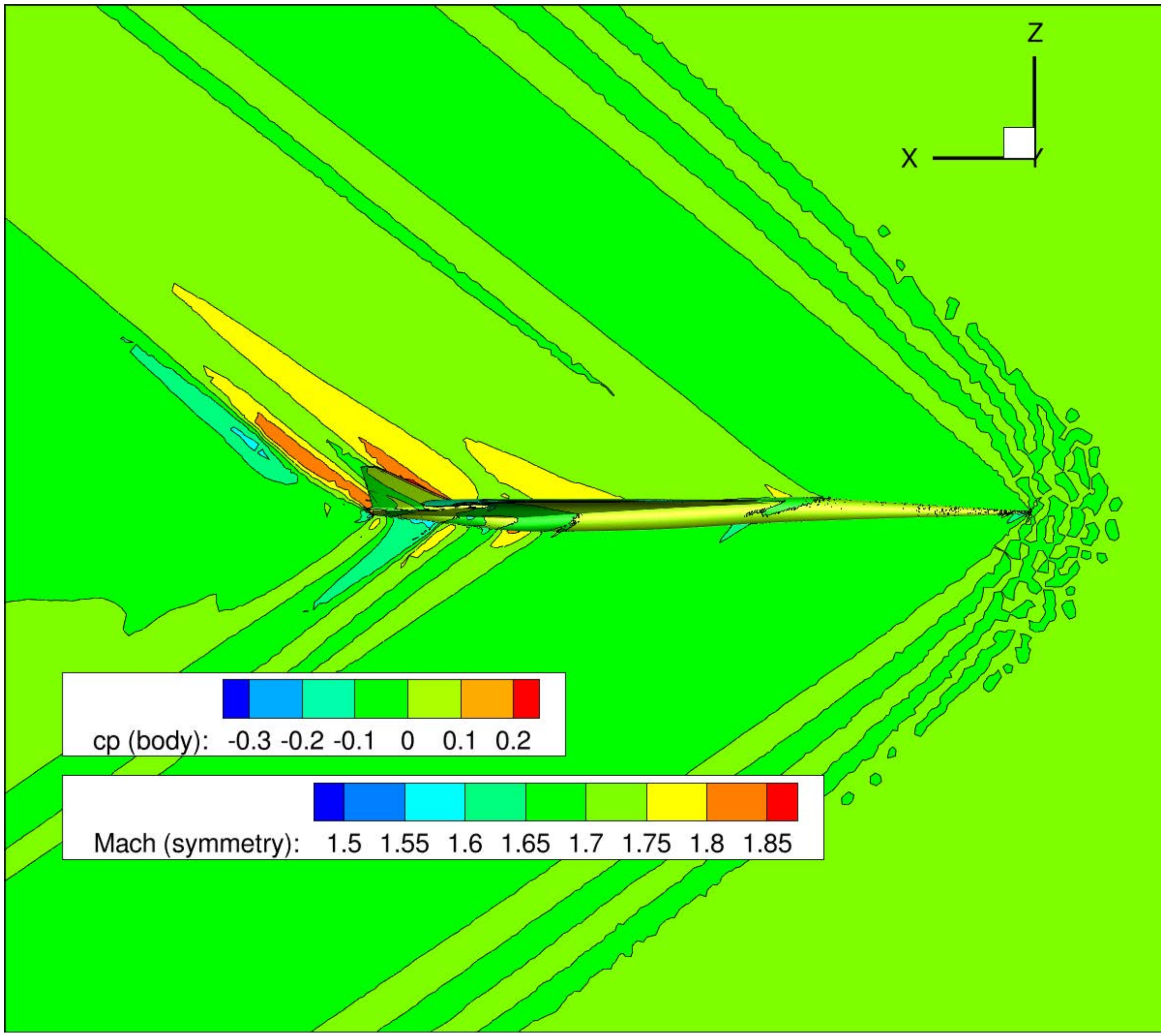
Sonic Boom Computational Domain



Challenges of Sonic Boom Calculations

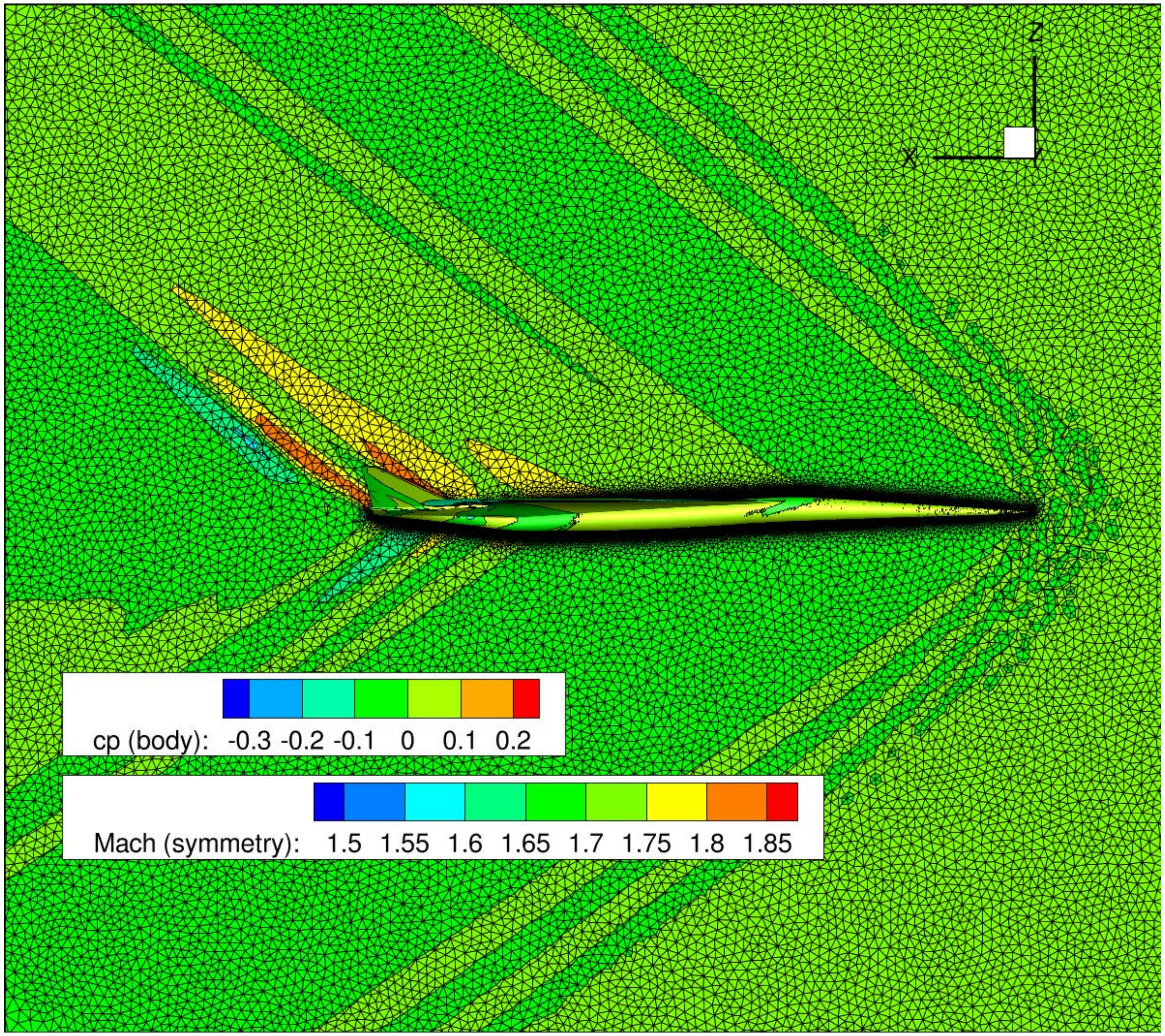
- Separate grid for every flow condition
- Extremely fine near-field grid required
- Where to extract pressure signature?
  - Too close and the pressure signature not fully developed
  - Too far away and the pressure signature is dissipated
  - Current practice is 3 body lengths
- Use of external program to propagate shock to ground level (sBOOM)
- Interpretation of ground signatures

Conventional CAE Solution
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^o$



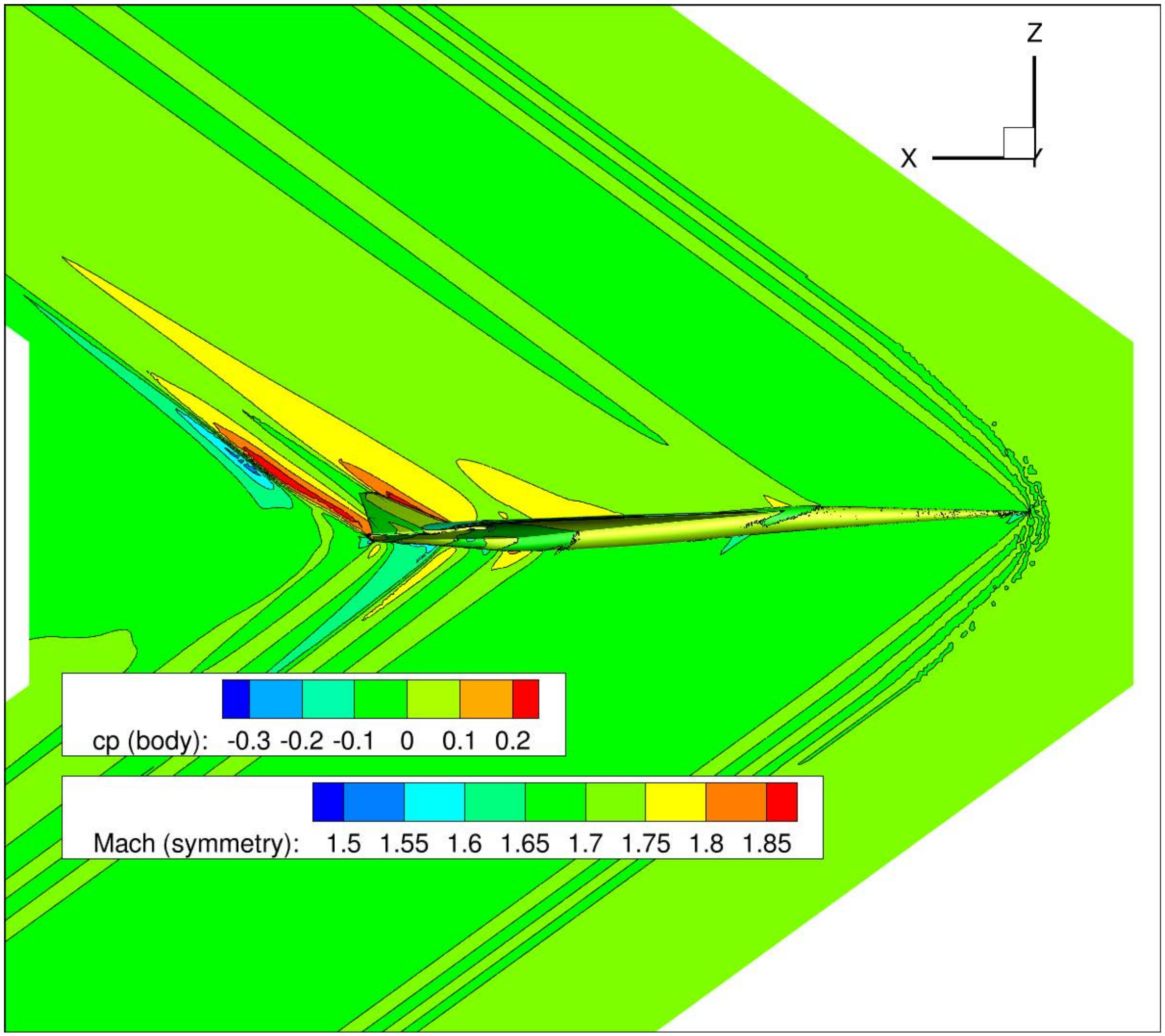
11.8 MGP, $C_L = 0.14343$, $C_D = 0.09220$

Conventional CAE Solution with Grid
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^o$



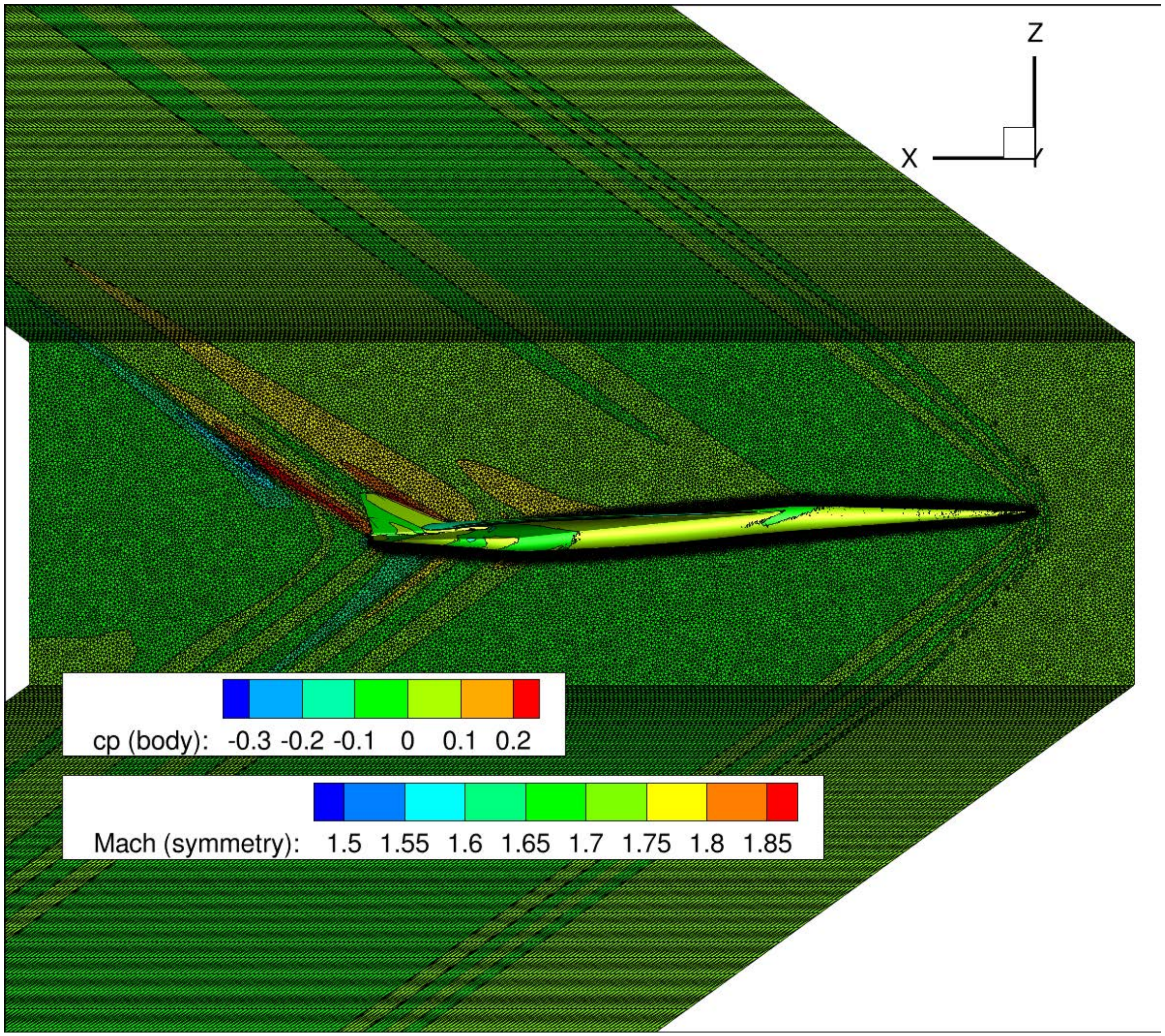
11.8 MGP, C_L = 0.14343, C_D = 0.09220

Sonic Boom Coarse Solution
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^o$



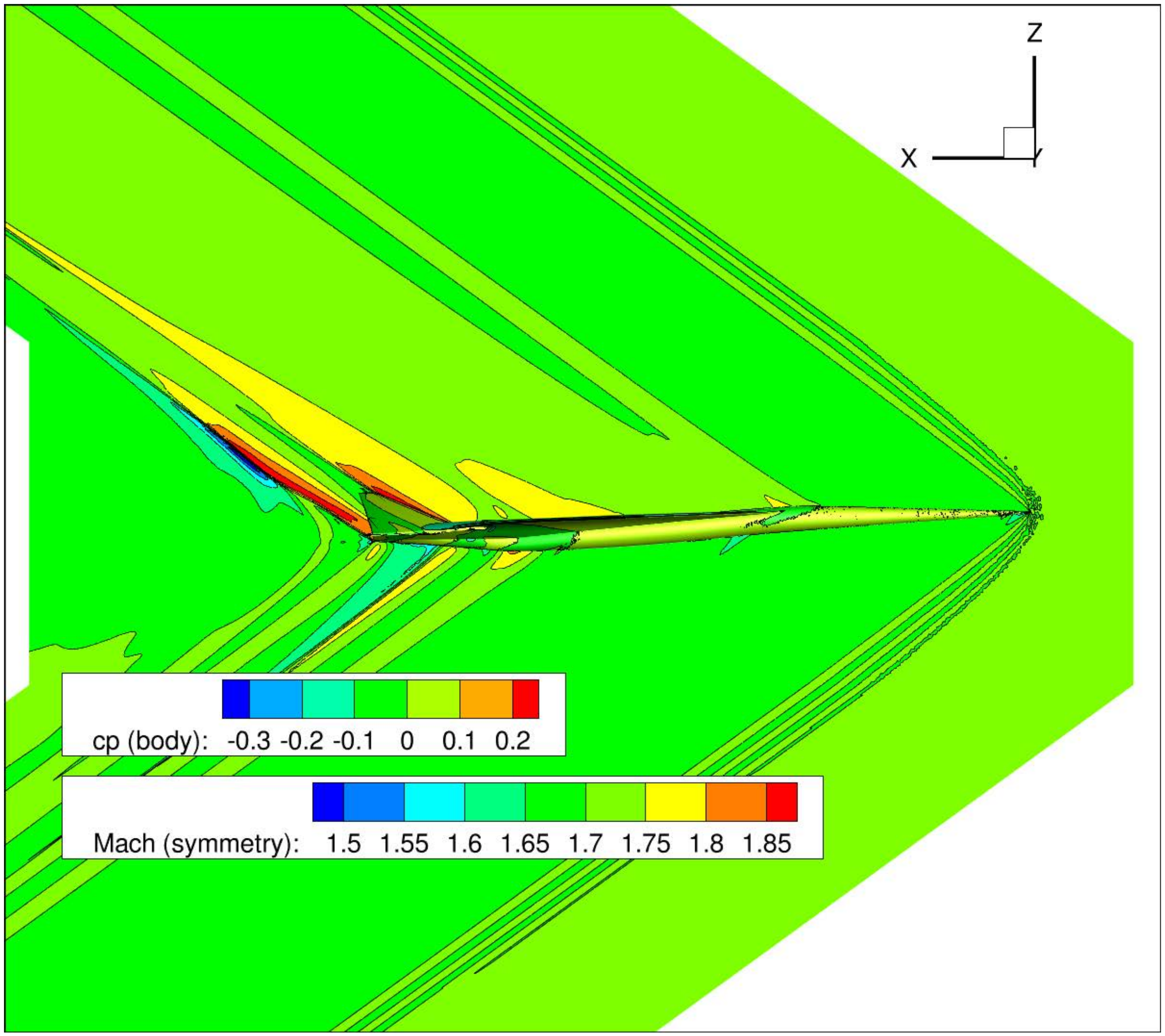
15.9 MGP, C_L = 0.14342, C_D = 0.09252

Sonic Boom Coarse Solution with Grid
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^o$



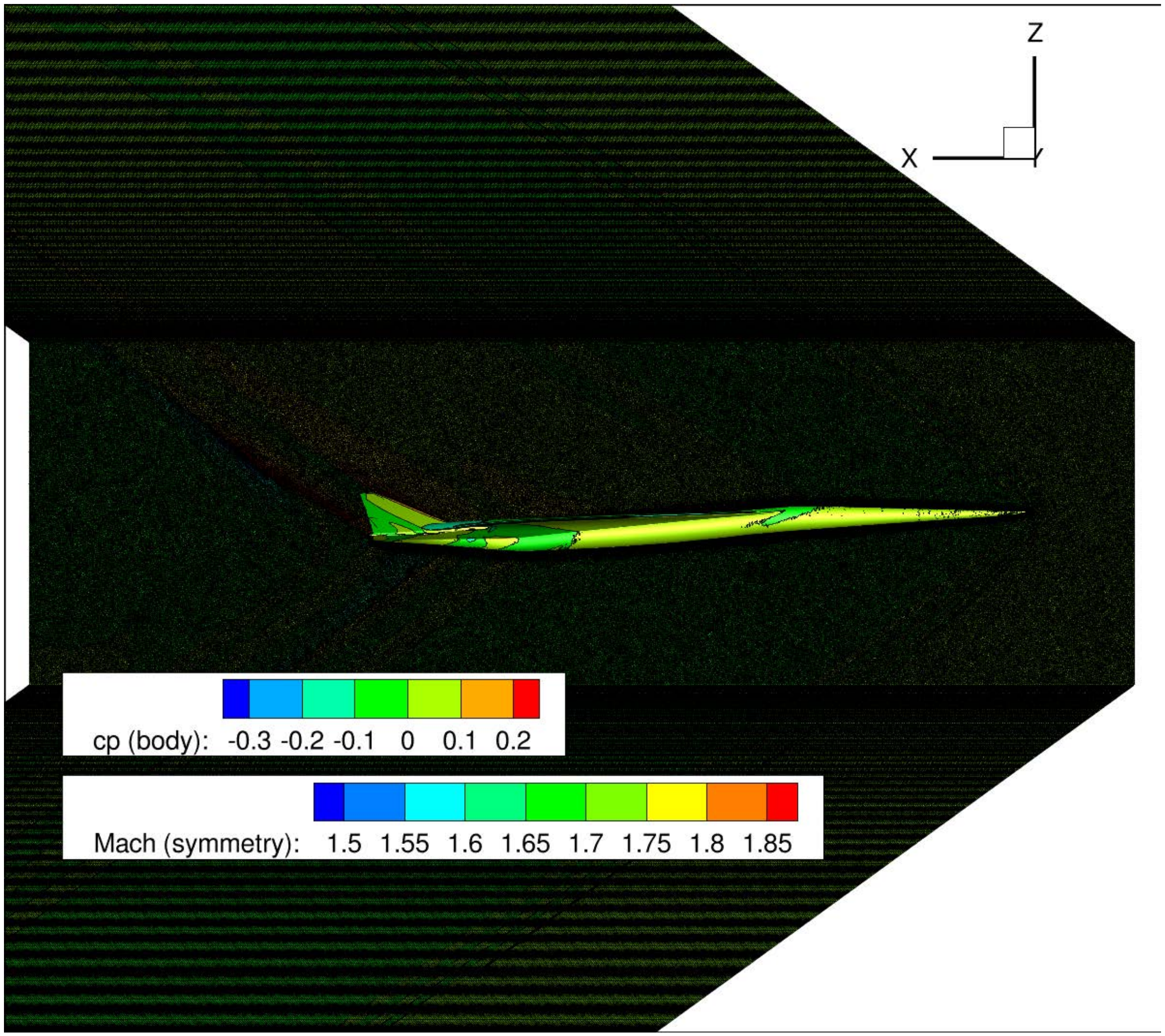
115.9 MGP, C_L = 0.14342, C_D = 0.09252

Sonic Boom Medium Solution
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^o$



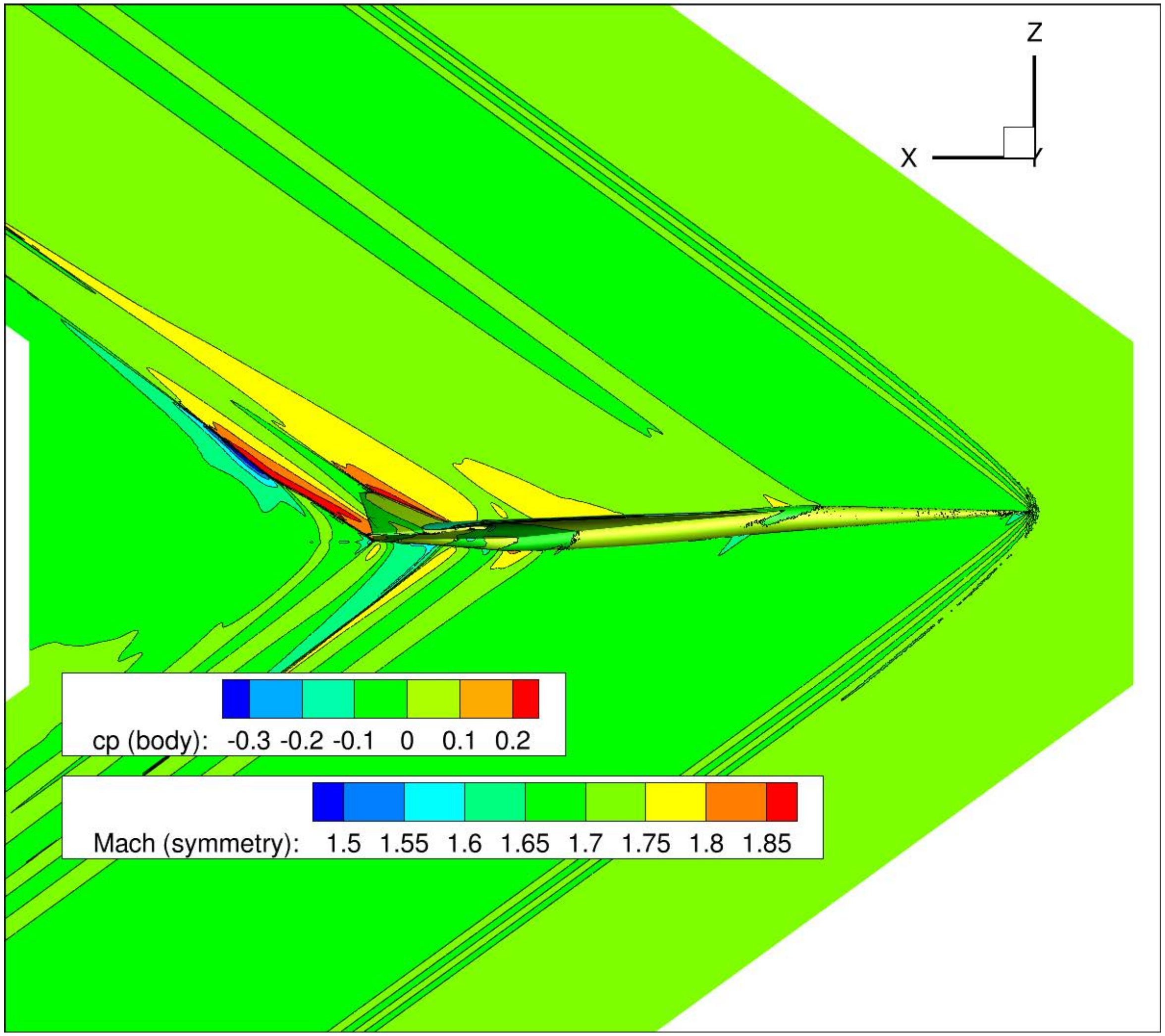
46.5 MGP, $C_L = 0.14343$, $C_D = 0.09251$

Sonic Boom Medium Solution with Grid
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^o$



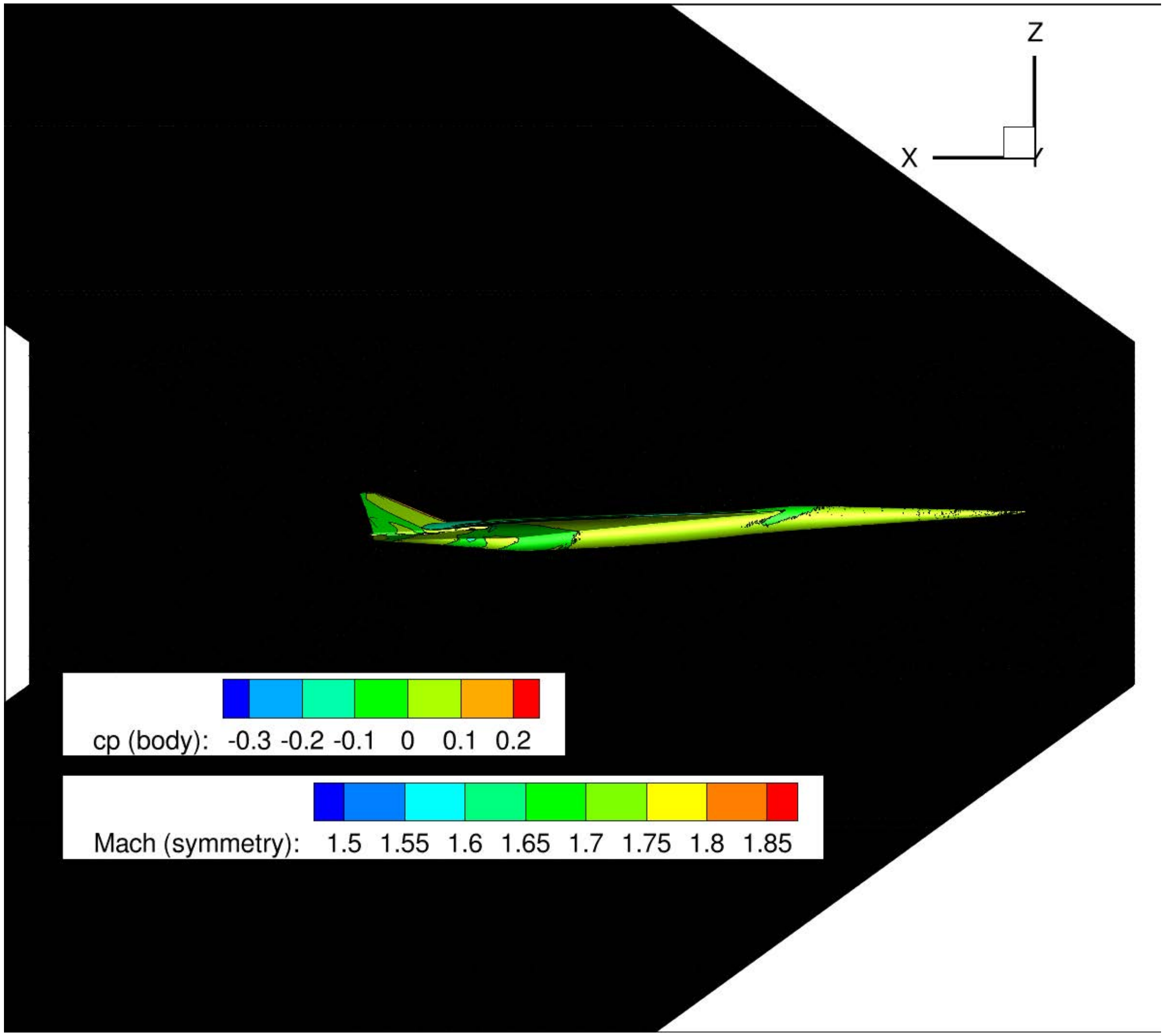
46.5 MGP, C_L = 0.14343, C_D = 0.09251

Sonic Boom Fine Solution
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^o$



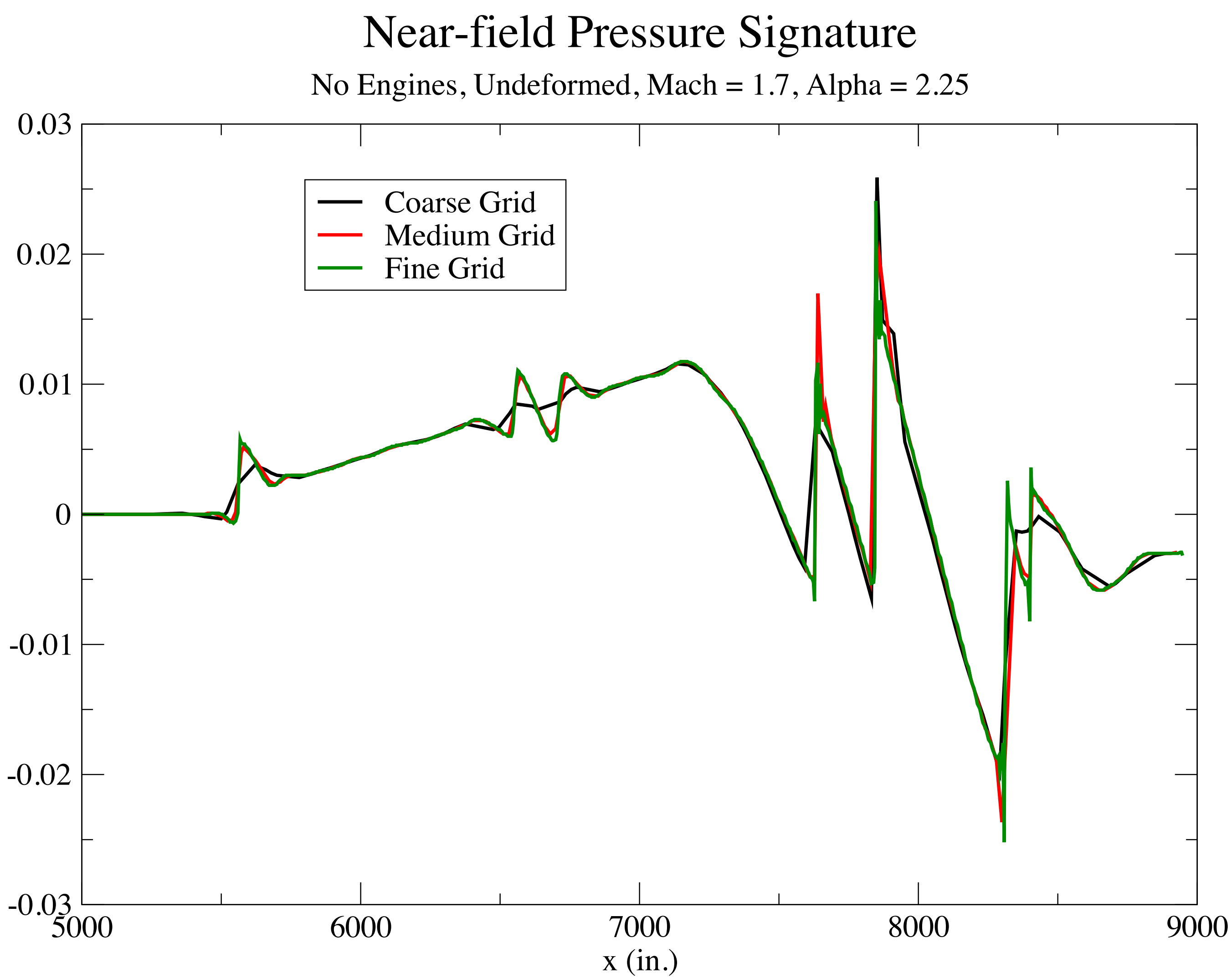
89.9 MGP, C_L = 0.14342, C_D = 0.09256

Sonic Boom Fine Solution with Grid
Inviscid, No Engines, Mach = 1.70, $\alpha = 2.25^o$

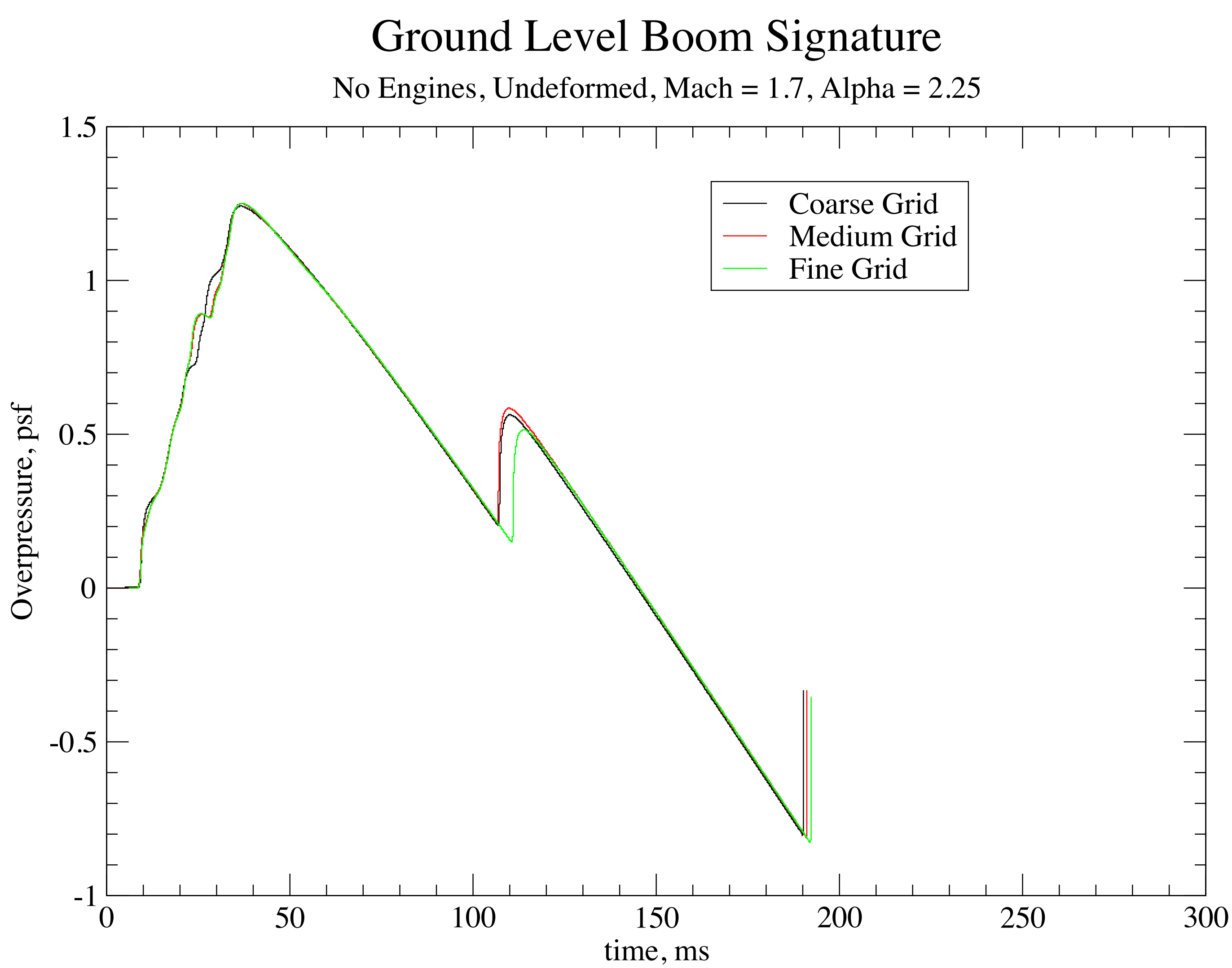


89.9 MGP, C_L = 0.14342, C_D = 0.09256

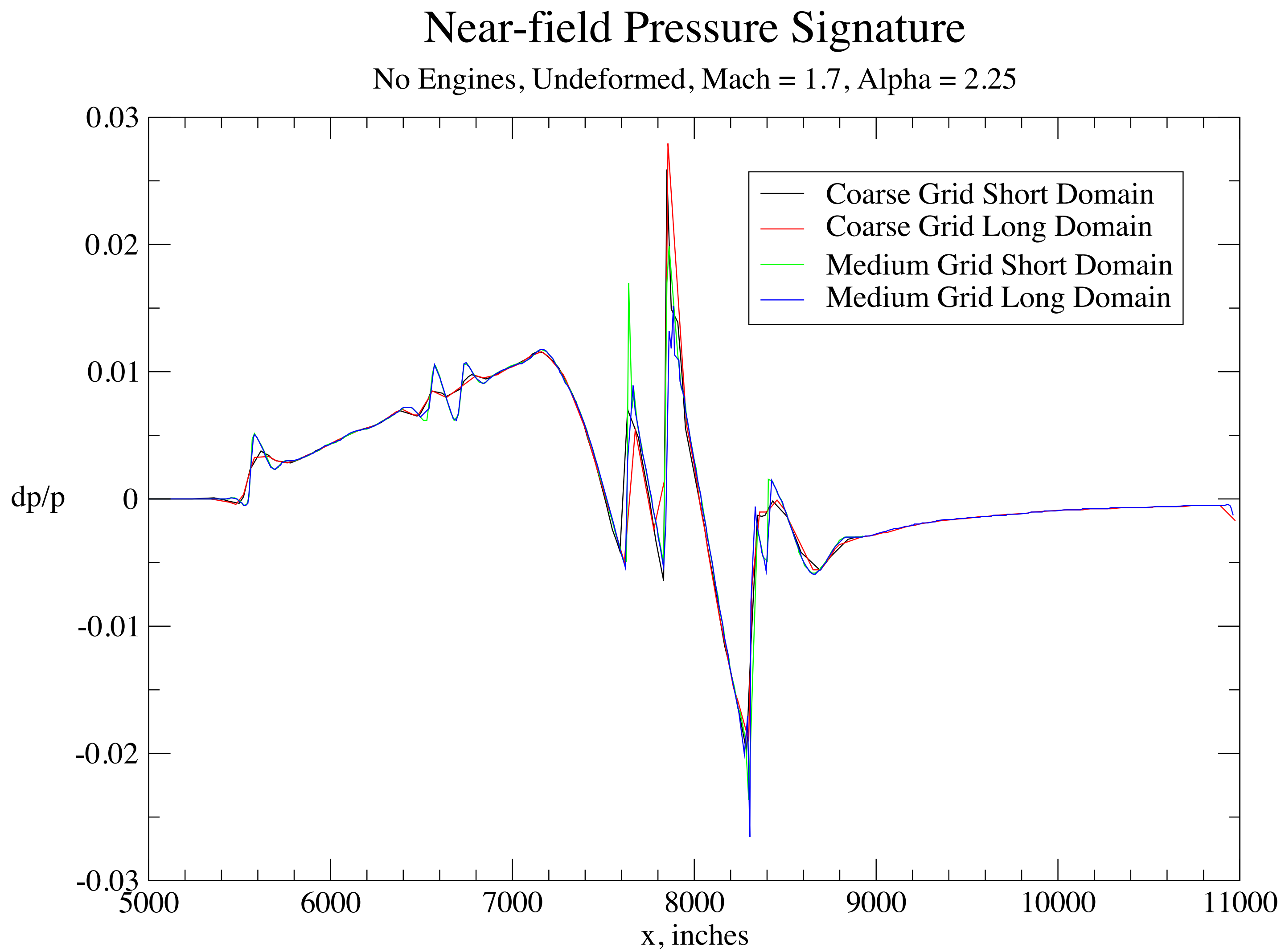
Sonic Boom Grid Resolution Study



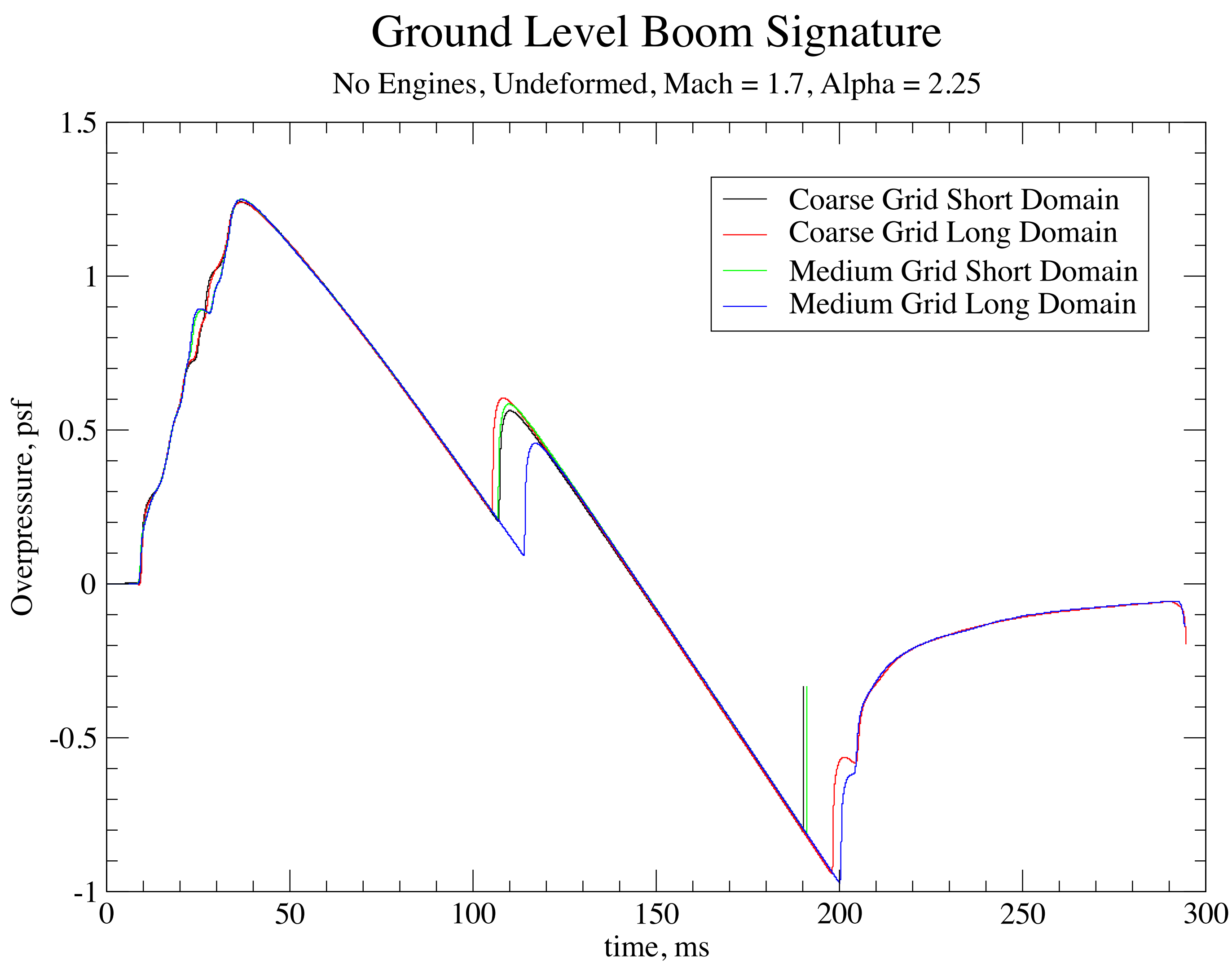
Sonic Boom Grid Resolution Study (cont.)



Sonic Boom Domain Size Study



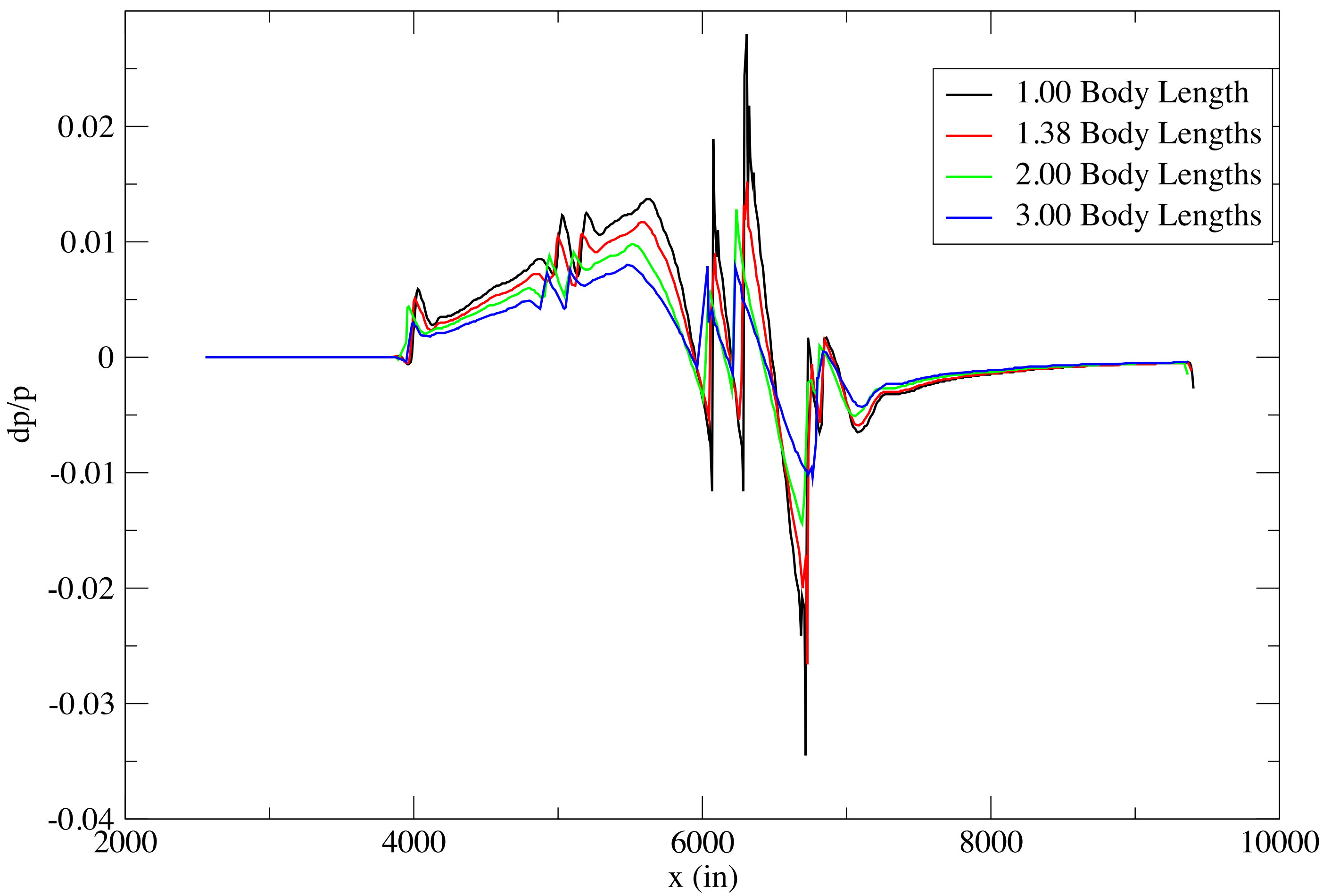
Sonic Boom Domain Size Study (cont.)



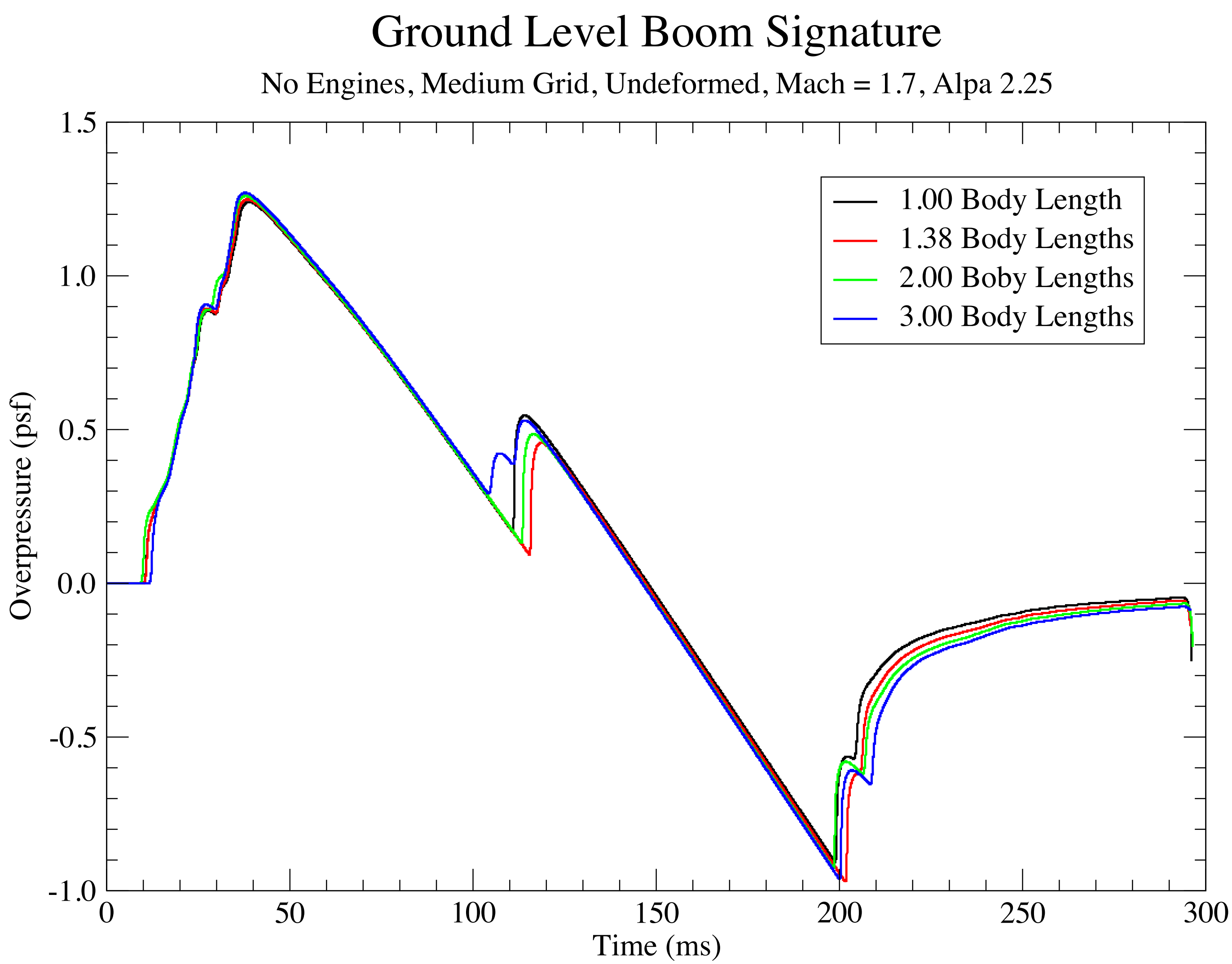
Sonic Boom Extraction Position Study

Near-field Pressure Signature

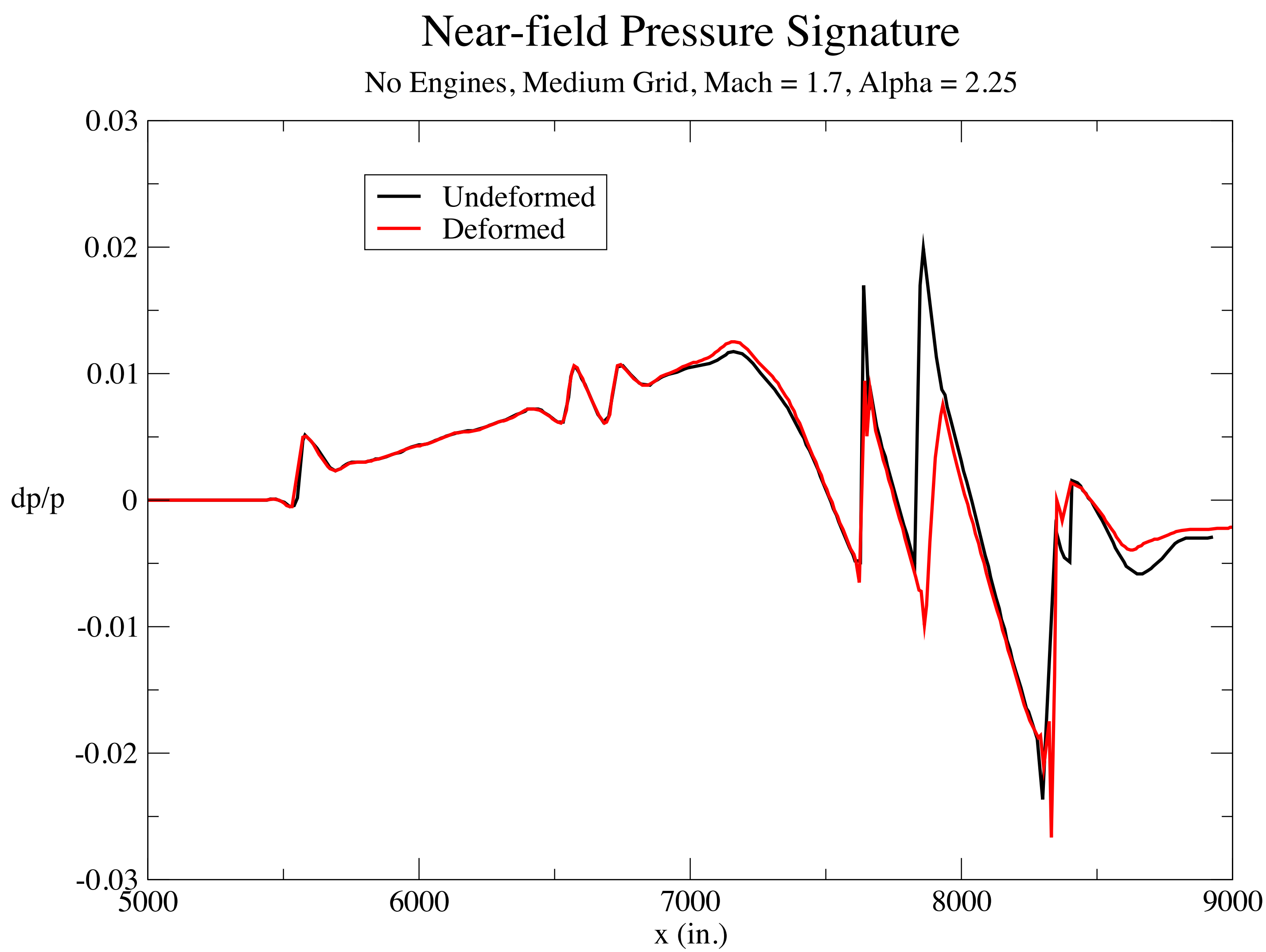
No Engines, Meduim Grid, Undeformed, Mach = 1.7, Alpha = 2.25



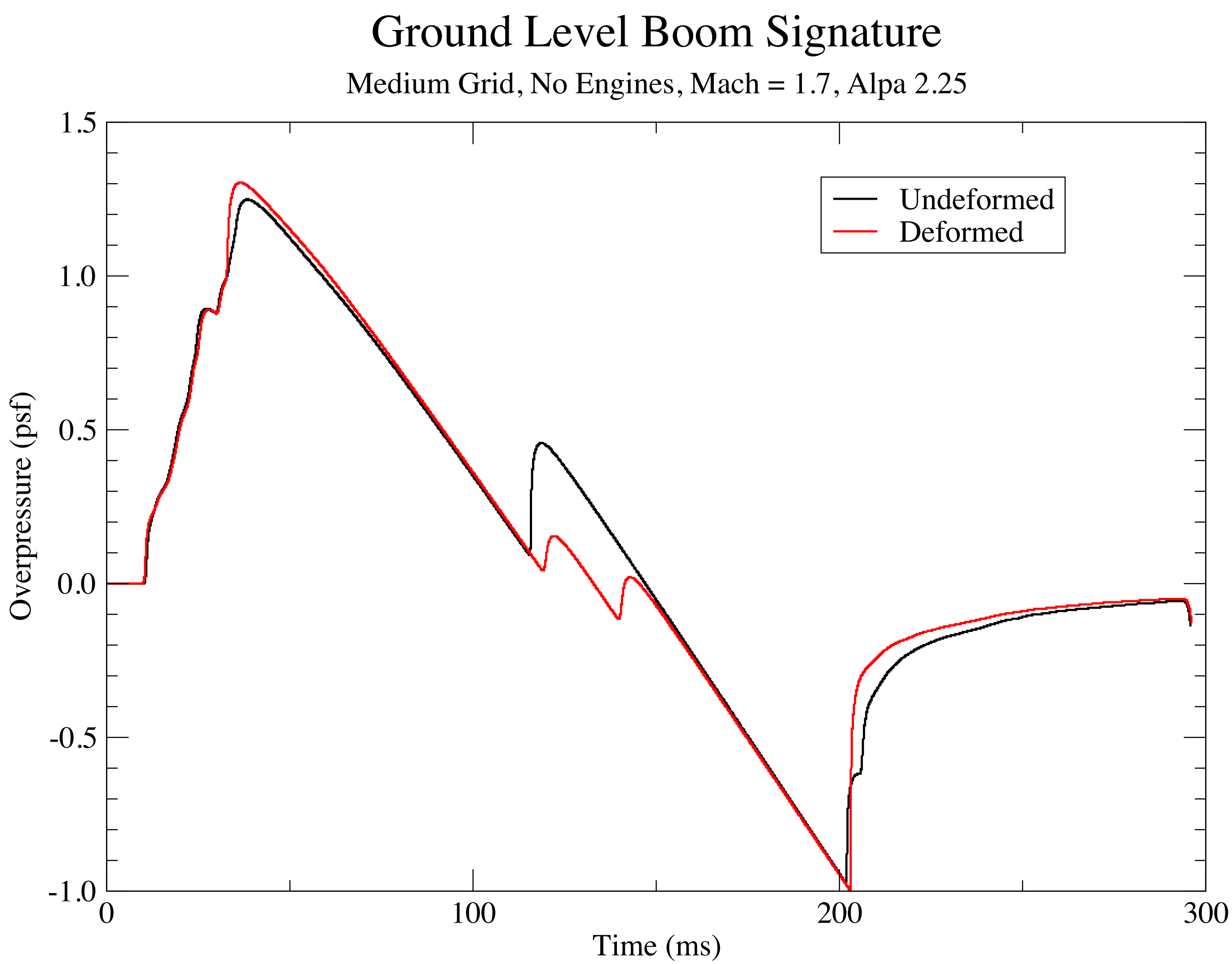
Sonic Boom Extraction Position Study (cont.)



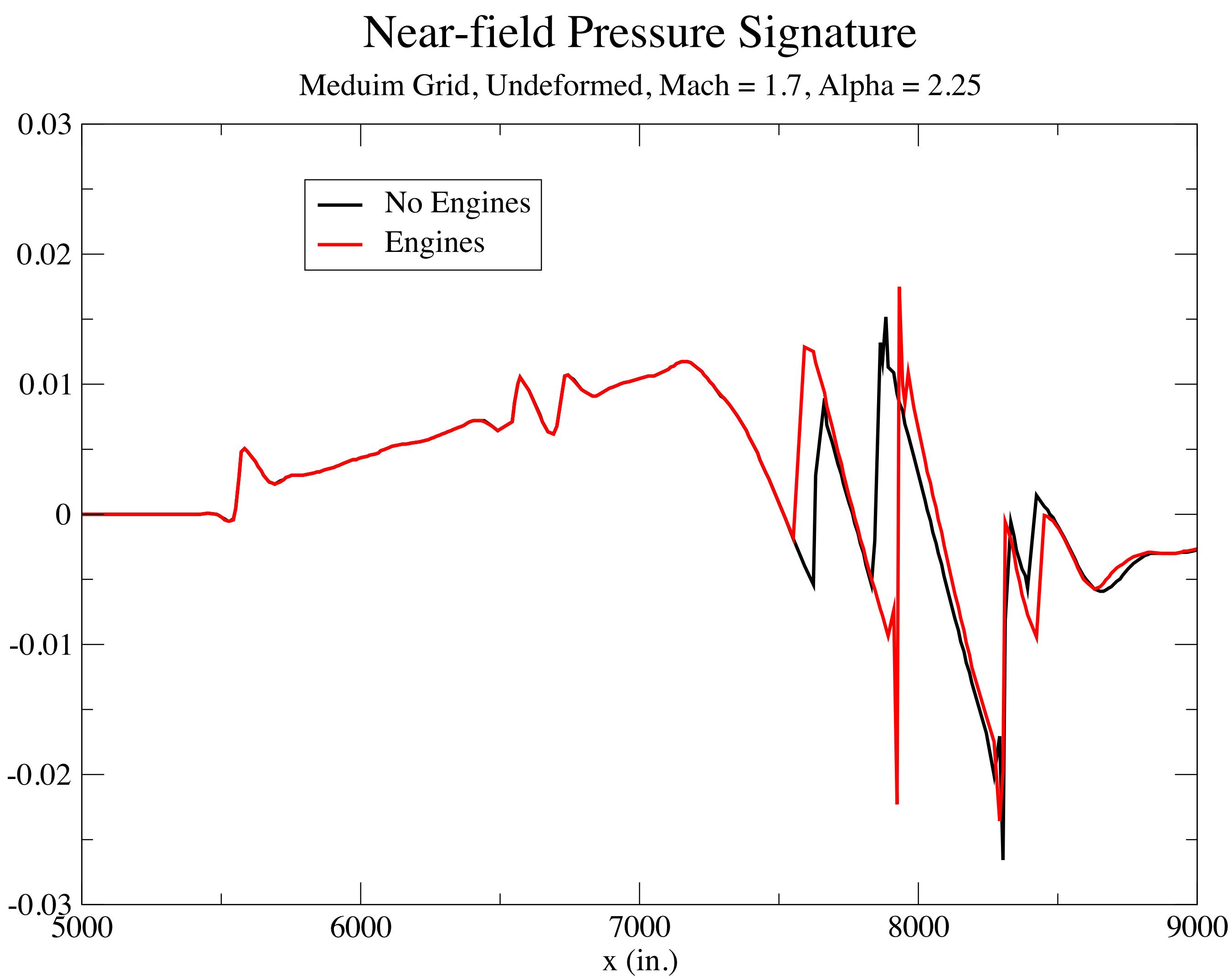
Sonic Boom Effect of Deflections Study



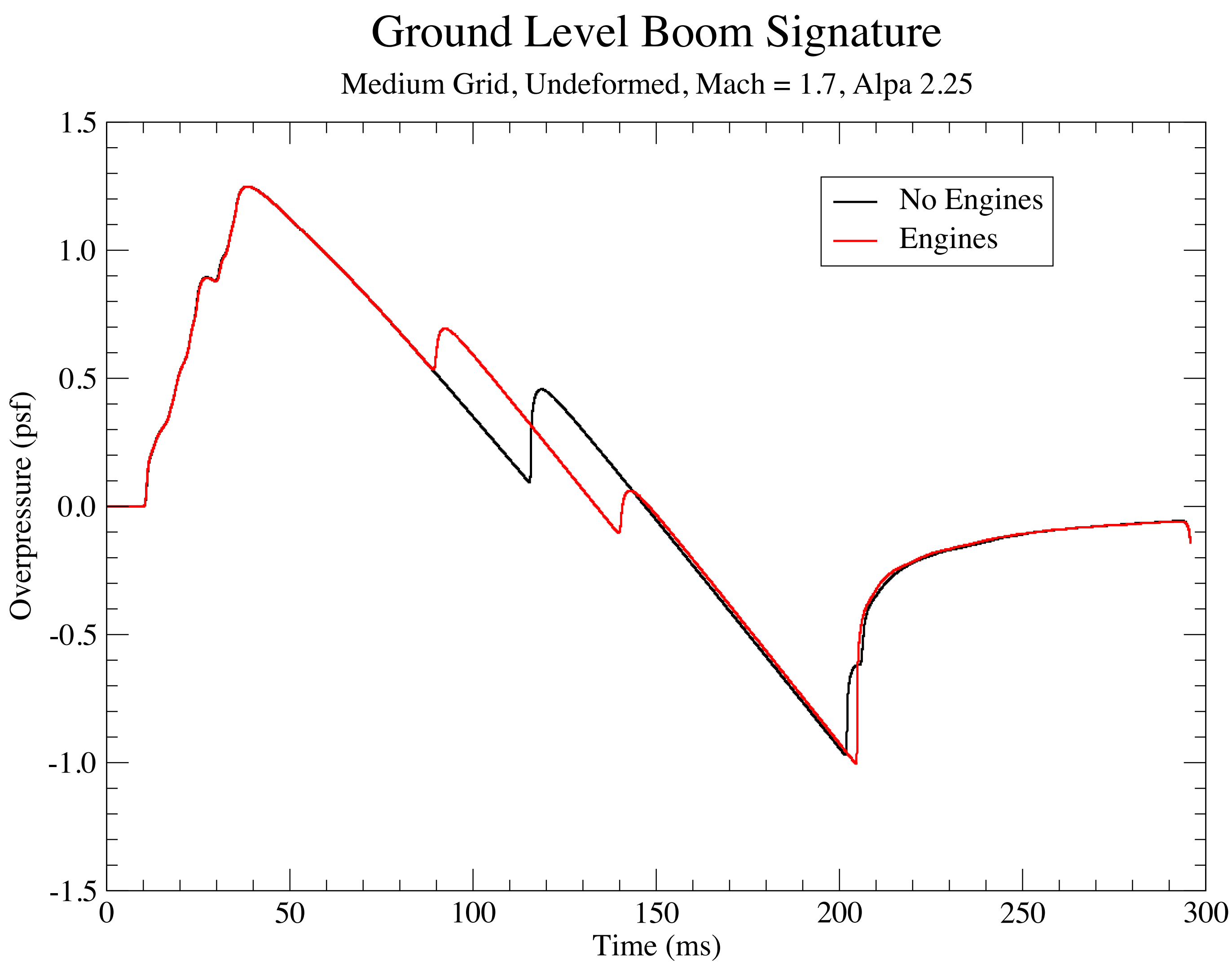
Sonic Boom Effect of Deflections Study (cont.)



Sonic Boom Effect of Engines Study



Sonic Boom Effect of Engines Study (cont.)



Concluding Remarks

- Sonic boom signatures have been computed for the N+2 configuration
- Still a work in progress; much learning to be done
- Major questions to be answered
  - Exactly what is the configuration are we analyzing?
  - What is the best procedure for static aeroelastic computations?
- Future Work
  - Additional computations with engines
  - More realistic engines?
  - Viscous Calculations
- A good start has been made in the investigation of the aeroelastic effects on the sonic boom signature

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