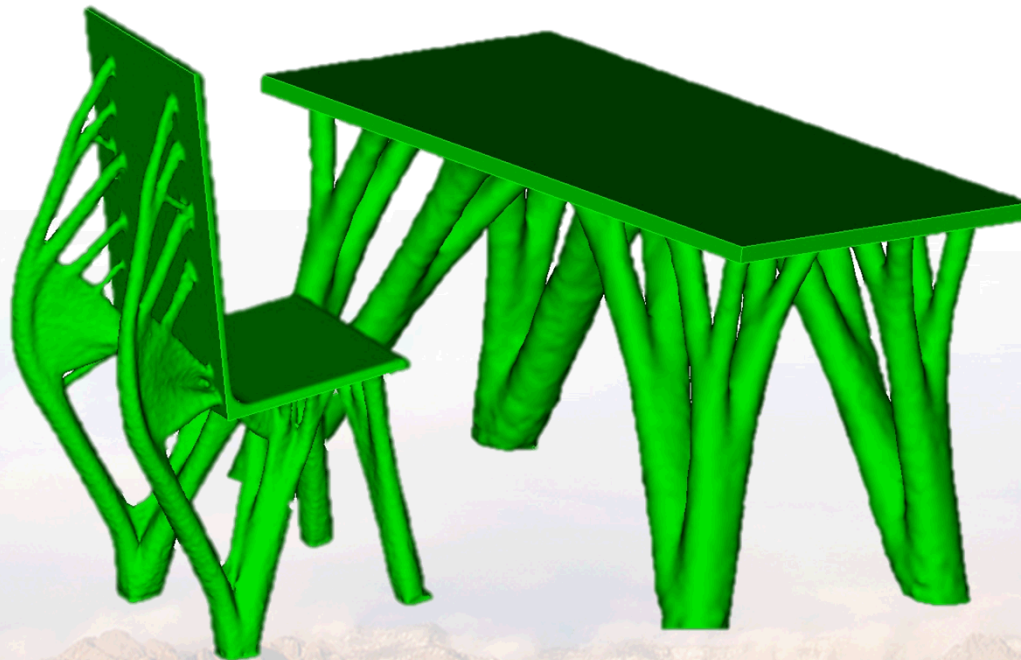


# Designing with Topology Optimization

SAND2015-6146C

**Brett Clark, Miguel Aguilo,  
Josh Robbins, Tom Voth**  
Sandia National Labs  
20 July 2015



Sandia National Laboratories is a multi-program laboratory operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin company, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

