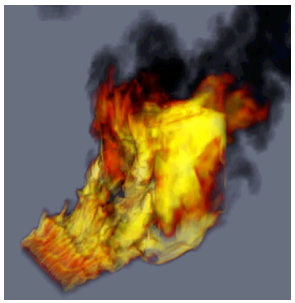

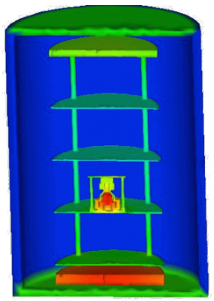

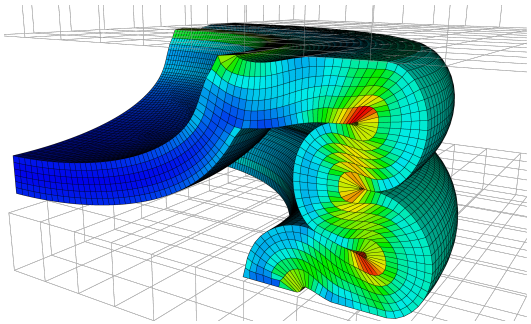

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Exceptional service in the national interest

Engineering Sciences Modeling and Simulation Application Drivers

Micheal W. Glass

Sandia National Laboratories

Salishan High Performance Computing Conference
April 21-24, 2014

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Sierra Overview

- Engineering analysis suite
  - Solid mechanics
  - Structural dynamics
  - Structural acoustics
  - Thermal mechanics
  - Low-mach CFD
  - High-mach CFD
  - Multiphase CFD
  - Multiphysics coupling
    - Fluid structure interactions
    - Blast on structures
    - Thermal/mechanical
- Used for design and validation of…
  - Components
  - Sub-systems
  - Full-systems
- In…
  - Normal environments
  - Abnormal/hostile environments

Mission Driven, HPC Enabled: Engineering Analysis With Sierra

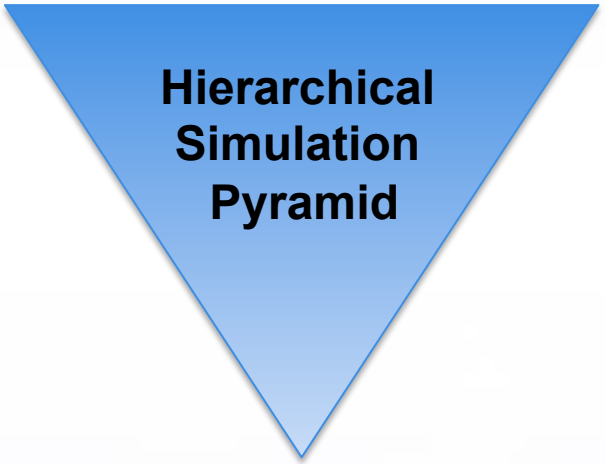
- How has it evolved and where is it headed
  - Purpose of the analysis
  - New application domains
  - Changes in the analyst workflow

Purpose of the Analysis

- Advances in HPC computing capability has enabled:
  - Higher resolution
  - More physical detail
  - Improved physics and engineering models
  - QMU workflows
- Modeling and simulation has matured and established credibility with mission programs
- ASC Driver: Predictive Capability – Contributes to Risk informed decision making

Predictive Capability

- Component design and qualification
- Assembly design and qualification
- Full-system qualification



More simulations
Smaller problem size

Less simulations
Larger problem size

http://nnsa.energy.gov/mediaroom/pressreleases/nnsa-achieves-significant-milestone-b61-bomb

