Create and Deliver Superior Products
Through Innovative Minds

AIAA Sonic Boom Prediction Workshop

Lockheed Martin Aeronautics

January 11, 2014

Michael Buonanno
Frank Marconi

Outline

- Summary of Cases
- Flow Solver / Computing Platform Overview
- Computational Grid Overview
- Convergence History
- Solution Details
- Conclusions

Flow Solver / Computing Platform

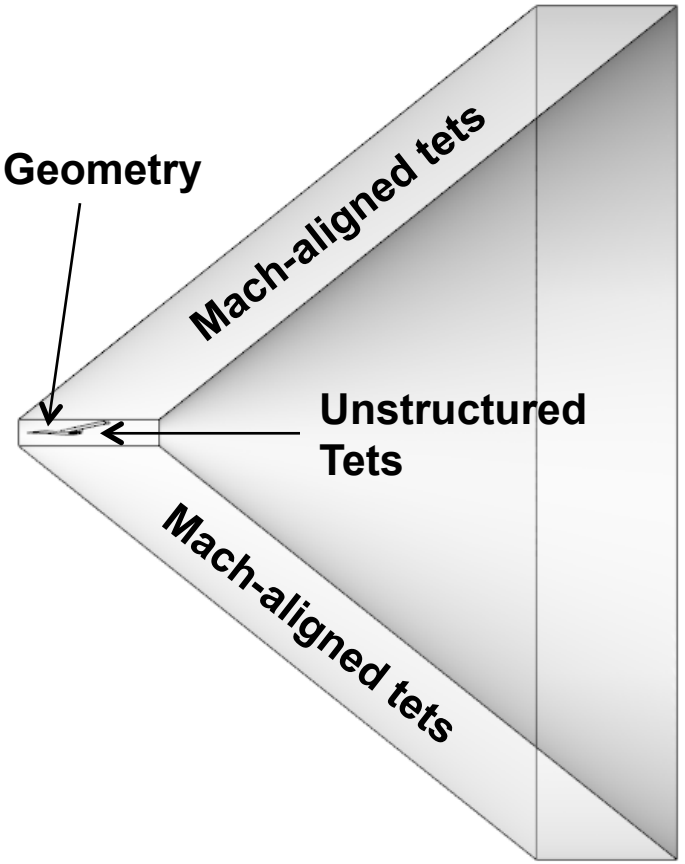
- **Flow Solver: CFD++ from Metacomp Technologies**
  - **Cell centered commercial solver**
  - **Viscous and inviscid capabilities (all solutions generated using viscous equations but for the 69 degree delta inviscid wall BCs were used)**
  - **Realizable k-epsilon tubulence model**

- **Computing Platform: LM Aero Supercomputers**
  - **Linux clusters with 16 cores/node, 64GB memory/node**
  - **Sandy Bridge CPUs (E5-2670; 2.6 GHz),**
  - **Jobs typically run on 8 nodes (128 cores)**

Advanced Development Programs

Computational Grid Overview

- **New grids generated for both the LM 1021 and SEEB-ALR, provided grid used for the 69 degree Delta Wing-Body**
  - **LM 1021 solution uses a computational grid generated using tri2cogsg/AFLR3 / bg from NASA LaRC/Miss St. (unstructured tets near the body, Mach-aligned tets in mid-field)**
  - **Viscous grid with 4.1M nodes and 23.7M cells (about 8M in the BL)**
  - **69 Degree Delta W-B solution generated using high density computational grid provided by the workshop**
  - **SEEB-ALR run with swept, structured, 2-D axi-symmetric grid of about 2.5 million 2-D cells** (other details no longer available)