SAND2014-18886 C

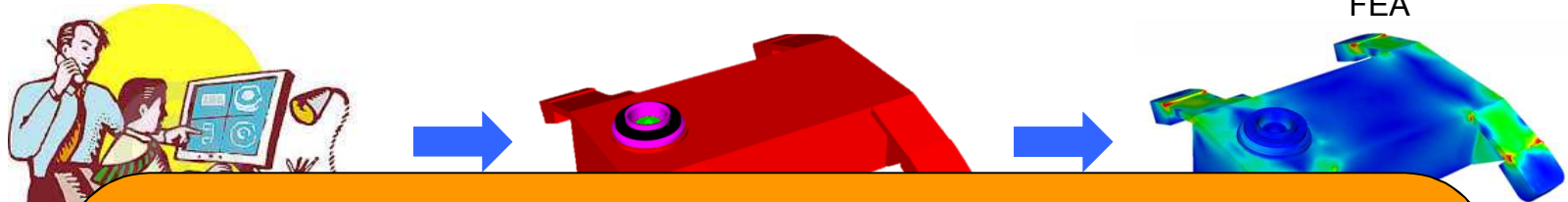
# Paradigm Shift: Form vs. Function

Specify Form

Design

Verify Function Using FEA

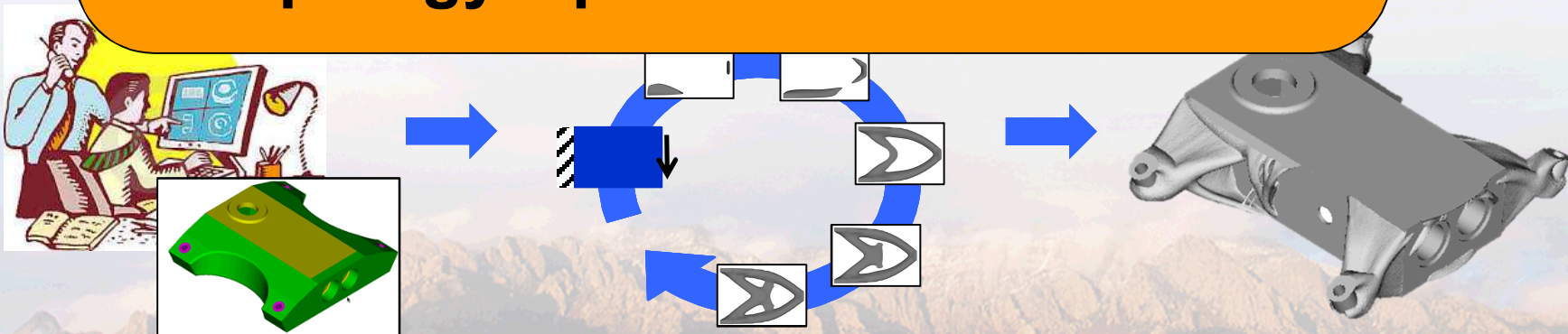
CURRENT



**Needs for Paradigm Shift at Sandia**

- 1. Various/Complex Physics**
- 2. High Performance Computing power**
- 3. Design environment tailored for Topology Optimization**

NEW



# Guided Topology Optimization



Based on evolving design results designer provides additional input/constraints to guide optimization

Designer

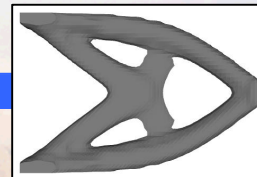
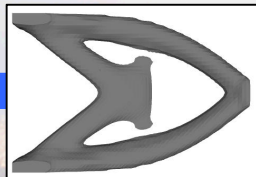
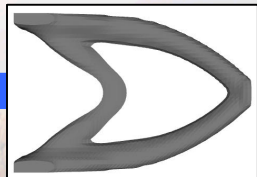
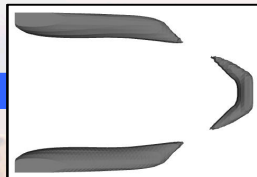
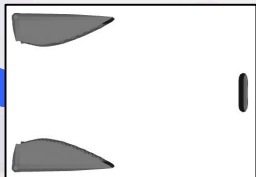