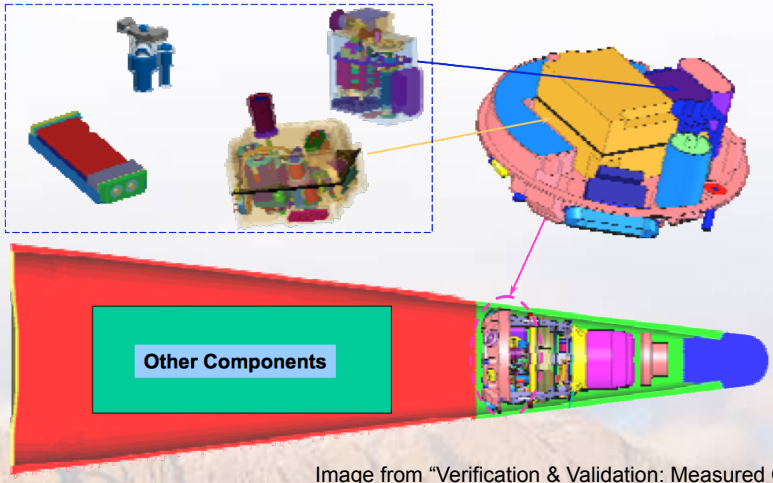


Image from "Verification & Validation: Measured Credibility, on Demand, for Stockpile Applications" SAND2007-2483C

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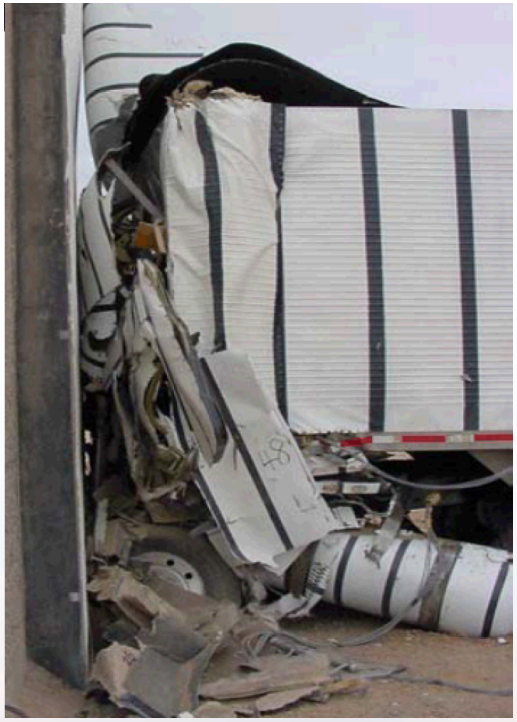
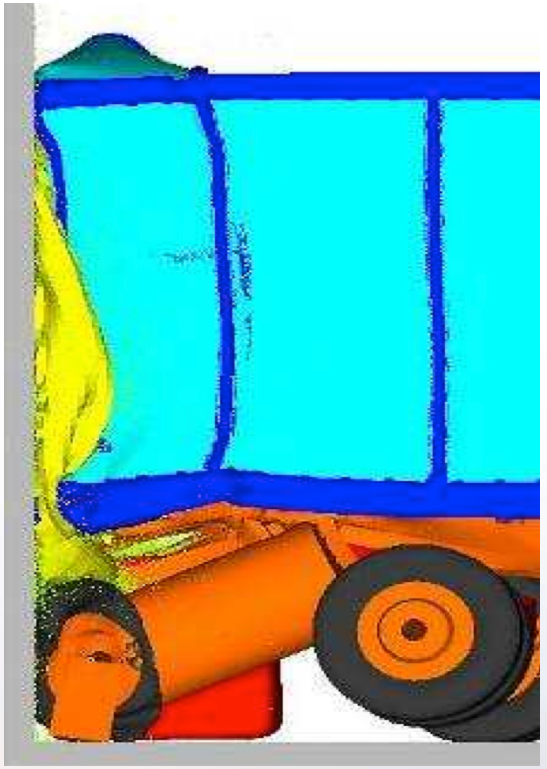
Predictive Capability

- Component design and qualification
- Sub-system qualification
- Full-system qualification

