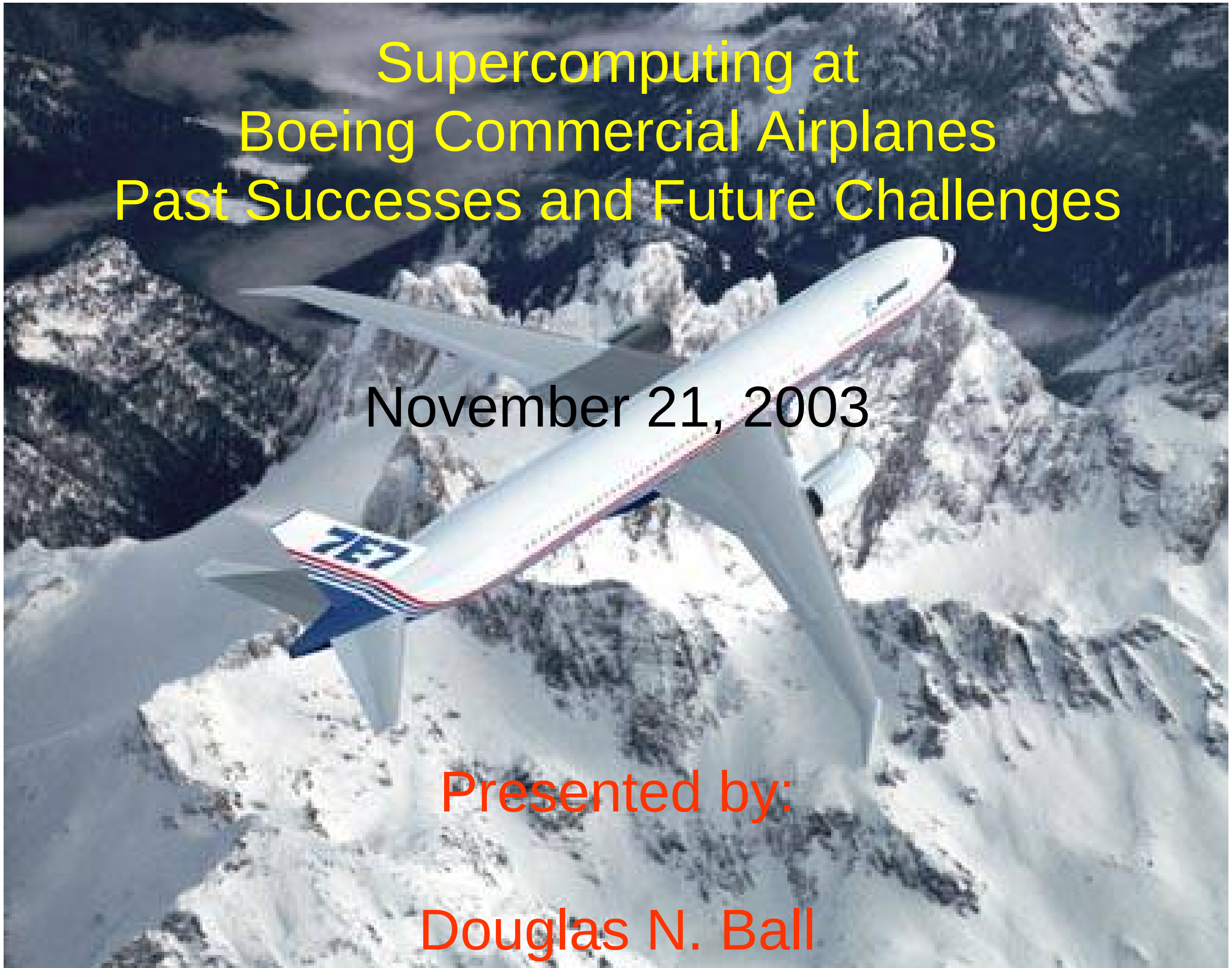
SC2003



Supercomputing at
Boeing Commercial Airplanes
Past Successes and Future Challenges