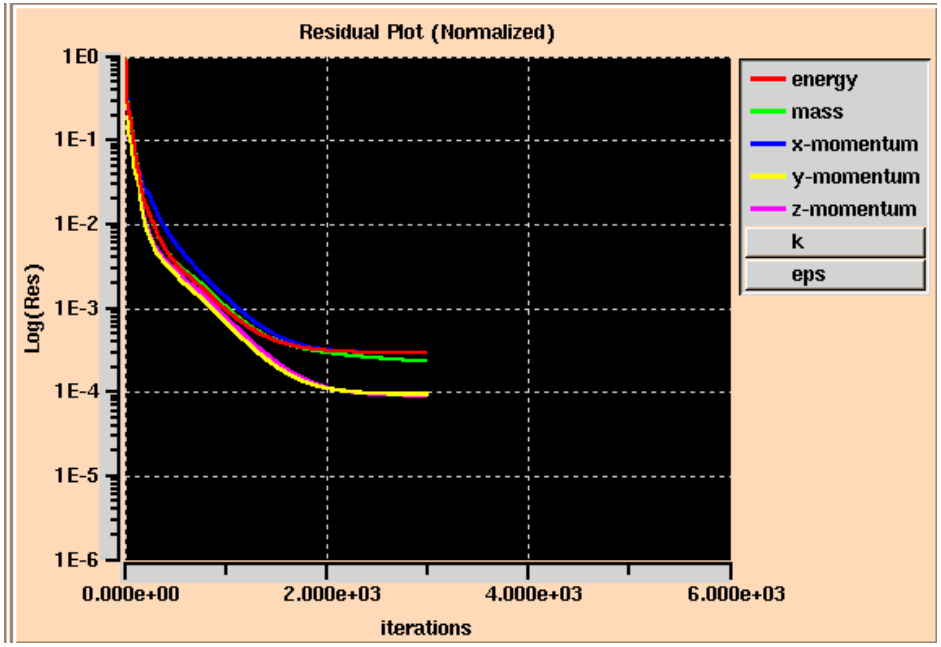


Advanced Development Programs

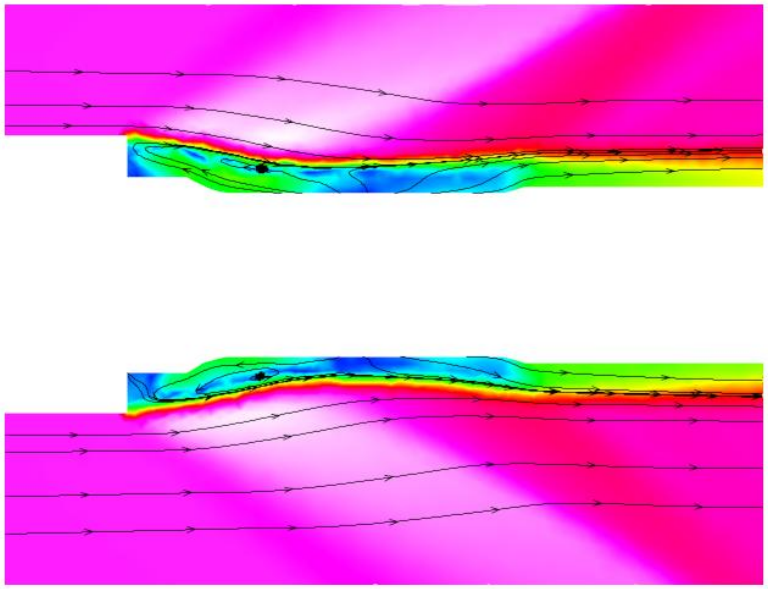
Flow Solver Details

- **Both solutions run to 3000 iterations**
  - **Good convergence observed on LM 1021 grid**
  - **69 degree delta residual stuck at 2 orders in the base region**

