Boeing Defense, Space & Security
PhantomWorks

Challenges toward increased reliance on physics-based modeling in design

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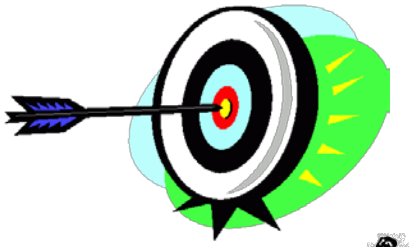
Several factors are important in industrial acceptance of physics-based modeling tools

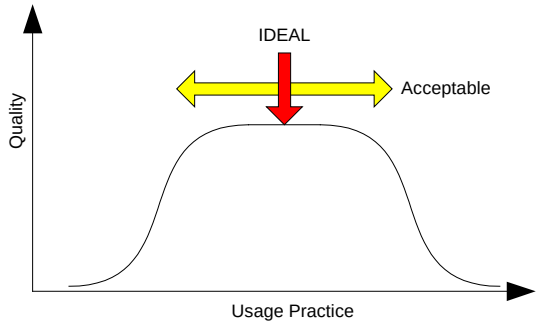
- **Accuracy**
  - Superior to other options?



- **Time**
  - Faster end-to-end than other options?

- **Cost**
  - Total cost cheaper than other options?
  - Process integration, user support, facilities