November 21, 2003

Presented by:

Douglas N. Ball

BOEING

HPC Service Components 2004

Cray T916

VECTOR & BANDWIDTH SPEED-UP

Cray T932

Cray X1

SCALAR SPEED-UP
(Distri. Mem. Architecture)

SGI Origin 3800

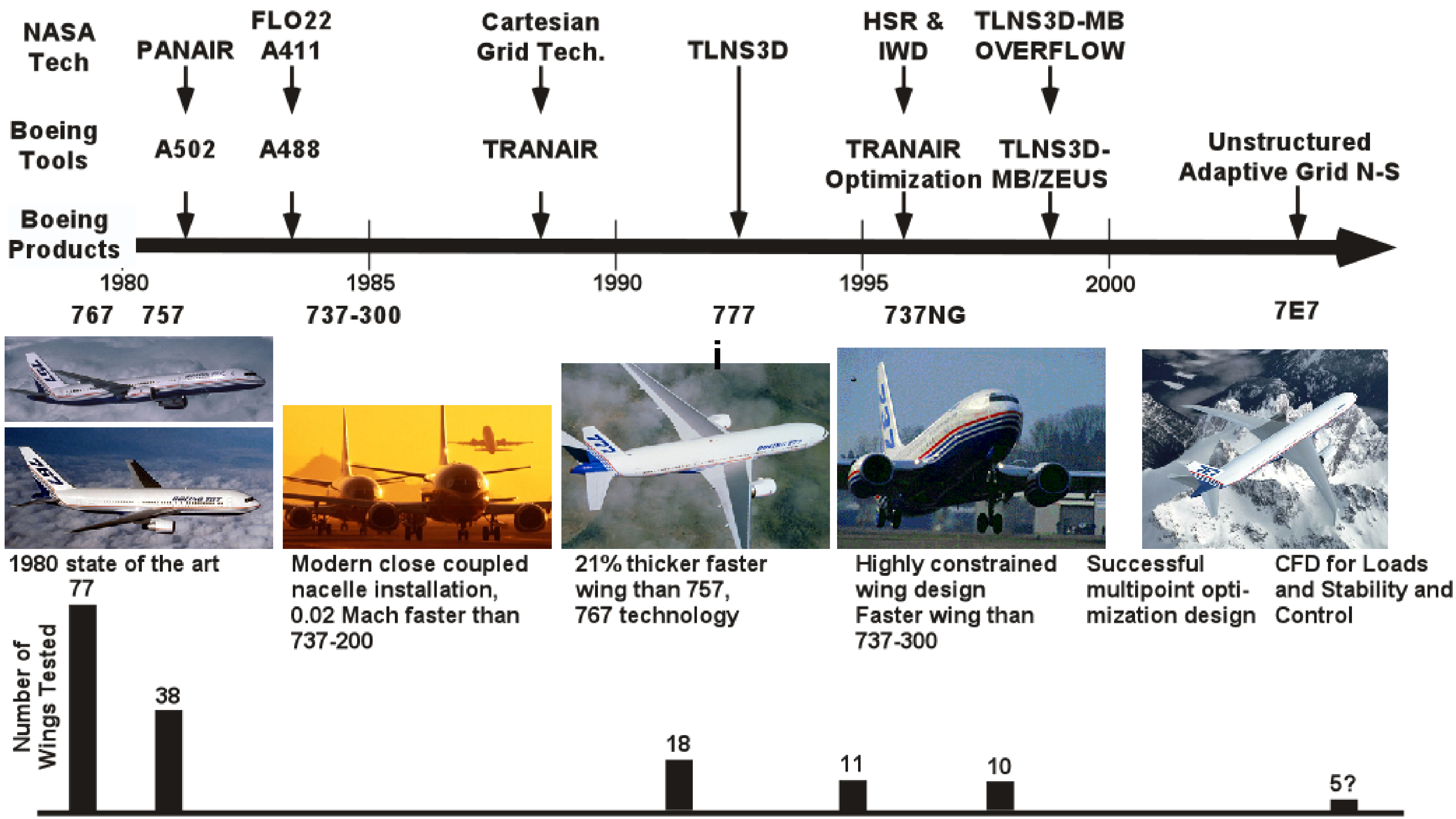
IBM SP

Cluster Computing (DQS/LSF)

