

Pervasive Technologies: Sonic Boom Modeling and Propagation

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What is Different Now?

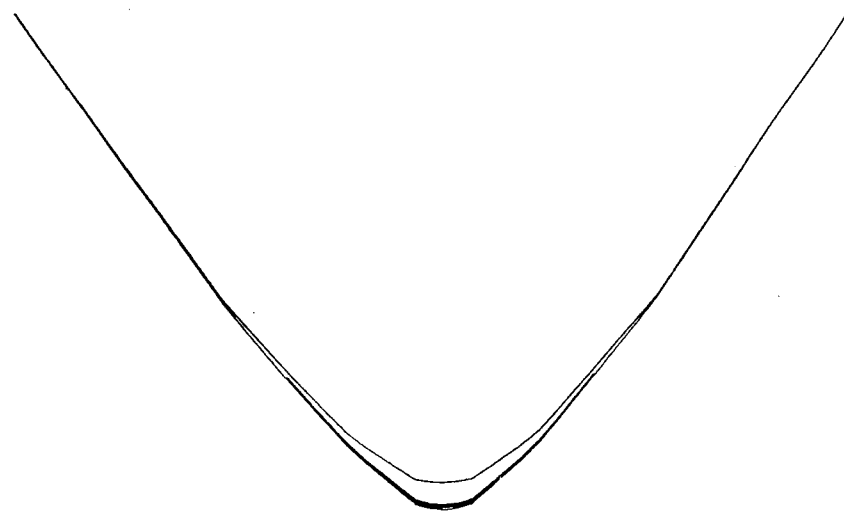
- Computer power
- Modeling tools
- Understanding and analysis of propagation
- Attitude

Sonic Boom Modeling

- 1970: Theory understood, first computer models (Hayes, Thomas) available. Compute one point at a time.
- Focus modeling in 1975
- Full missions: early 1980s through present
- Computer power increased by orders of magnitude
- Feasible to integrate full sonic boom analysis into design/optimization tools

Footprint Calculated in 1983

About a dozen trajectory points – took 3 days



F-15 Level Acceleration at 10 kfeet
Carpet boom = 5 psf
6 psf: 1.08 sq mi
11 psf: .084 sq mi
14 psf: .002 sq mi

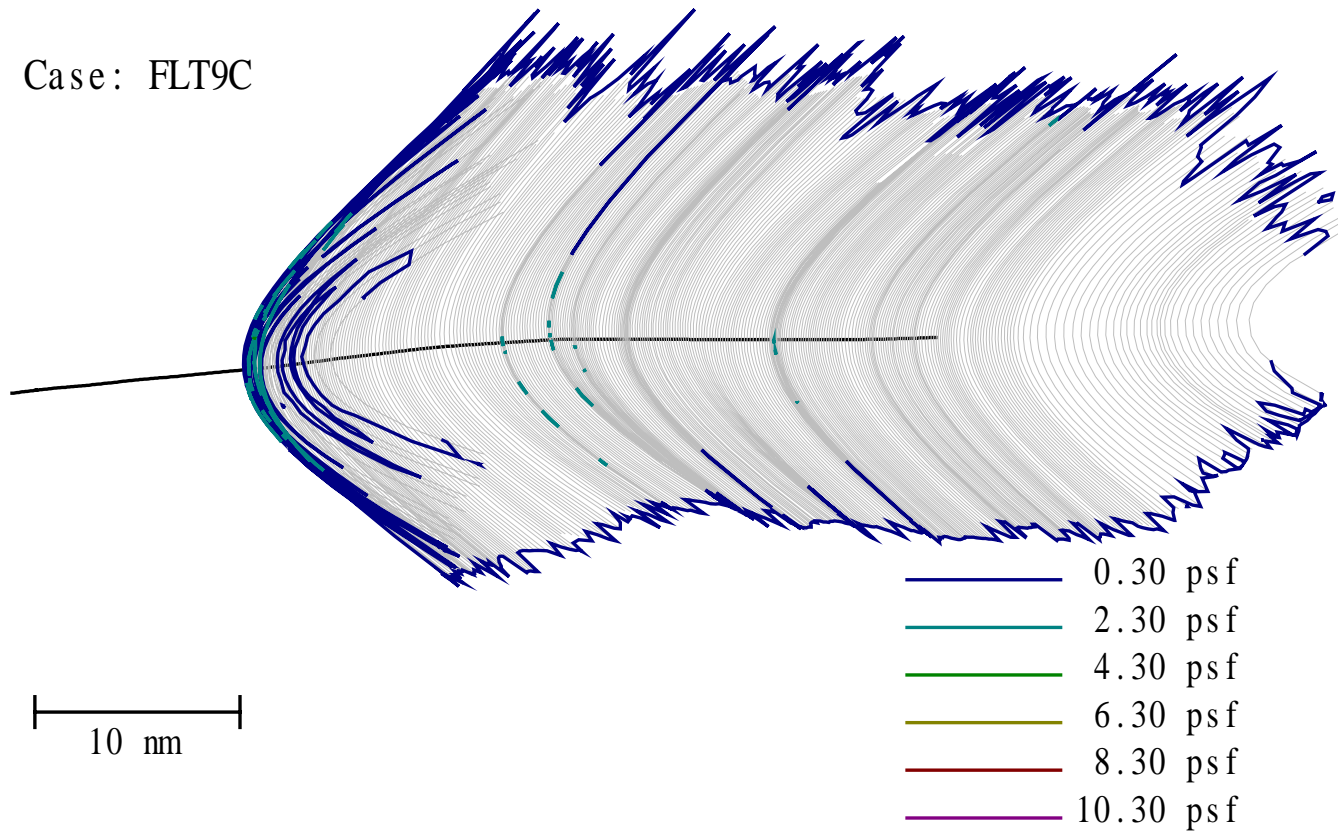
M = 1.22
Time = 7
M = 1.14
Time = 0

10000 feet

PCBoom4 Today

450 Time Steps – Less than a minute

Case: FLT9C



Low Boom Configuration Modeling

- 1970 – just starting – but we knew the optimum shape to seek (George-Seebass solution)
- Mid-1970s through 1980s: George-Seebass parametric scheme, linear methods (analysis by Darden, Mack)
 - But aircraft design uses CFD
- Late 1980s: HSCT – integration of CFD and ray tracing models
- Today: CFD from flight altitude to ground (Kandil et al)

Propagation - 1970

- Basic effects: ray tracing, aging well understood
- Turbulent distortion qualitatively understood, semi-analytic (sometimes heuristic) models
- Shock rise times – role of turbulence understood, but molecular relaxation (the basic rise time mechanism) unknown to sonic boom community
- Focal zones – physics understood, flight test results, no calculated signatures.

(Gill-Seebass numeric solution in 1974)

Propagation - Today

- Rise times – molecular relaxation effects understood, computable
- Turbulence effects – some numeric analysis, good progress, but still at a research level
- Still only analyze horizontally stratified atmospheres
- Focal zones – 25 years after Gill-Seebass solution, there is at last a modern numeric solution (Coulouvrat et al)
 - Points to ways of mitigating foci
 - Feasible to analyze minimized signatures

Attitude/Opportunity

- 1970: Momentum of faster and faster came to a halt against economics, environment
- Technology kept alive through 1970s, 1980s
- Late 1980s: HSCT – good run at exploiting technology, spurred by NASA
- Today: QSP – government program, but spark came from industry. Aggressive adoption of low-boom technology by airframe partners.