- **Consistency**
  - Variability equals risk



Today's Situation

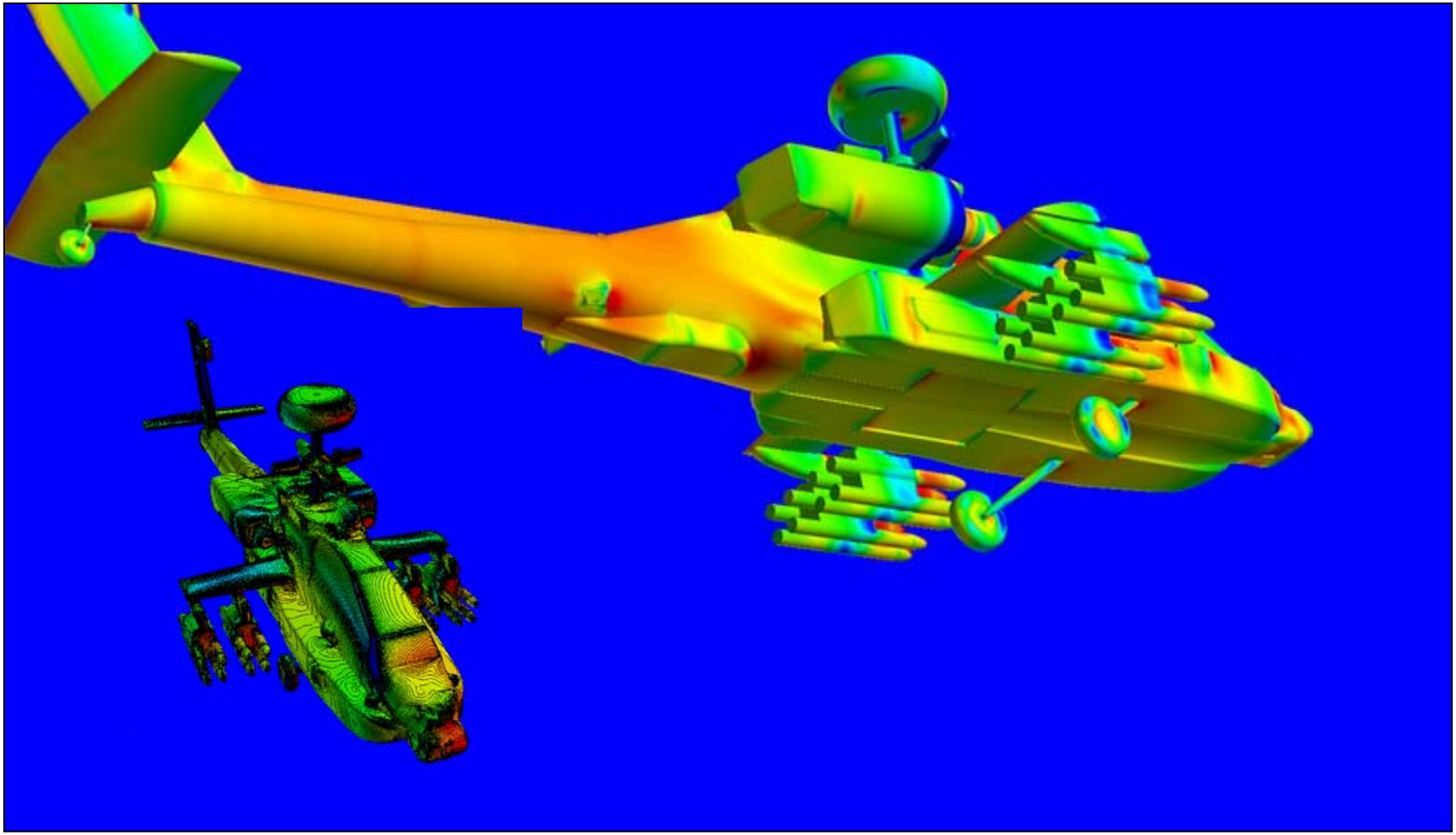
Routine

- Steady-State Navier-Stokes in all programs
  - Assess flowfields, conduct trade studies, identify options
  - Diverse applications
- Design confirmation in wind tunnel

Emerging

- Multi-disciplinary
  - Aeroelastics
    - Simple modal analysis
    - Coupled to NASTRAN
  - Aero-acoustic, Aero-optics
- Automated Optimization
- Unsteady flow
  - Routine for rotary wing applications
  - Gaining traction for fixed-wing aircraft (where appropriate)

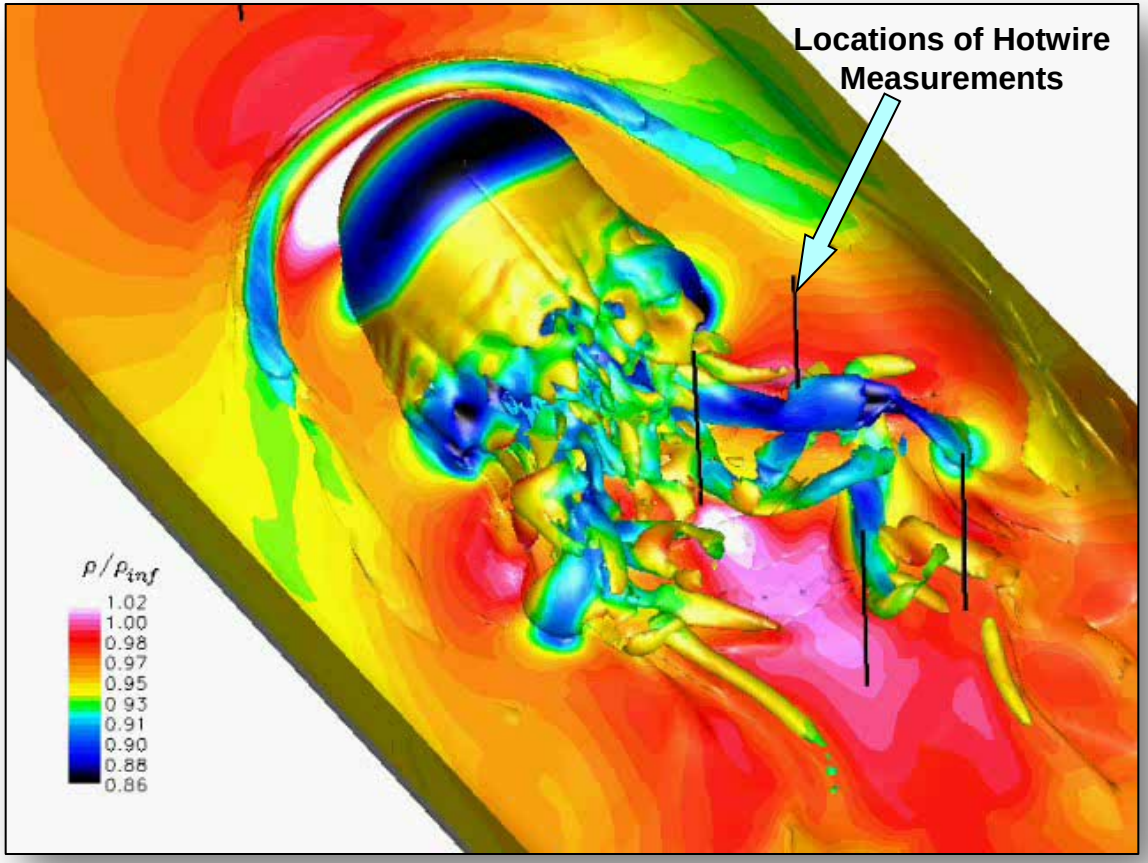
AH-64 Apache
Computed Surface Pressure Contours



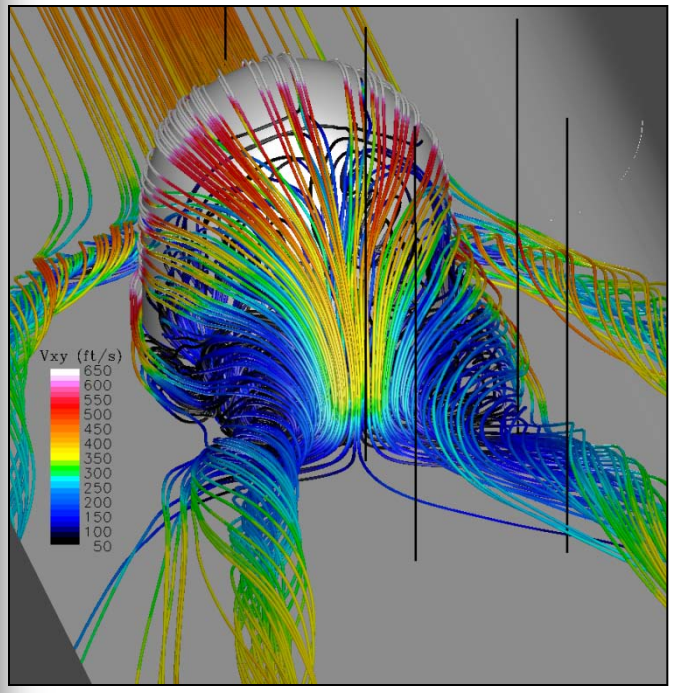
Unsteady Analyses of Hemispherical Turret for Aero-Optic Performance