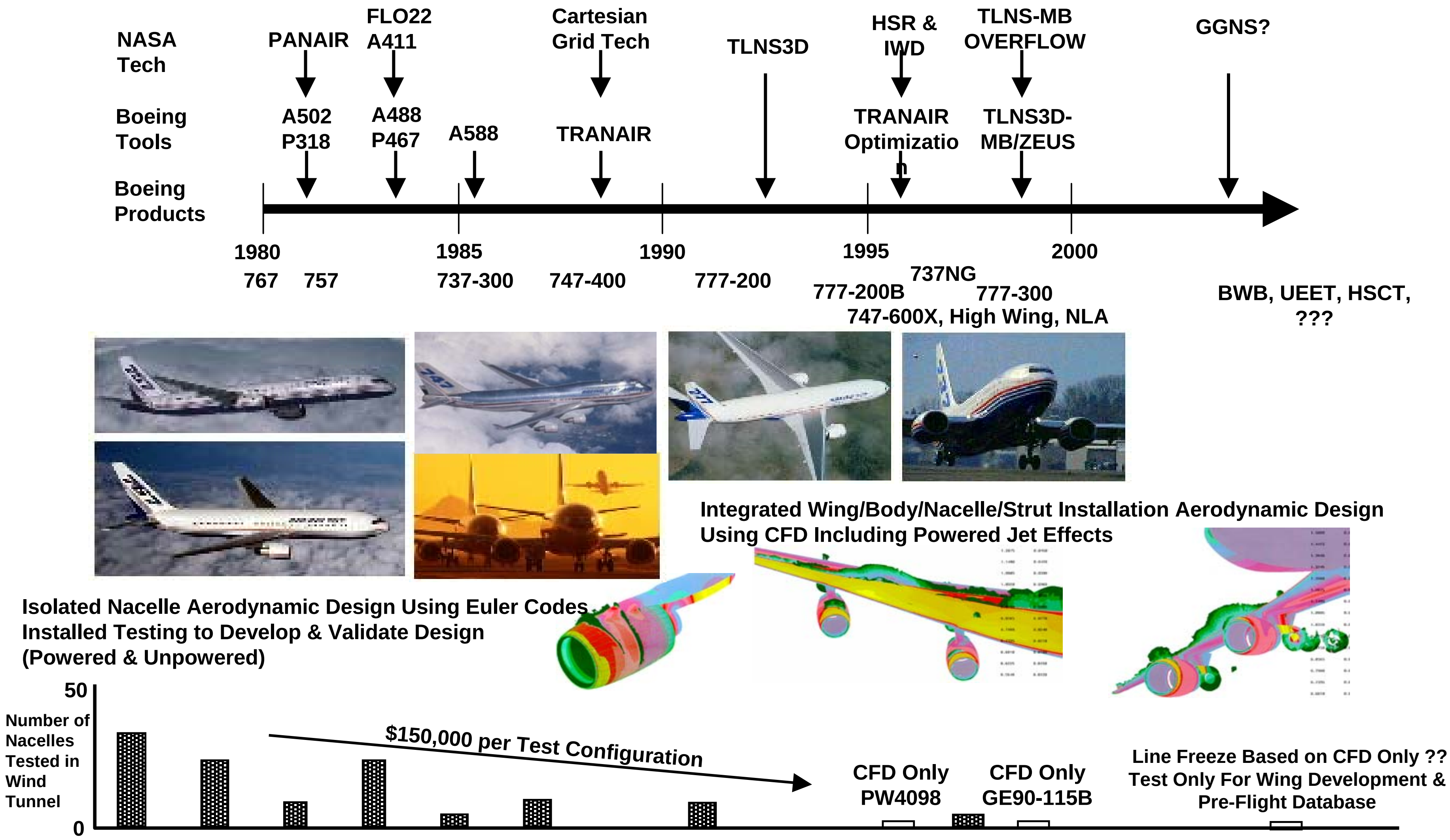
Cluster SPEED-UP

256-CPU Linux NetworX

Impact of CFD on Wind Tunnel Testing for Configuration