- Safety analysis



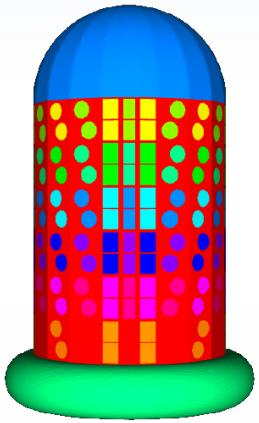


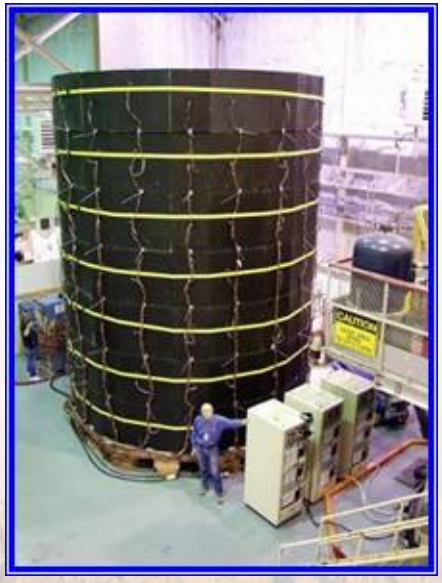
Images from “The Need for Advanced Computing”, SAND2014-0477C

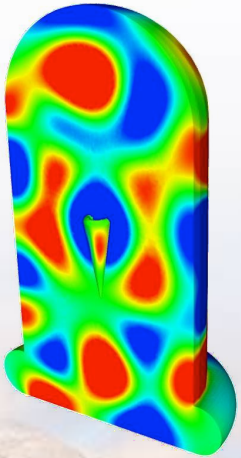
Predictive Capability

- Component design and qualification
- Sub-system qualification
- Full-system qualification