D=12”, M=0.3, SST/LESb Turbulence Model

Animation of Iso-Vorticity Surface



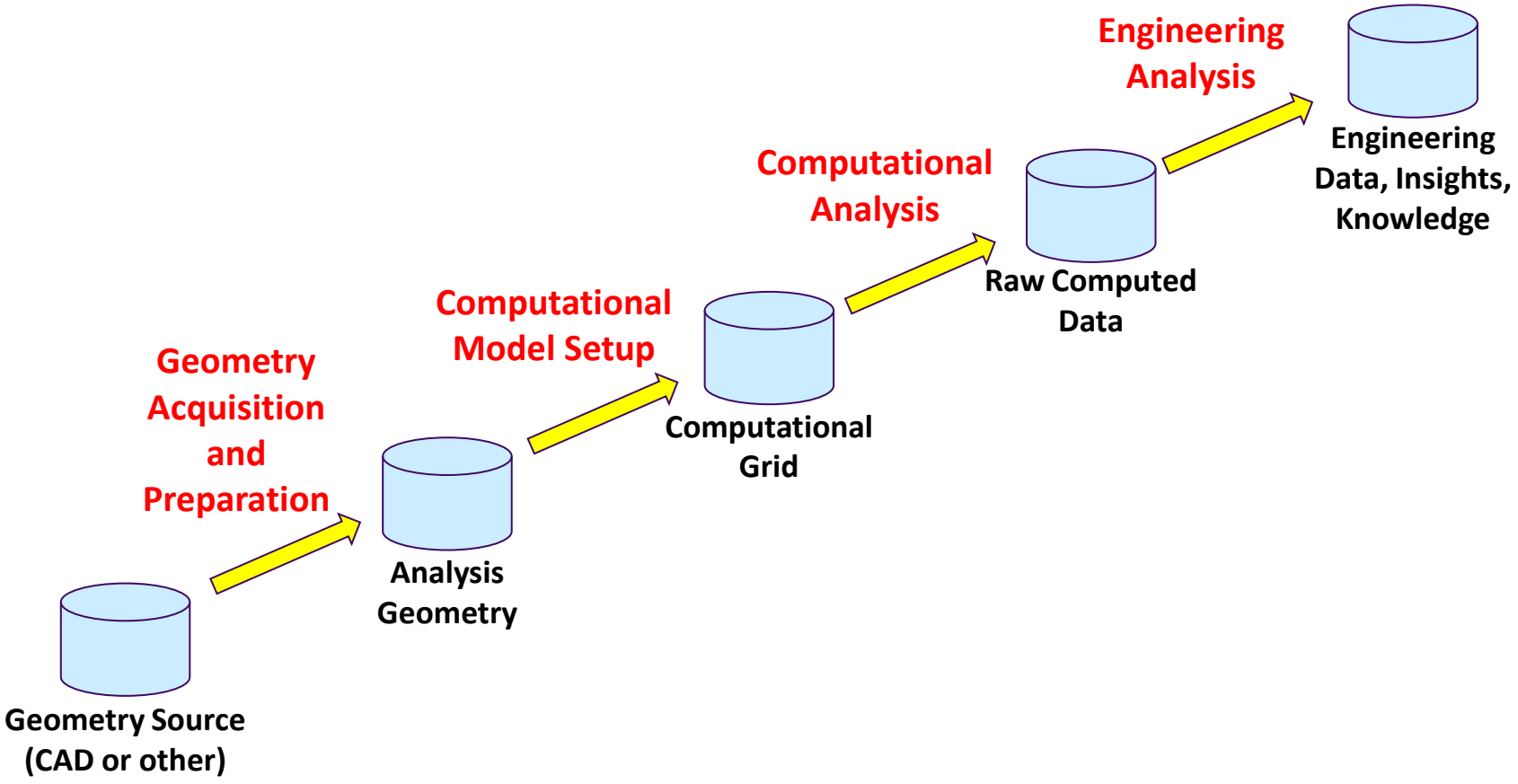
Streamlines in Mean Flow Solution



What's Holding Us Back?

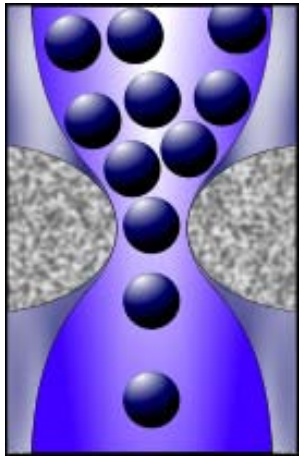
- **Throughput and End-To-End Cycle Time**
  - Consistent quick turnaround essential in a schedule-driven development program
  - Engineering development culminates in large databases for loads, stability and control, flight simulation
- **Consistency (quality control)**
  - One "awshit" cancels out a hundred successes
- **CFD is a specialist tool – to a significant degree**
  - User skill is often key factor in getting consistent high quality results
  - CFD groups have lots of Ph.D.s

Process performance set by the weakest link in the chain



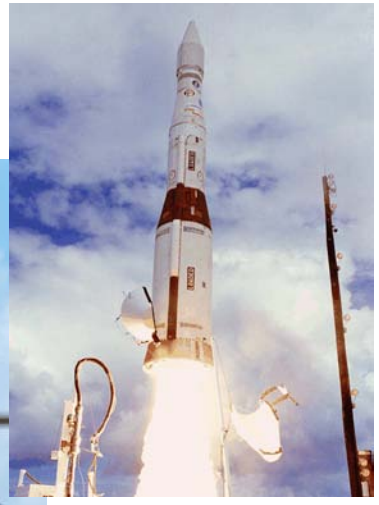
Data Quality Management

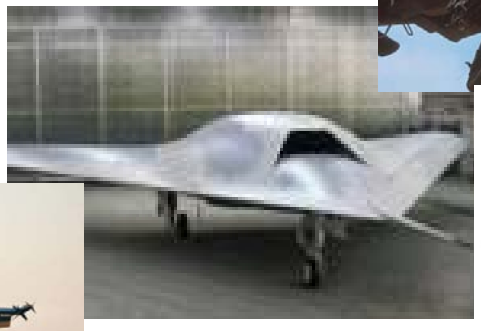
- **Many ways to foul up an analysis**
  - Geometry setup, grid generation, modeling choices, solution execution, data analysis and interpretation
  - Essential to understand the expected flow physics, and the knowledge that must be obtained from the data
- **Rely on identifying / using best practices to set up analyses**
  - Validation studies
  - After-action reviews
  - Trial-and-error when faced with a new problem
- **Rely on expert review to assess completed analyses**
  - Can we trust these results – for critical decisions?



Versatile tools pay off in many ways

	Accuracy	Time	Cost	Consistency
Staff training and tool maintenance	✓	✓	✓	✓
Expert support focused on a few tools	✓	✓	✓	✓
Tailor computing infrastructure		✓	✓	





Engineering Acceptance of Simulation Tools

- **Accuracy**
  - Meets the design process need? Throughout the operational envelope?
- **Cost**
  - Cheaper than other sources?
  - Person-hours, facilities, licenses, power, …..
- **Time**
  - Faster than other sources of data?
  - From the decision to acquire data, to final delivery of data?
- **Consistency (Risk)**
  - Will we get consistently good results (accuracy, time, cost)?