Lines Development



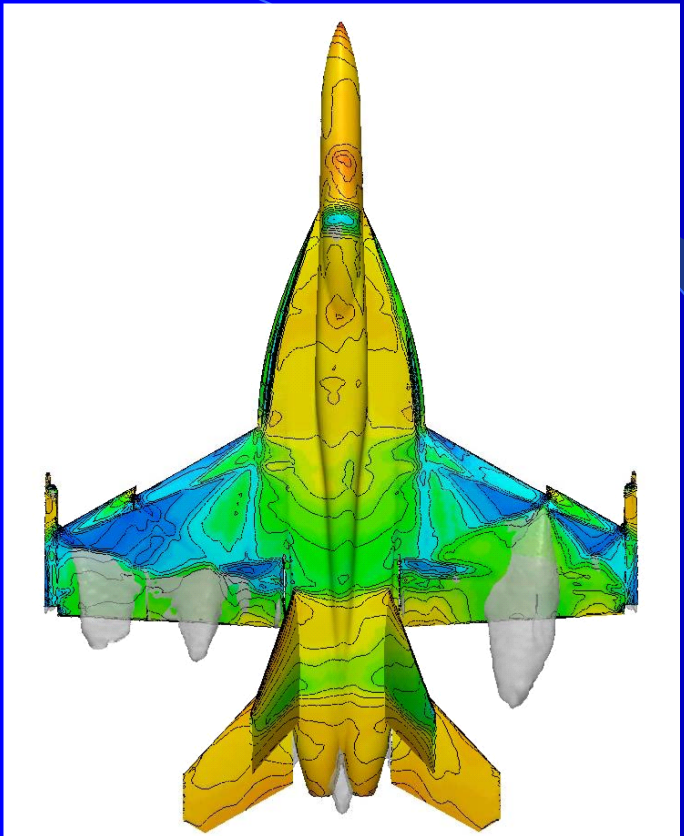
Impact of CFD on Wind Tunnel Testing for Propulsion Integration