- Safety analysis
- Test design



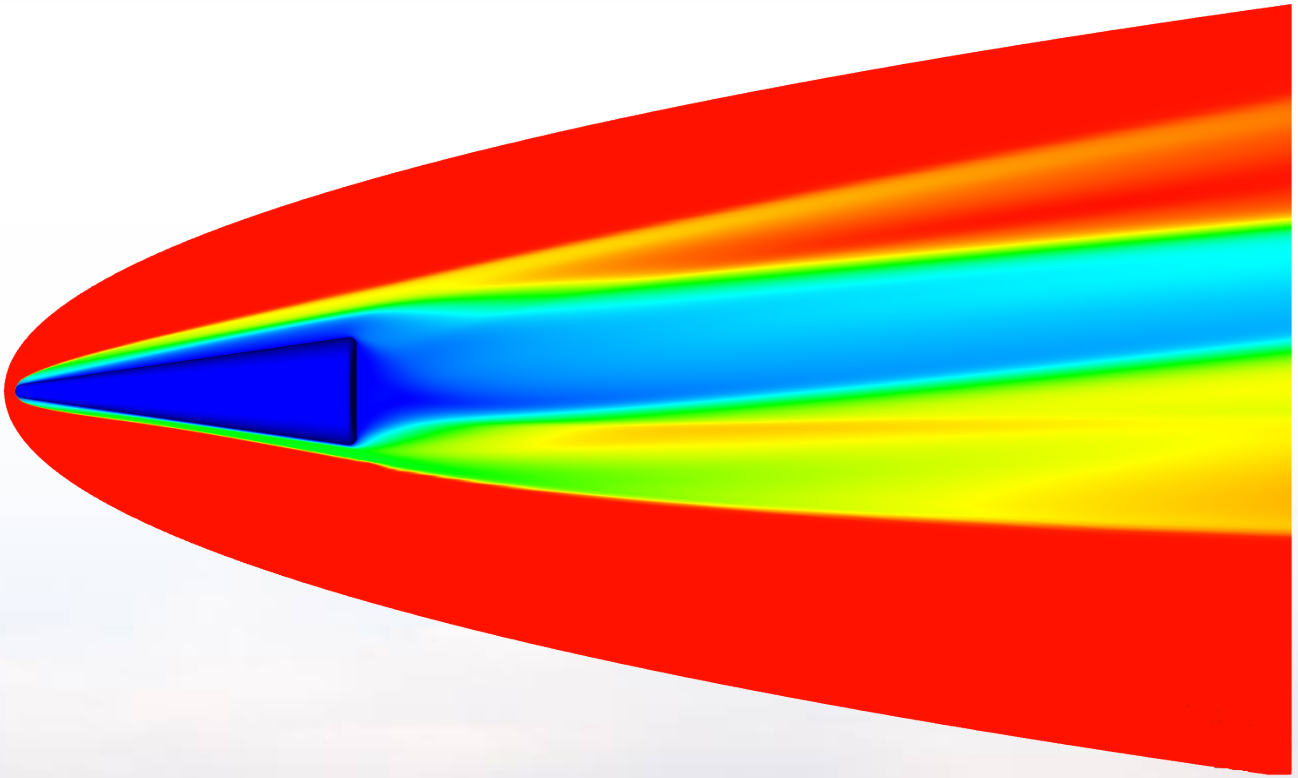




Images from “Structural-Acoustic Analysis and Test Design”, SAND2013-7916C

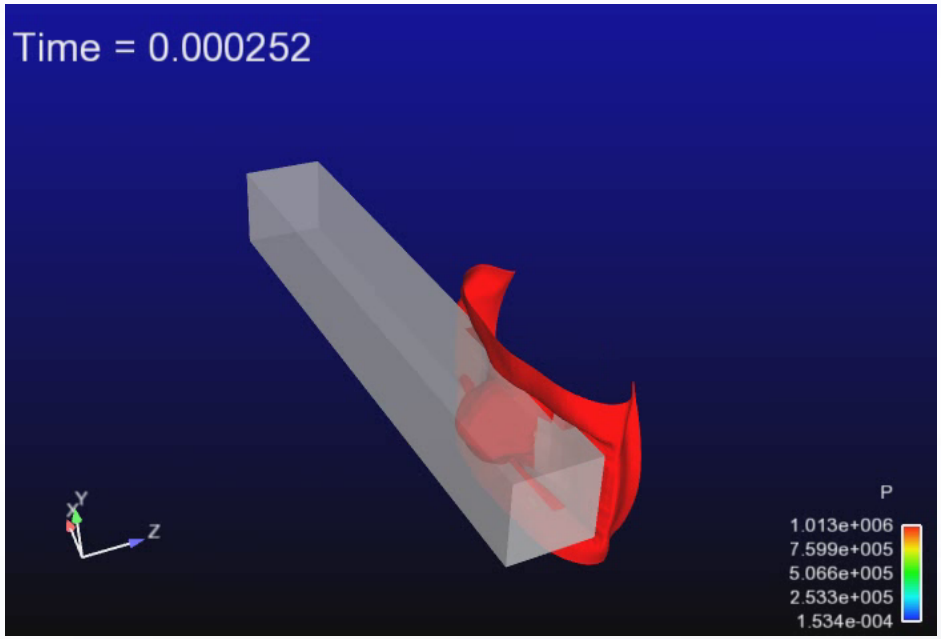
New Application Domains

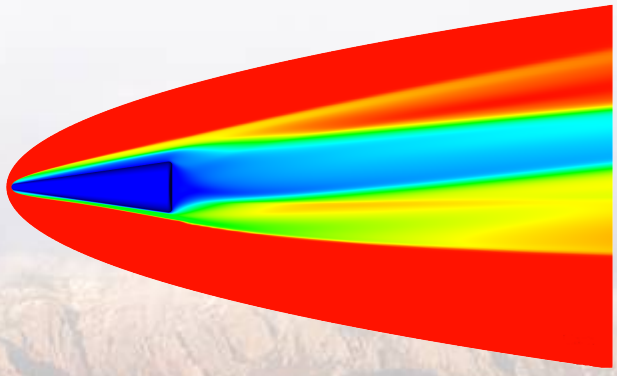
- High-Mach CFD



New Application Domains

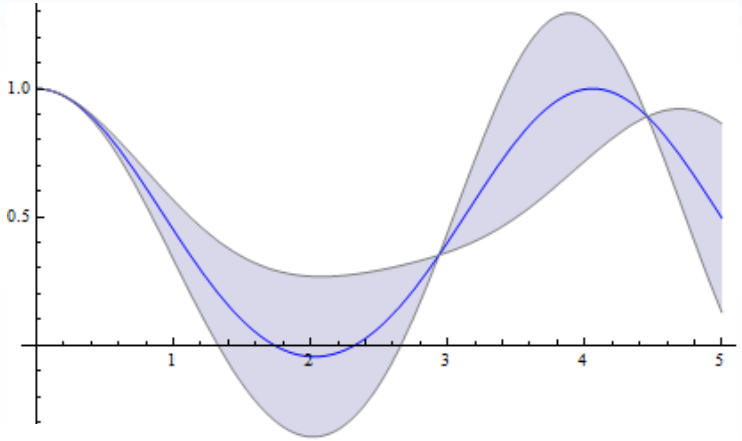
- Multi-physics analysis
  - Fluid structure interaction (FSI)
    - High-mach CFD coupled with structural dynamics
    - Acoustics coupled with structural dynamics
    - Blast hydrodynamics coupled with high-mach CFD coupled with structural dynamics
    - Blast hydrodynamics coupled with solid mechanics or structural dynamics
  - Thermal/Mechanical
    - Coupled thermal/mechanical with organic material decomposition, pressurization, and breach

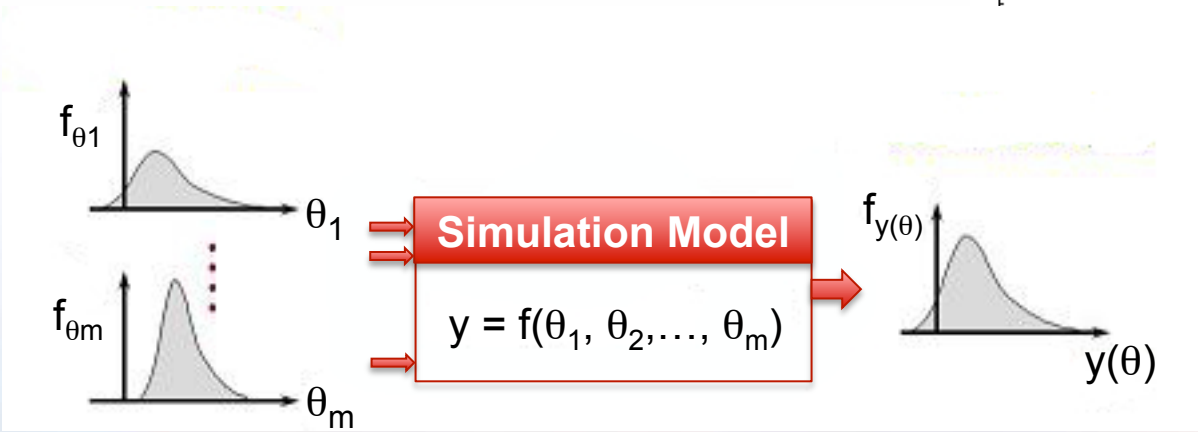




New Analysis Workflows

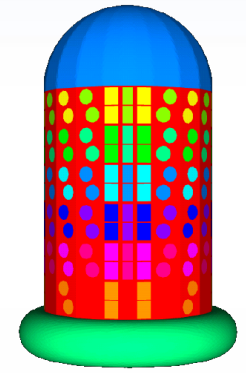
- Sensitivity analysis and uncertainly quantification

