Sensitivity Analysis (SA) and Uncertainty Quantification (UQ) Tools in Sandia Analysis Workbench (SAW)

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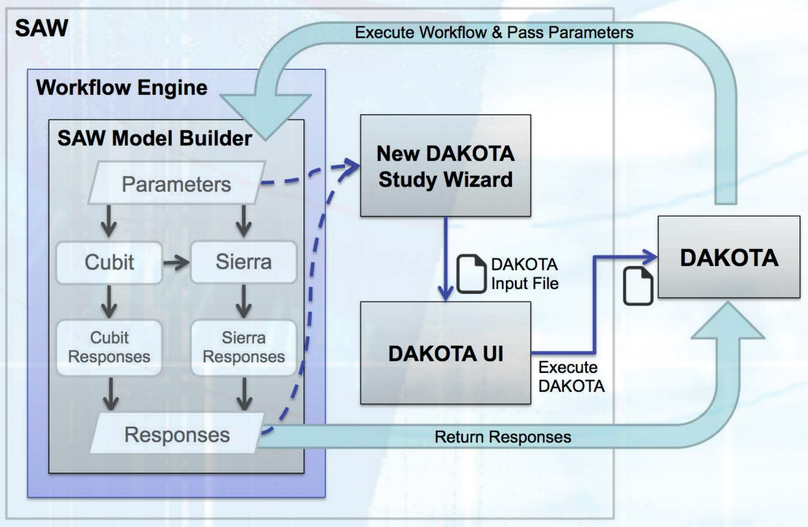
Enabling V&V of Modeling & Simulation Workflows

Problem: SA/UQ studies are difficult to performt

- Requires significant scripting for workflow and response extraction
- DAKOTA is a powerful toolkit of methods for SA/UQ, but has a steep learning curve
- Overall model complexity increases

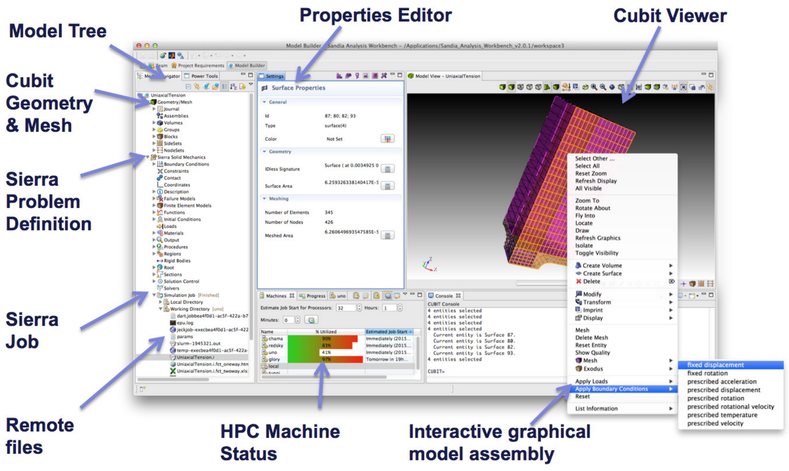
Solution: Lower the barriers to using DAKOTA by facilitating the setup and execution of sensitivity analyses from within SAW Model Builder

- Assist users in creating "DAKOTA Ready" models
  - Wrap SAW Model Builder in a workflow (Cubit→ Sierra →Responses)
  - Model parameterization tools
  - Model Response Toolkit (MRT): extracting responses for common QOI
- Integrate DAKOTA problem definition into SAW Model Builder
- Create architecture for SAW to launch DAKOTA and for DAKOTA to execute SAW workflows

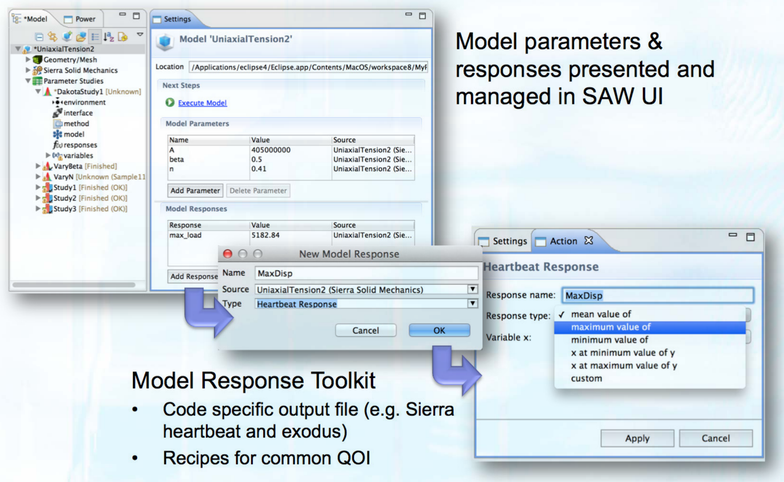


What is SAW Model Builder?