Isosurface of u=0, surface colored by pressure

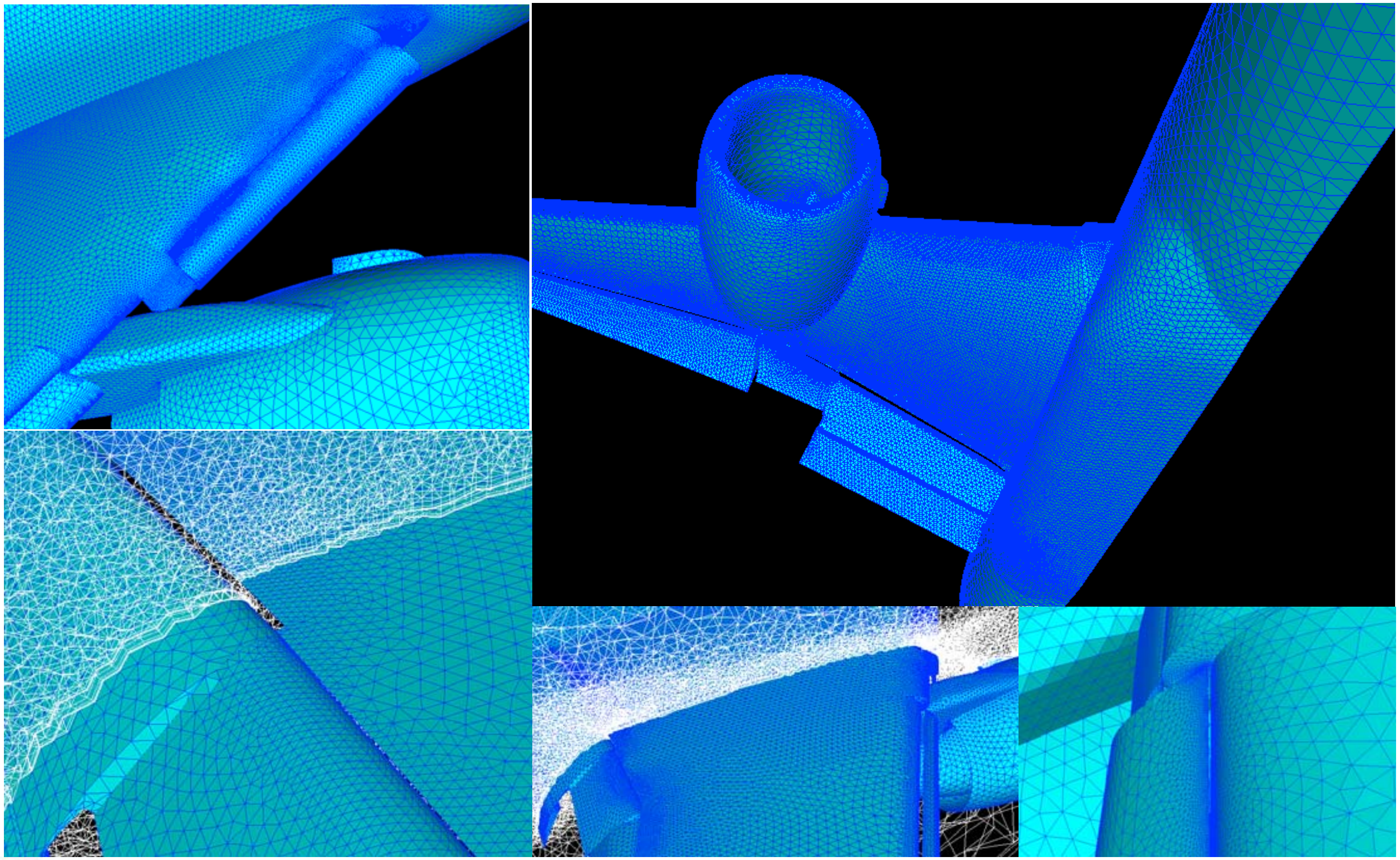
Run 247 ($\theta \sim 7°$), $\phi \sim 30°$

SST



Calculations performed by Cobalt Solutions using the Aeronautical Systems Command Major Shared Resource Center