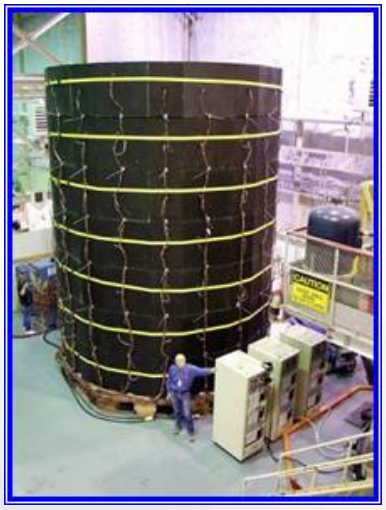


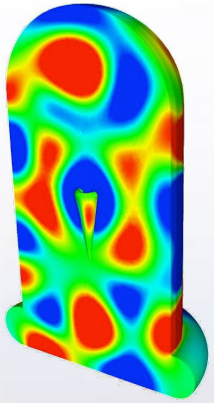


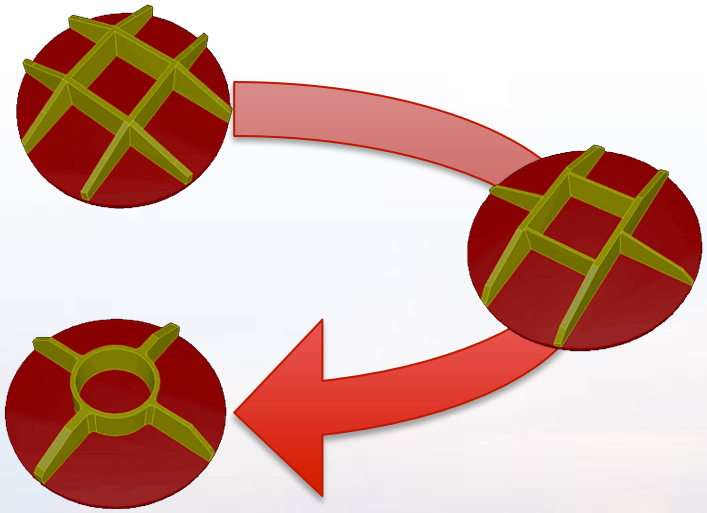
New Analysis Workflows

- Sensitivity analysis and uncertainly quantification
- Optimization/Inverse Problems









Images from "Virtual Prototyping with Advanced Simulation Tools: Sandia's DAKOTA Optimizes Computer Models", SAND2000-2703

New Analysis Workflows

- Sensitivity analysis and uncertainly quantification
- Optimization/Inverse Problems

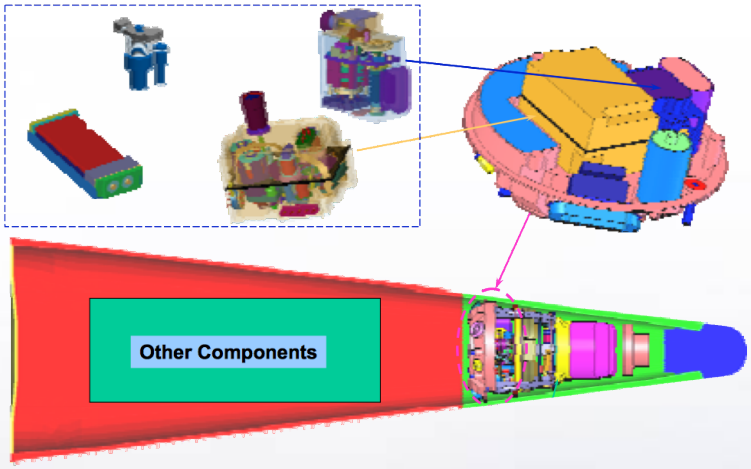
All of these require ensemble calculations

Impact on HPC Systems

- Code performance profiles – the usual suspects
  - Floating point op count density vs. integer op count density vs. memory bandwidth/latency vs. communication bandwidth/latency

Impact on HPC Systems

- Code performance profiles – the usual suspects
  - Floating point op count density vs. integer op count density vs. memory bandwidth/latency vs. communication bandwidth/latency
- Problem Size
  - Data size increases (per file)
    - I/O performance
    - Data movement on/off the HPC platform
    - In-situ data analysis and visualization
  - System robustness
  - Model setup



Impact on HPC Systems

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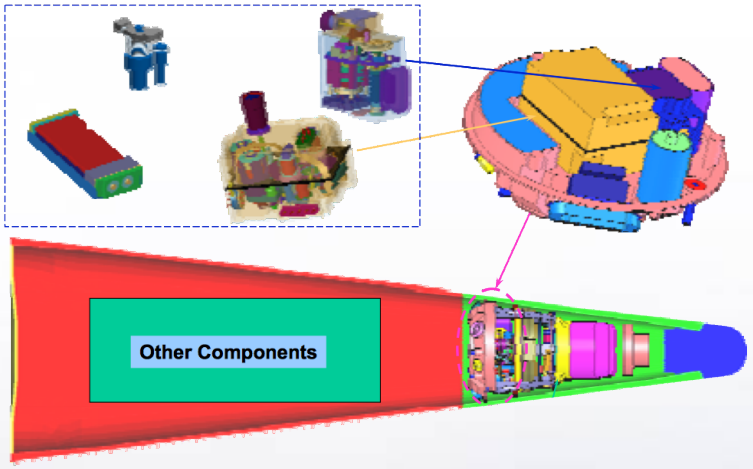


- Ensemble Calculations
  - Data size increases – number of files increases dramatically
    - File management
    - Data movement on/off the HPC platform
    - Local, remote, or in-situ data analysis and visualization
  - System robustness

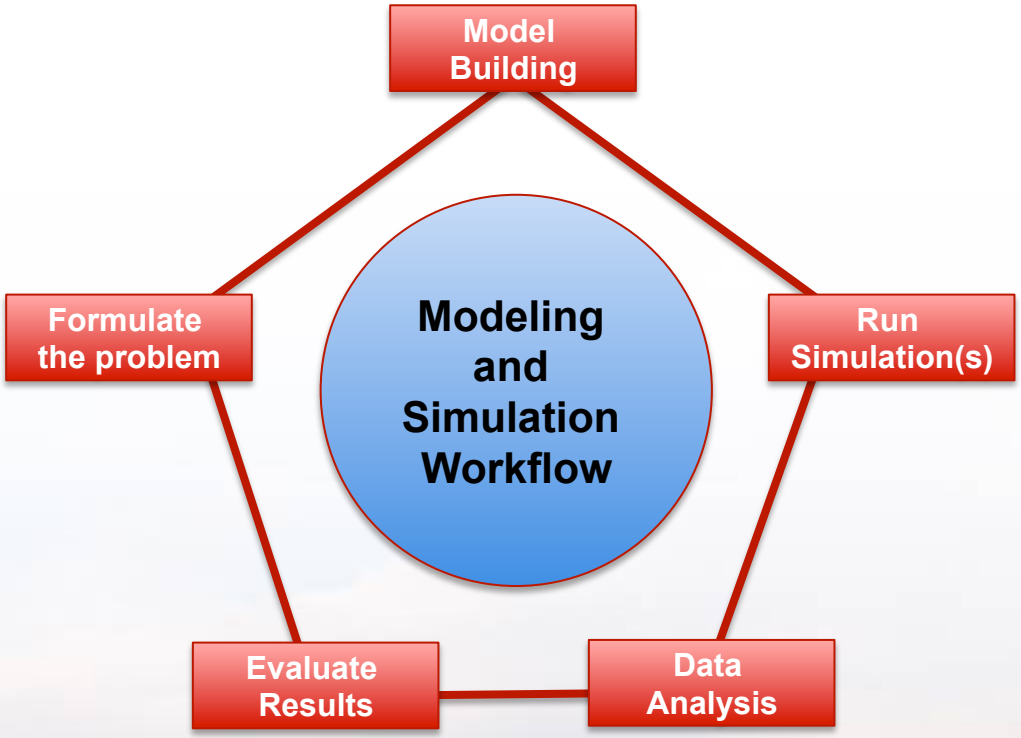
What Does This Mean for “Goodness”?

Why We Do Analysis…

- Gain understanding
- Influence decisions

- How can we make this easier?

What's the Overall Workflow?



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Then…

How many people did you used to see walking around and talking on a cell phone?

Now…

How many people do you see now walking around and using a cell phone?

Can we change the number of HPC users in a similar manner?

How Does the Ecosystem Affect "Goodness"?

Those consumers who have experienced seamless integration of products and platforms – which Apple has mastered – describe the ecosystem experience as something that makes their lives easier and simpler.

White paper: "Mobile Ecosystem: Current Experiences and Future Implications", https://research.yougov.co.uk/white-papers/mobile-ecosystems

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Thank You

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