Compute Engine



## GUIDED OPTIMIZATION

Continuous feedback from optimization showing evolving design





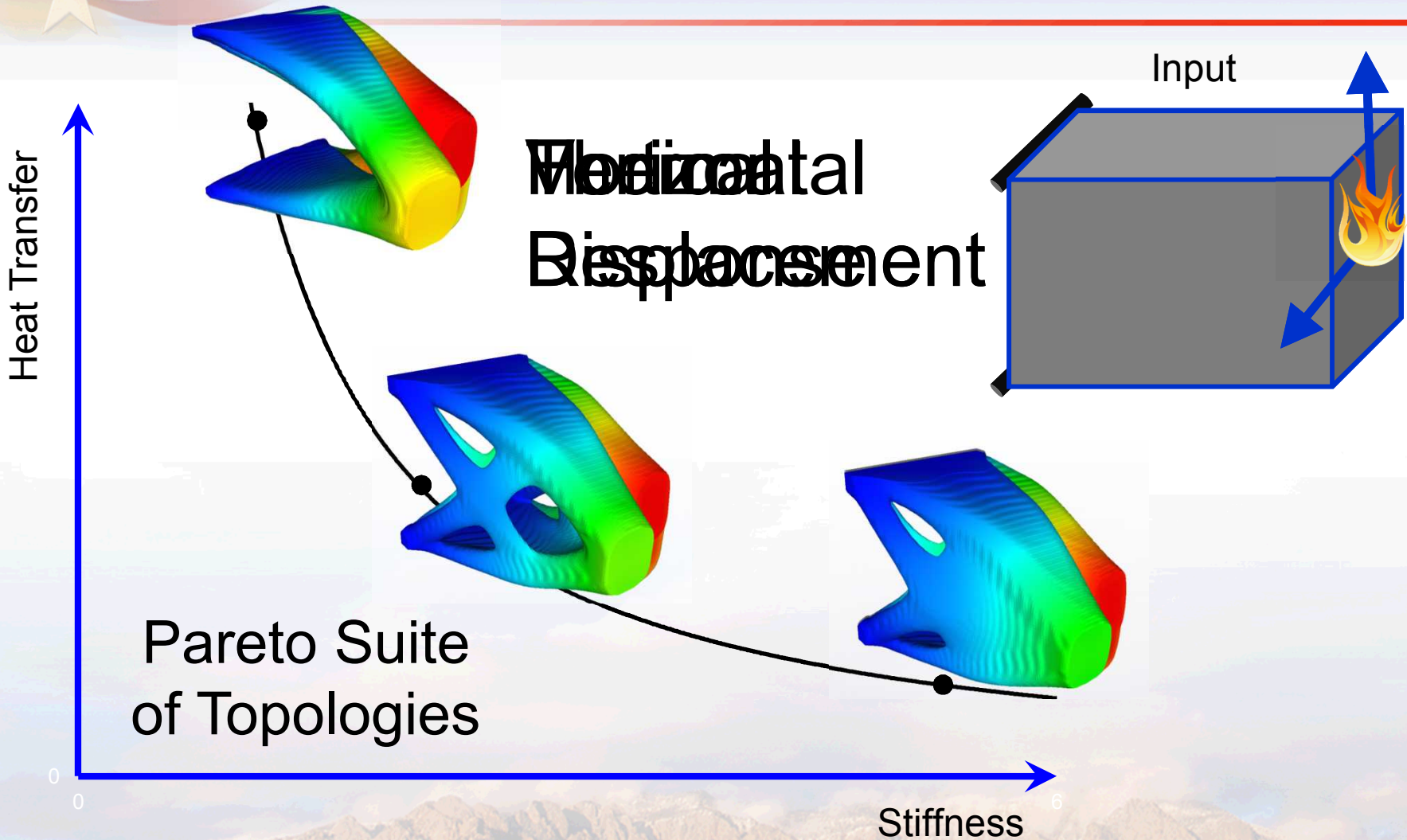
# Some Details of Interactivity

---

- Initial guess/Restart
- Mid-process interactivity
  - Simple parameter changes
  - Mesh modification
    - Adaptivity for performance
    - Adaptivity for design resolution
    - For specifying new constraints
    - For expanding optimization domain
- Post-processing
  - Smoothing optimized design
  - Design editing



# Environment for Making Design Decisions



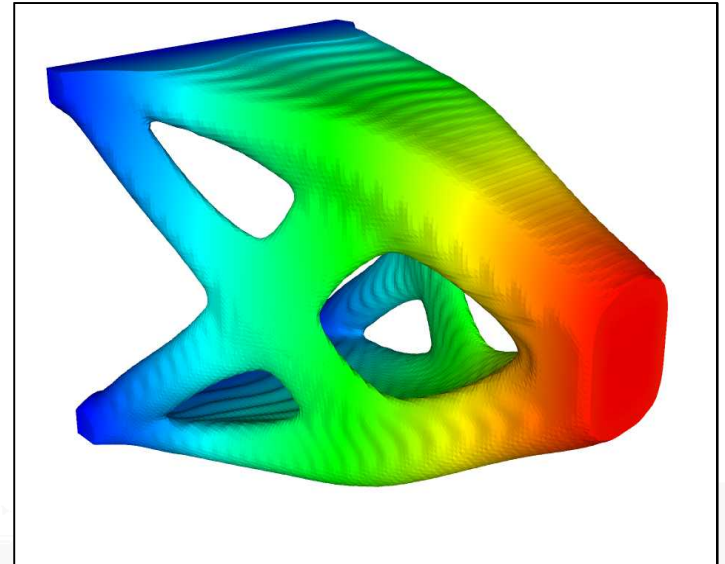
# Current Capabilities

## Albany Physics research platform

- Linear Statics
- Thermal
- Multi-physics
- Multi-load scenarios

## Sierra Physics production platform

- Linear Statics coming on line



## Design Environment based on Sandia Analysis Workbench (“Albany inside”)

- Problem setup
- Job Submission on HPC platforms
- Continuous visual feedback of evolving design
- Post-processing (smoothing, export)
- Interactive optimization





# Live Demo



# Movie

QuickTime Player File Edit View Window Help

Model Builder - Model Builder

Model Navigator Power Tools

- gggg
- housing
- lantern\_bracket
- mitchell
- mitchell\_from\_scratch
- mitchell\_from\_scratch2
- mitchell\_from\_scratch3
- mitchell2
- ryan\_fine\_mesh
- square\_under\_torque
- tester
- therm\_mech
- therm\_mech\_dup
  - Geometry/Mesh
    - therm\_mech
    - TimeStep10
    - TimeStep12
    - TimeStep16
    - TimeStep2
    - TimeStep4
    - TimeStep5
    - TimeStep6
    - TimeStep8
- albany
  - Finite Element Models
  - Functional Requirements
    - stiffness ( weight = .1 )
      - constraint ( x = 0 )
      - constraint ( y = 0 )
      - constraint ( z = 0 )
      - load ( sig\_y = 5e4 )
    - stiffness ( weight = .3 )
    - thermal conduction ( weight = .6 )
      - constraint ( p = 0 )
      - load ( p = 5e4 0 0 )
  - Material Properties
  - Optimization Parameters
  - Simulation Job [Finished]
  - Parameter Studies
- toa10
- toa3
- toa4
- toa5

Settings Command Panel

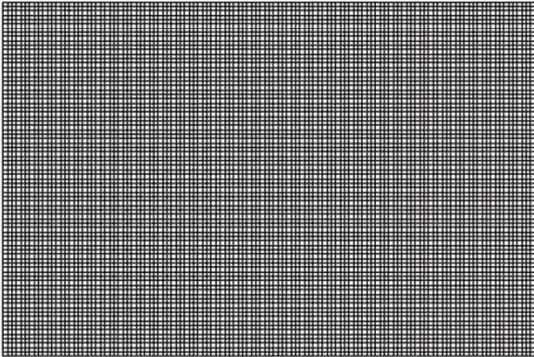
Geometry/Mesh: 'therm\_mech'

Cub File /Users/bwclark/CompSimUIModels/therm\_me  
Journal File /Users/bwclark/CompSimUIModels/therm\_me  
Mesh File /Users/bwclark/CompSimUIModels/therm\_me

Next Steps

- Execute Geometry/Mesh Node

Model View - therm\_mech



Job Status

Showing 73 jobs, 2 filters are active.

Job Name	Stage	Queue
therm_mech_dup	Finished	Comple
mitchell_from_scratch3	Finished	Comple
mitchell_from_scratch3	Killed	Removi
mitchell_from_scratch3	Killed	Comple

Console Cubit Command History Machines

CUBIT Console

```
CUBIT> edge vis on  
Edge visibility ON.  
  
CUBIT>
```

Copying /Users/bwclar...m\_scratch.gen

# Future Directions

Albany research platform for prototyping interactive optimization

Sierra production platform

- Thermal
- Multi-physics, multi-load, multi-constraint
- XFEM (for modal and implicit boundaries)
- Sierra Solid Mechanics

Design Environment

- Support for Sierra
- Continued development of interactive optimization
- Expanded design editing/post processing