Emerging Capability – 3D Viscous High Lift



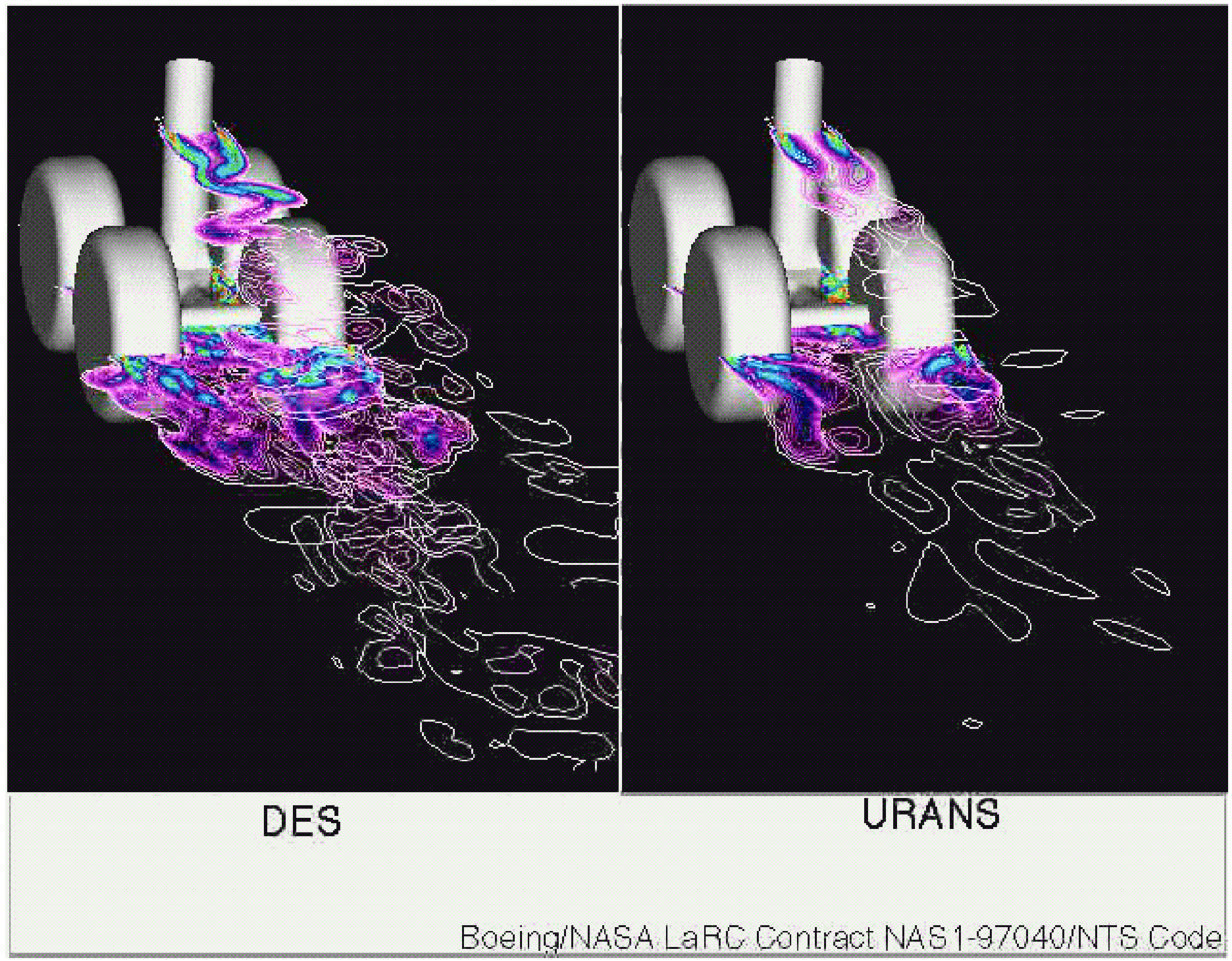
21st Century Challenge

The challenge:

Computationally determine the acoustic signature of an airplane in one day.

Compute time:
3 months
8 cpus
NASA Ames Origins

Represents ~5 sec.



21st Century Challenge

Challenge:

“Fly the Navier Stokes equations and NOT a database!