- **Multiple tools combined into an integrated modeling environment**
  - Geometry and meshing (Cubit)
  - Model Attribution (Sierra Editor)
  - Materials data management (formerly Materials WISDM)
  - Job submission
  - Simulation Data Management
  - V&V/UQ (DAKOTA)
- **Model-centric, not file-centric**
  - Unified model tree (geometry/mesh, physics, jobs, results, etc.)
  - Files are managed by SAW
- **Interactive graphical model building**
  - BC's, loads, materials, are applied directly to geometry
- **Dashboard view of distributed resources**



DAKOTA Ready Models



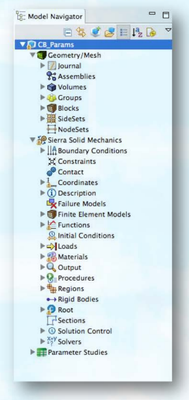
Model parameters & responses presented and managed in SAW UI

Model Response Toolkit

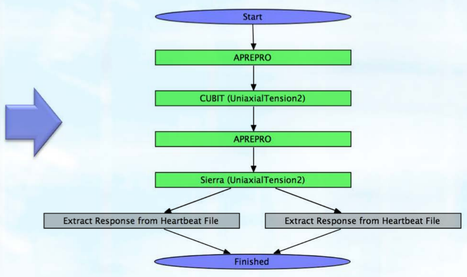
- Code specific output file (e.g. Sierra heartbeat and exodus)
- Recipes for common QOI

Automated Workflow Generation

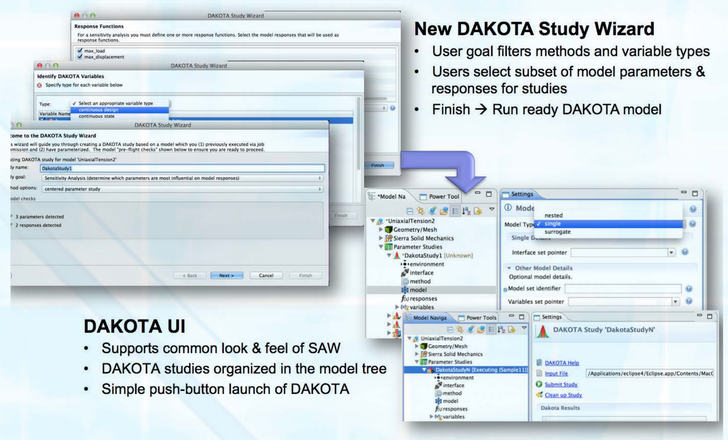
Model Tree Viewer



- SAW captures user actions in the context of Sandia's computing environment into a workflow that can automatically be run over and over
- Generated workflows can be run in optimization loops or parameter studies using DAKOTA



Problem Setup & Execution



New DAKOTA Study Wizard

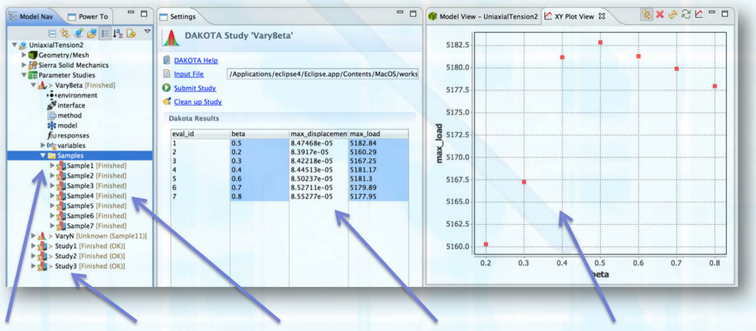
- User goal filters methods and variable types
- Users select subset of model parameters & responses for studies
- Finish → Run ready DAKOTA model

DAKOTA UI

- Supports common look & feel of SAW
- DAKOTA studies organized in the model tree
- Simple push-button launch of DAKOTA

View Results

Providing insight into model sensitivities



DAKOTA study samples in model tree | **Multiple studies per model** | **Monitor progress of running DAKOTA studies** | **Summary of DAKOTA studies** | **Visualization of DAKOTA study results**

Summary

- V&V/UQ is conceptually embedded in SAW Model Builder so users can focus more on exploring uncertainty than on running DAKOTA.
- The V&V/UQ capabilities in SAW make it possible to create and execute a DAKOTA study without writing complex scripts.
- Initial implementation focused on Cubit/Sierra workflow, but the SAW/DAKOTA architecture supports any workflow (e.g. XYCE).

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