Case 3 (LM 1021) convergence history



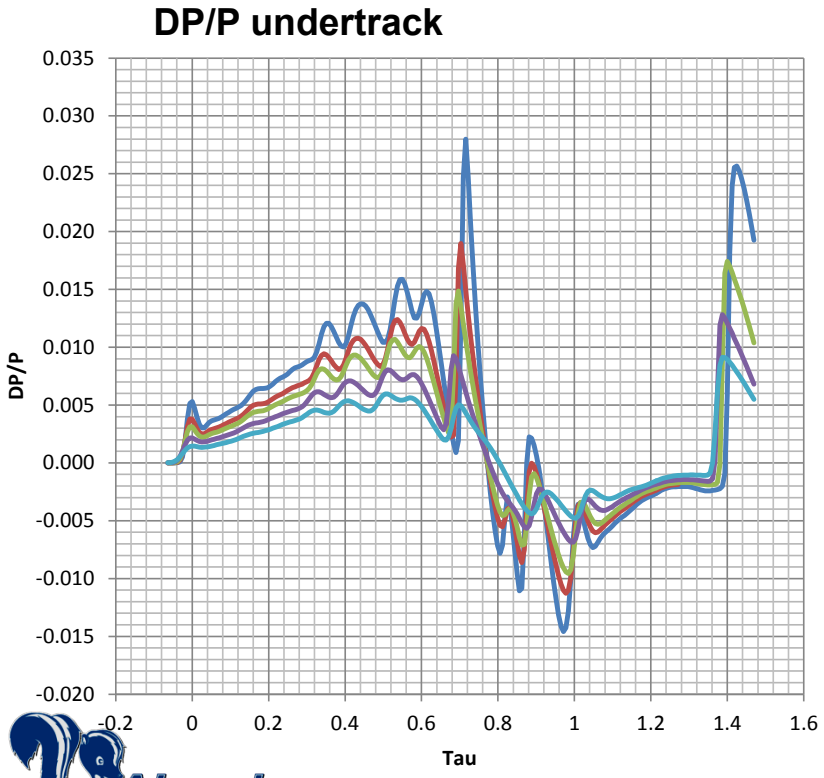
Recirculation in base region of 69 degree delta model

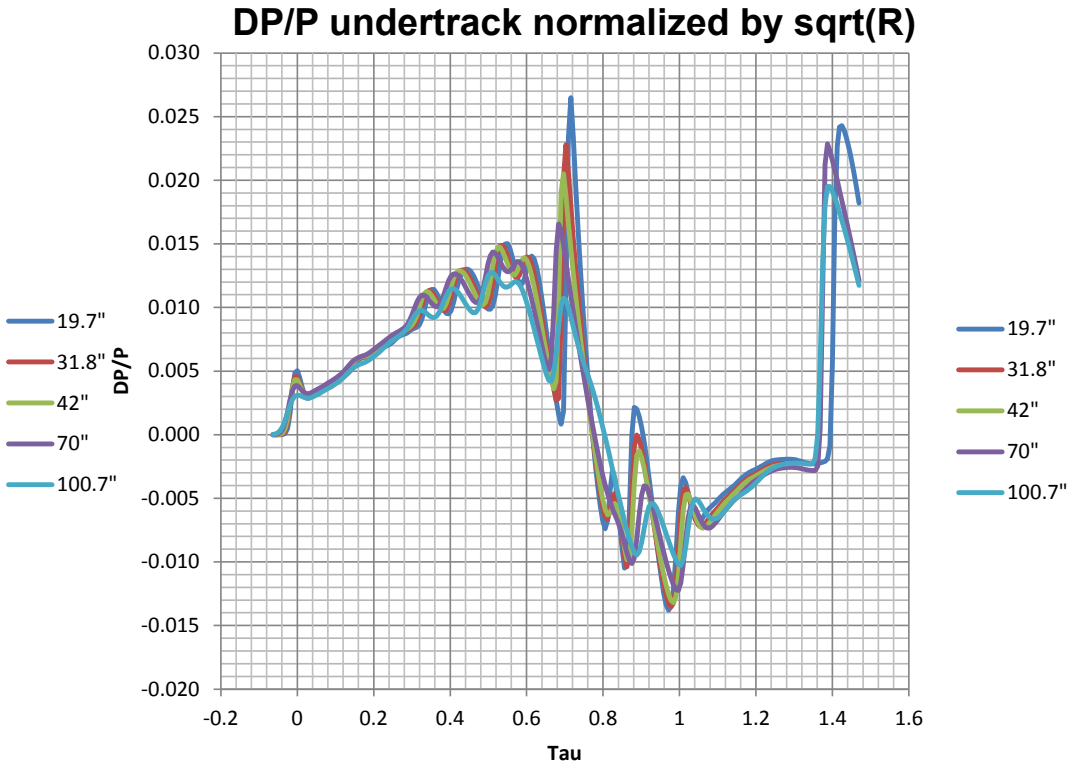


Advanced Development Programs

LM 1021 Under Track Solutions

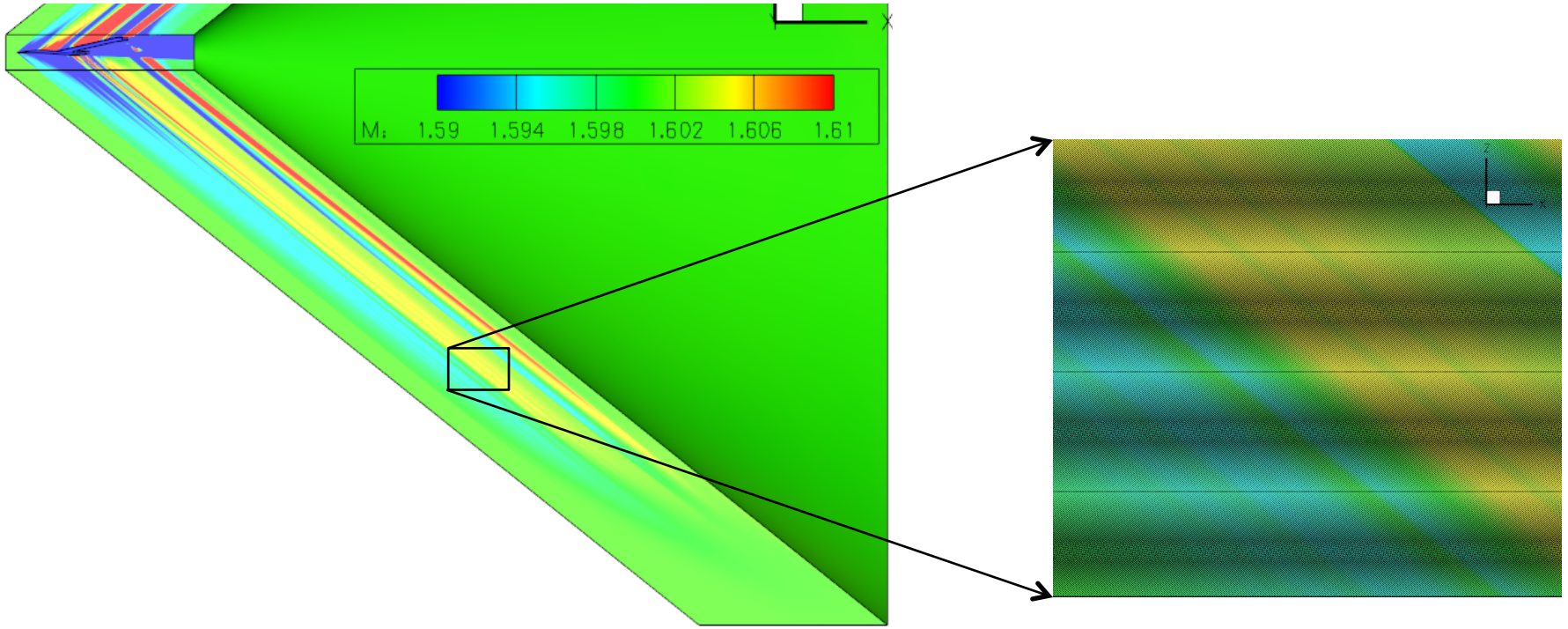
Under-track predictions appear reasonable, but examination of normalized data indicates that predictions at 100.7” are not consistent with the rest of the data – may be a limitation of the particular grid or indication that solution is not quite converged at the outer boundary





Advanced Development Programs

LM1021 Symmetry Plane Mach Contour

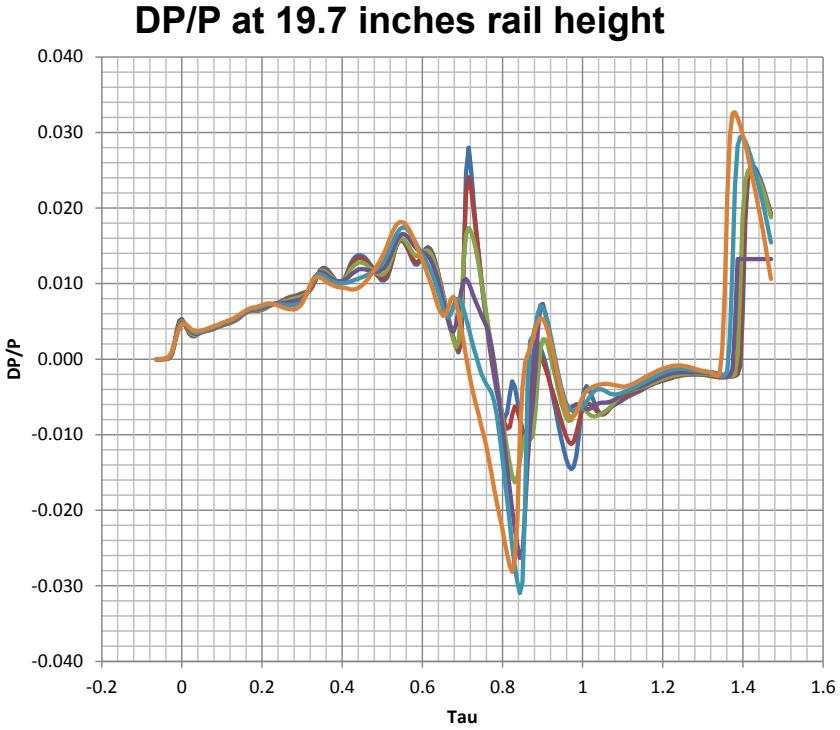


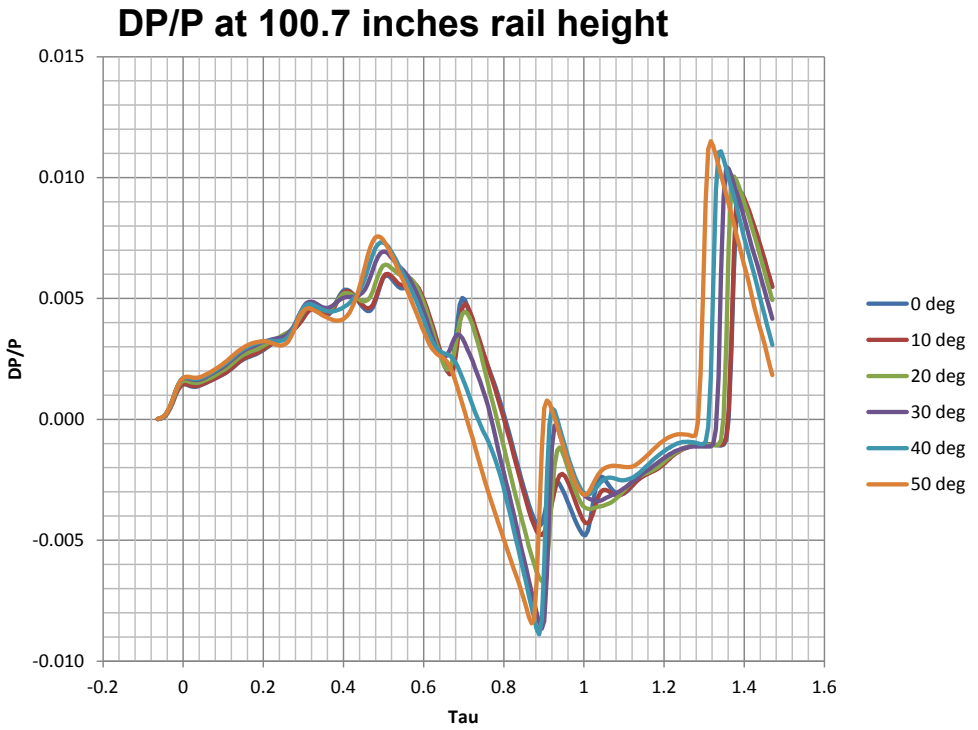
Default tri2cogsg/bg parameters result in very high aspect ratio tets at large off-body distances, negatively impacting the 100.7 inch predictions – AR progression should be modified to improve accuracy and convergence at these large distances

Advanced Development Programs

LM 1021 Off Track Solutions

Off-track predictions have approximately the same level of sharpness as under-track due to the fact the Mach-aligned grid is centered on the nose of the configuration

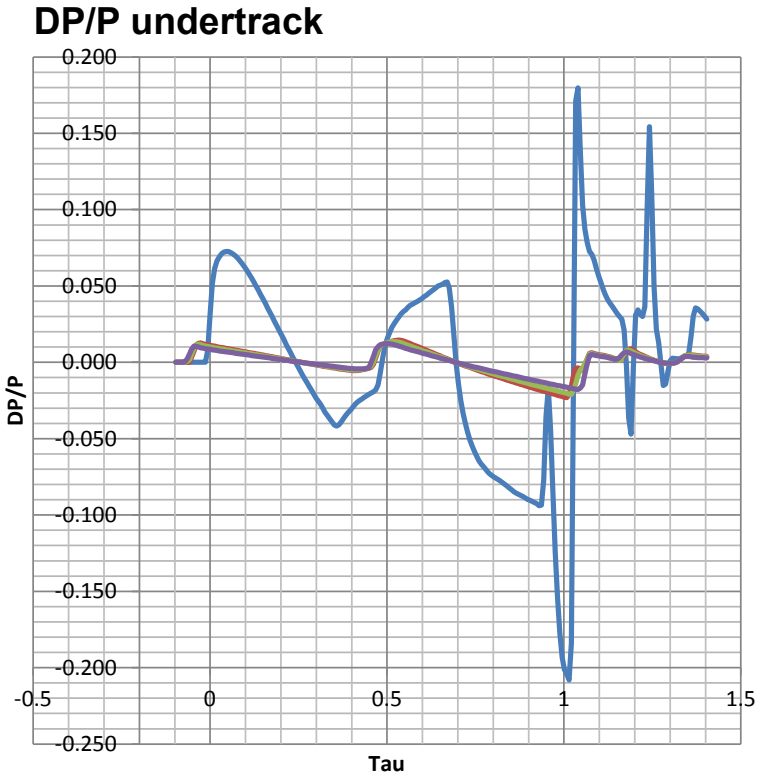


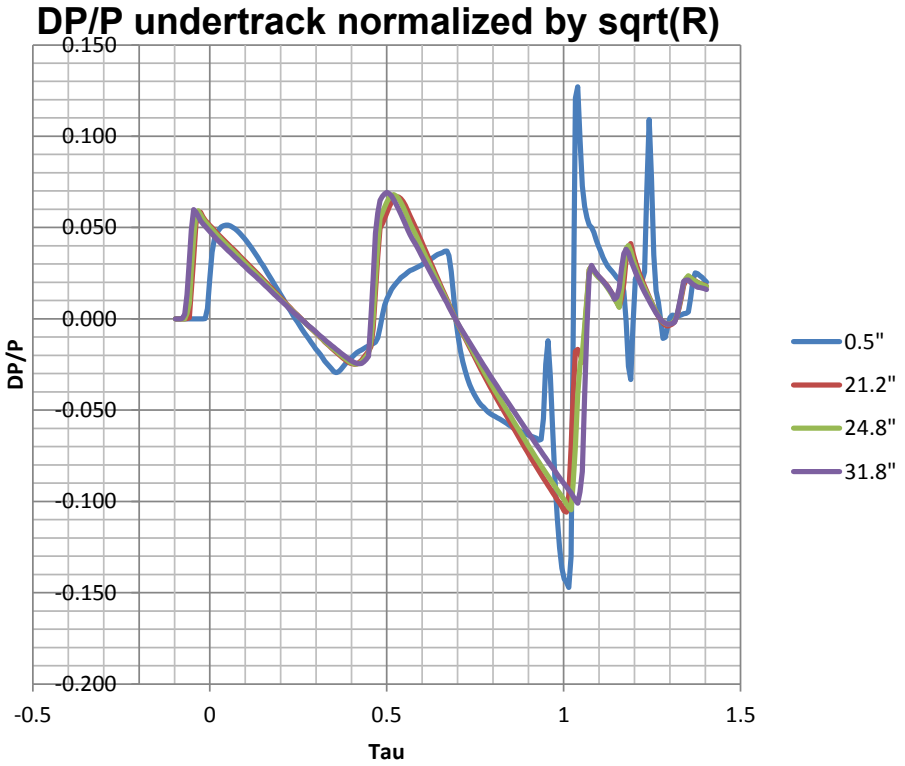


Advanced Development Programs

69 Degree Delta W-B Solution

Solution on the provided 69 Degree Delta grid provides very consistent results for the three reasonable rail heights

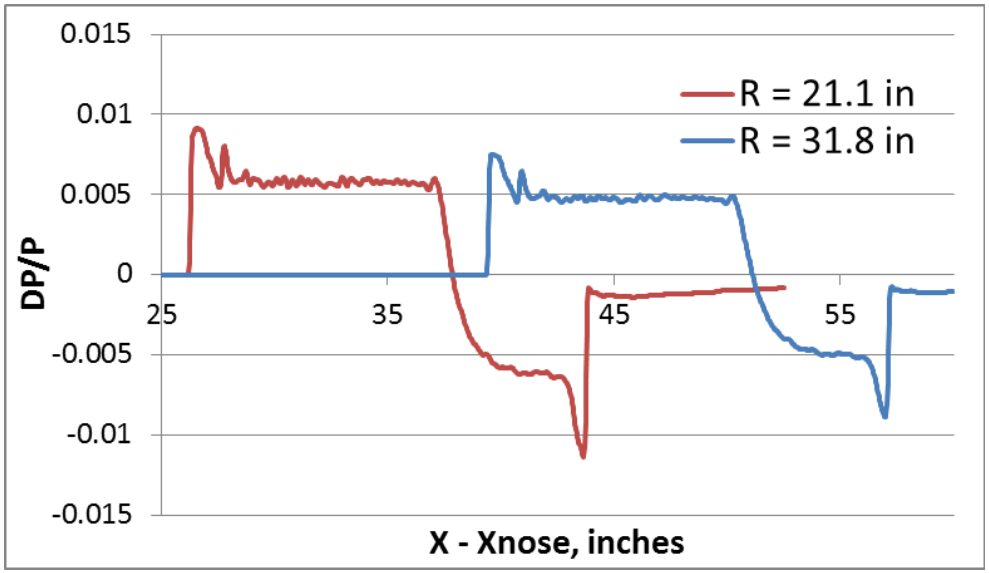


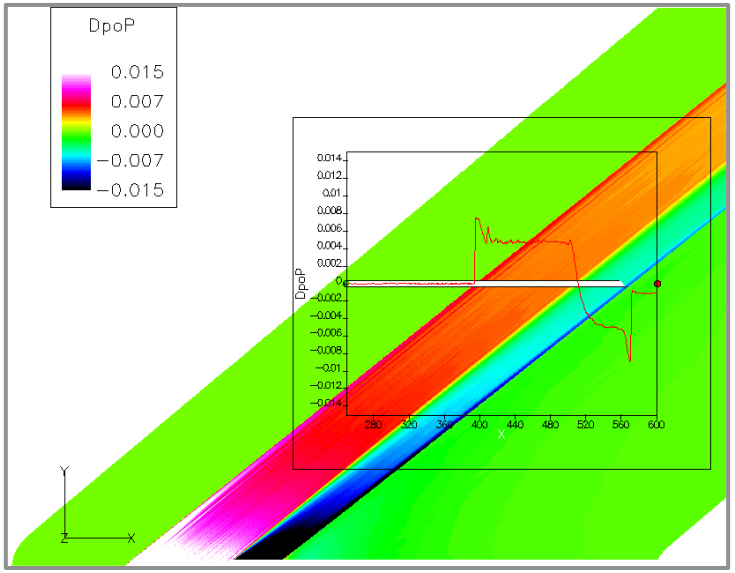


Advanced Development Programs

SEEB-ALR

- **Axi-symmetric solution ran efficiently and quickly** (other details NLA) **while swept structured grid provided very sharp resolution of surface slope variations. (Solution performed by a now-retired employee)**





Summary/Conclusions

- **The combination of tri2cogsg and CFD++ allow the user to rapidly generate reliable, accurate near-field pressure predictions for low sonic boom aircraft configurations out to reasonable (>15 R/(b/2) or 3 R/L) distances**

- **Ability to use tri2cogsg/bg with prism BL elements and hex or prism far-field elements would be very useful and should reduce computational cost and increase accuracy due to reduced numerical dissipation**

- **Inconsistency of predictions at 100.7 inch rail height appear to be due to insufficient convergence and very high AR elements in the volume grid; additional attention should be paid to the growth in AR of the Mach-aligned grid at large off-body distances**

Advanced Development Programs