Accurate loads throughout the flight envelope

Current solution: 600cpu hours, 10 wall hours

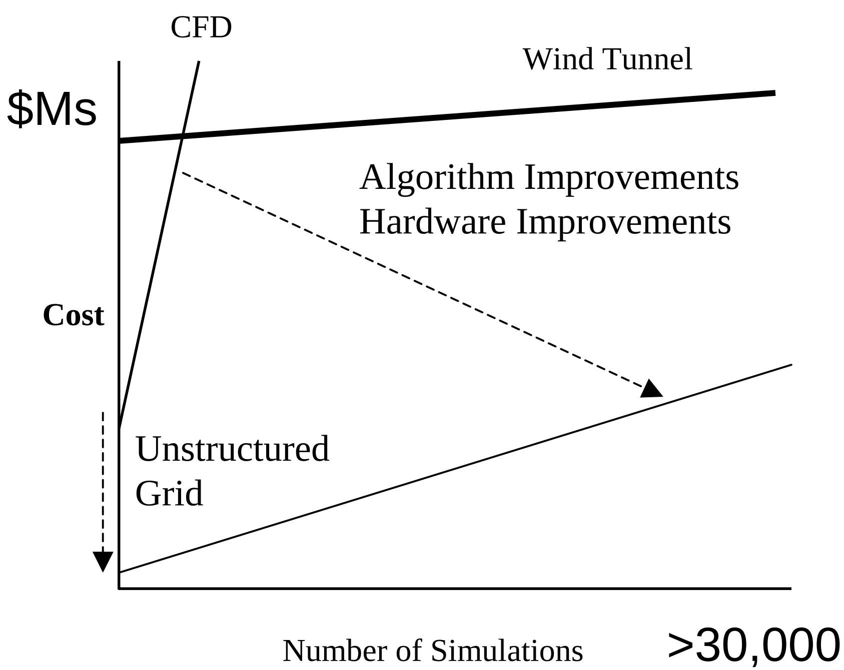
The challenge: 50 solutions per second

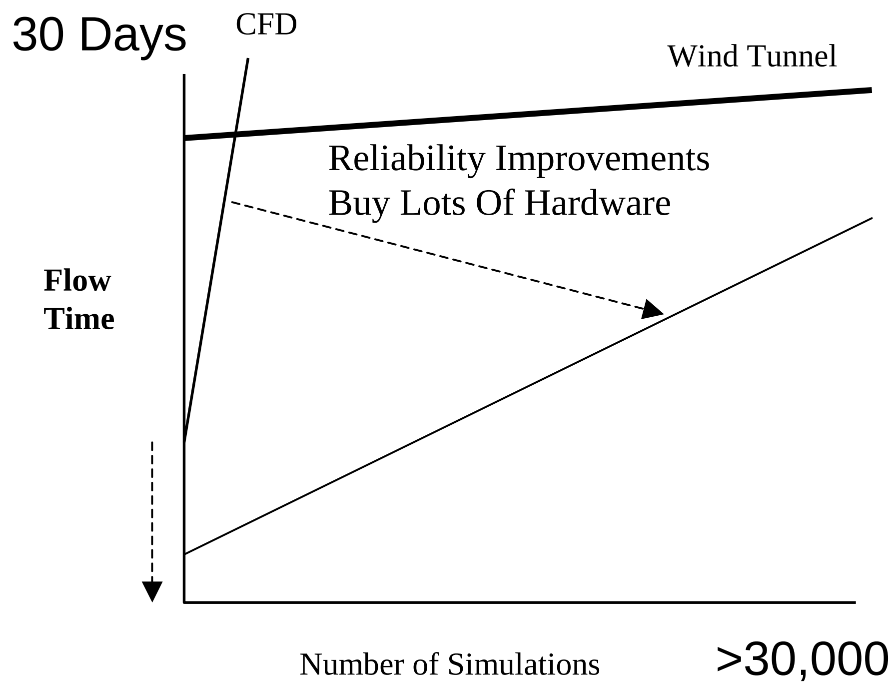
In the meantime, this is what we'd like . . .

- CPU Speed-up per Moore's law sufficient
- Balanced systems with improvements in latency and bandwidth by at least 2 orders of magnitude
- Efficient implementation of parallelism in a reliable manner up to 10,000 CPUs
- Application & algorithmic developments to take advantage of the hardware enhancements mentioned above
- Reasonable cost to justify replacing experimentation with simulation

CFD And The Wind Tunnel

Opportunity exists for computing to be a cost-effective replacment for the wind tunnel. The trade is the cost of the first simulation versus the cost of simulations 2 to N.





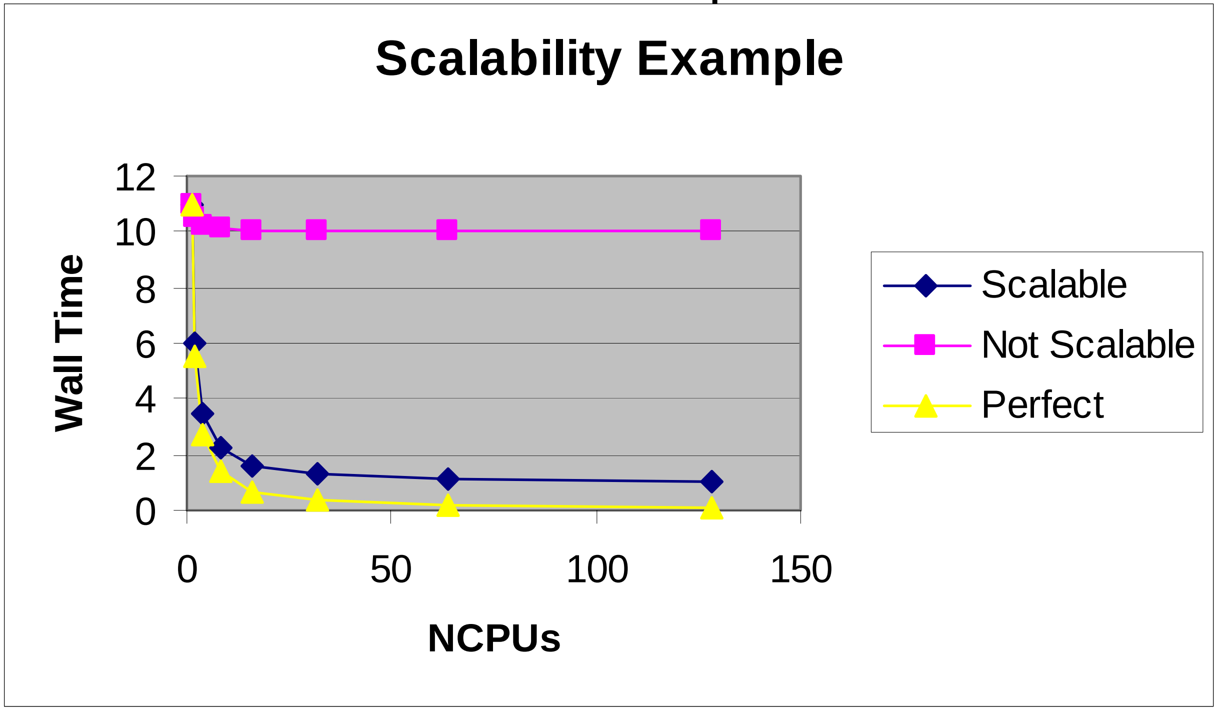
Backup Charts

Fundamental Limitations

- Fundamental Industrial Need Is Rapid Acquisition Of Knowledge
- Computational Modeling Contribution To Knowledge Governed By Amdahl's Law (Scalability)
- Scalability Determined By Serial Vs Parallel
  - $T_{wall} = T_{serial} + T_{parallel}/NCPU$
  - Limiting Cases:
    - $T_{serial} >> T_{parallel}$ (Not Scalable)
    - $T_{parallel} >> T_{serial}$ (Scalable)
    - $T_{serial} = 0$ (Perfect)

Scalability Example

- Perfect: $T_{serial} = 0$, $T_{parallel} = 11$
- Scalable: $T_{serial} = 1$, $T_{parallel} = 10$
- Not Scalable: $T_{serial} = 10$, $T_{parallel} = 1$
- Results:



Latency And Bandwidth

- Determines Tserial And Tparallel
- All Computational Processes:
  - Initiate Action ("Latency" Until We Begin To…)
  - Gather Data (Bandwidth Determines How Long Until We…)
  - Operate (CPU Clock Speed)
  - Do It Again
- Scalability Limited By Latency And BW

So What Do We Need?

- In A Word, Balance
- And We’d Love To Have It At Low Cost
- Then We Can Buy Lots Of It And Do Lots More
- Issue:
  - Drives Network/Interconnect, Not Just Memory Hierarchy
  - Advances Being Made, But Continued (Open Architecture?) Investment Needed
  - One CPU Isn’t Enough For Problems Of Interest

CFD And The Wind Tunnel: Today

Qualitatively We Have: