



Proposal for FY14 V&V Challenge Workshop

SAND2013-4090C

Greg Weirs, Brian Carnes, Ken Hu,
George Orient, Vicente Romero, Laura Swiler
Sandia National Laboratories

Presented at the ASME V&V Symposium
24 May, 2013

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.



Motivation & Vision

- V&V field is developing fast
 - PSAAP schools beginning to use V&V
 - 2012 ASME V&V Symposium abstracts
 - Workshops help move the field forward
- **Vision** – series of workshops
 - Range of topics: Verification, Validation, UQ
 - Range of audiences: Industry, Academia, Labs
 - **Increase awareness, interest, and innovation**



Current Trend - Challenge Problems

- Challenge problems are popular
 - SNL V&V Workshop (2006), UQ workshop (2002)
 - SNL Fracture Challenge (2012)
 - USACM UQ Benchmark (2013)
 - NASA Langley UQ Challenge (2014)
- UQ field often focuses on comparing methods
- V&V workshop should focus on assumptions, choices, impact on intended use of models
 - Emphasize experience over tools and methods



Outline

- *Motivation and Vision*
- Workshop
 - Timeline
 - Initial Plans
- Draft of a Challenge Problem
 - Concepts
 - Expectations
- What's Next?



The Workshop

- Workshop timeline
 - Summer 2013 – Present draft problem at conferences
 - Fall 2013 – Finalize problem, formally announce workshop
 - Summer 2014 – Hold workshop (ASME V&V Symposium?)
- Hope to partner with ASME
 - Other possibilities: USACM, SIAM, or independent workshop
 - Will meet w/ steering committee 21 May → update slide



Goals ↔ *Topics*

- Goals

- Engage with the V&V community
- Emphasize experience over tools and methods
- Demonstrate the state of the art

- Topics

- Wide range of methods, theory required
- Choose topic for which many approaches exist
 - Diversity in ideas
- No methods development



What is the State of the Art?

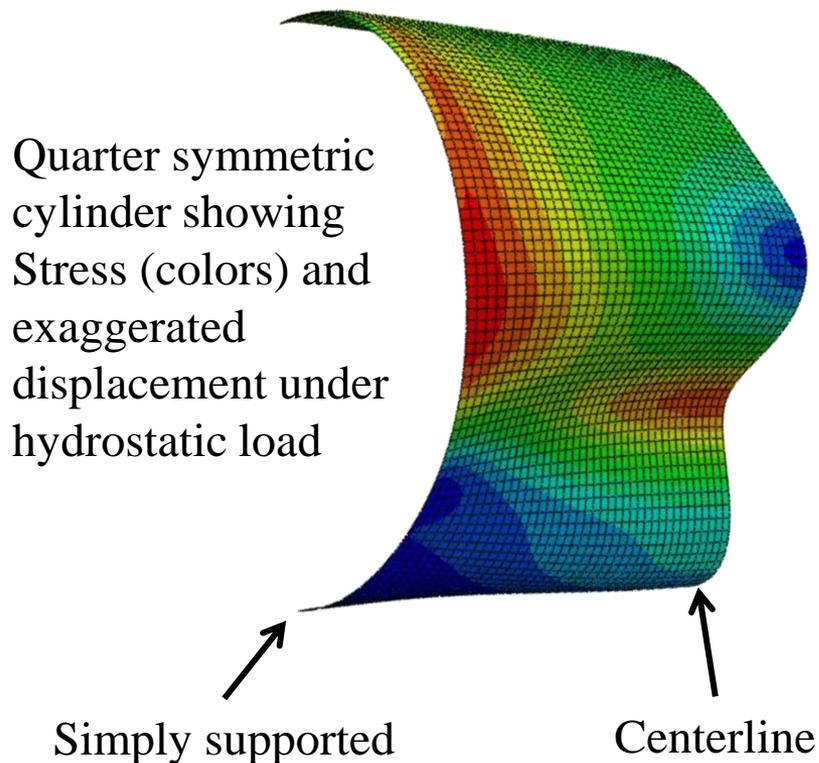
Gaps: synthesis of methods, interpretation of results

- “**Aggregation**” of uncertainty
 - Combine uncertainty of QoI due to multiple sources
 - Parametric uncertainty
 - Experiment-related uncertainty
 - Model form uncertainty
 - Numerical uncertainty
- **Decision making** with V&V/UQ information
- “Relevancy” of information throughout a hierarchy of analyses, a.k.a. rollup

**Green color = V&V/UQ
feature of interest**

The Problem

- Storage tank – contains some liquid, under pressure
- Experiences a range of conditions
 - Temperature, Loading
- One tank fails from tensile overload



- Use test data and modeling to determine the probability of failure
- **Decide whether to retire all tanks**

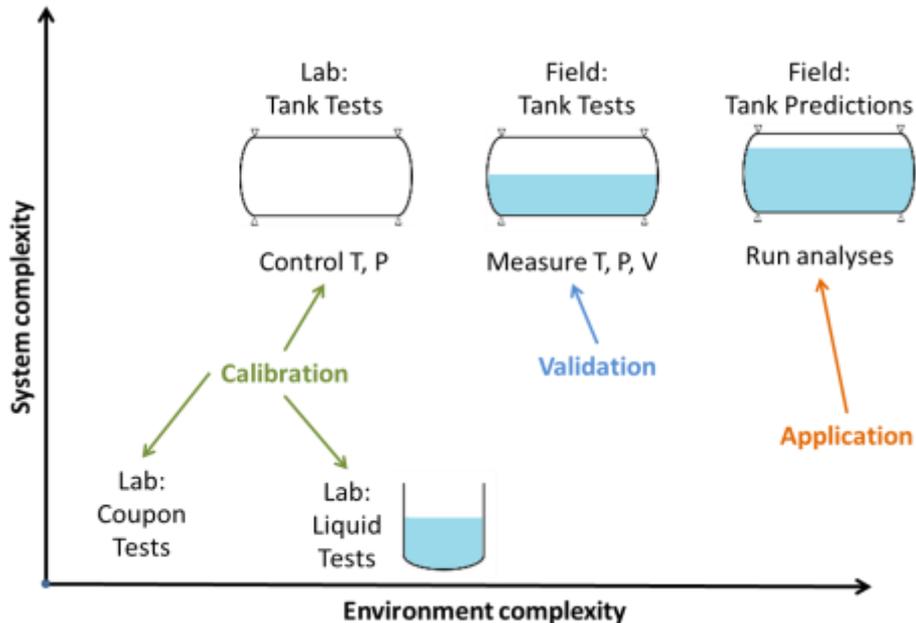


Problem Features

- Relevant: Multiple levels → V&V hierarchy
- V&V/UQ topics: require calibration, solution verification, validation, aggregation
- ‘End-to-end’ problem
 - Data and models → prediction, uncertainty, credibility
→ Decision informed by Modeling and Simulation
 - “Realistic”, intuitive, and interesting story
- Physics based, but no physics expertise required
 - Computationally affordable; unclassified, unlimited release

The Story → V&V Hierarchy

- Intended Use: Predict Probability of Failure at a range of temperatures
- Establish credibility of models → V&V Hierarchy



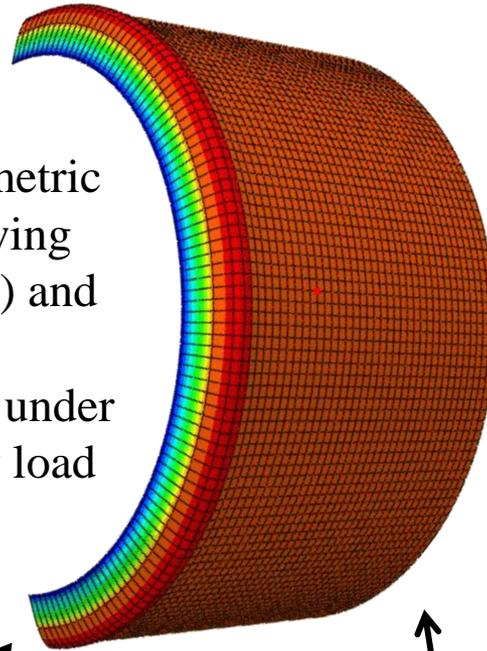
- “System Level”
 - Calibrate system model
 - Validate @ Mild conditions
 - Predict @ Extreme conditions
- “Physics Level”
 - Calibrate liquid property
 - Calibrate failure threshold
 - Calibrate material model

Domains: Calibration Validation Application

The

- Intended Use: Full range of temperature
- Establish credibility

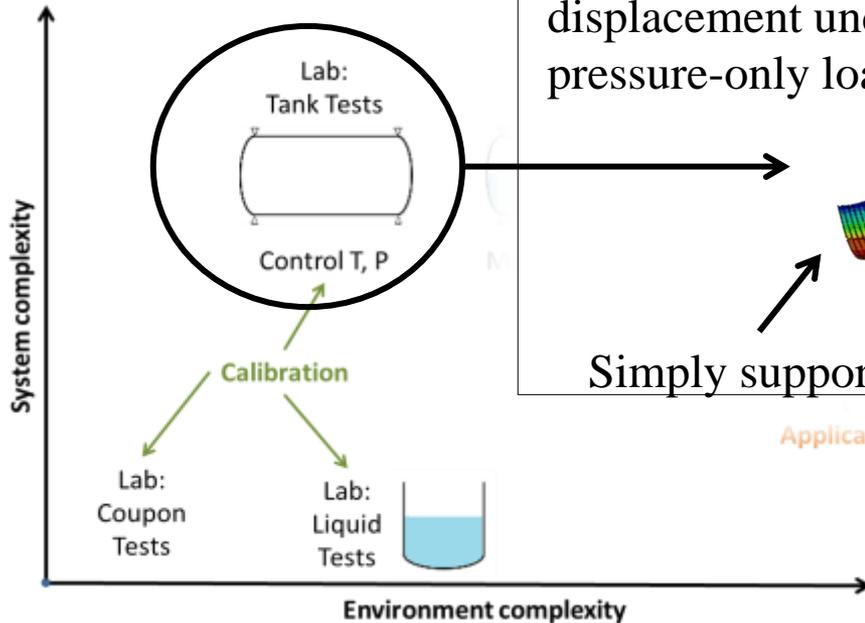
Quarter symmetric cylinder showing Stress (colors) and exaggerated displacement under pressure-only load



Simply supported

Centerline

Application



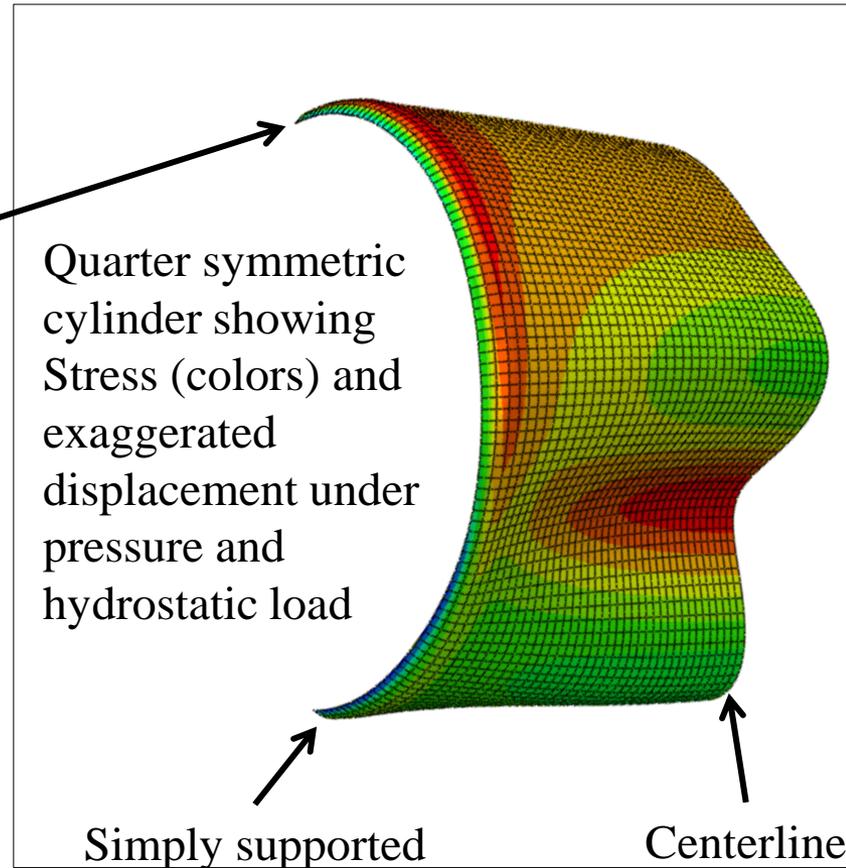
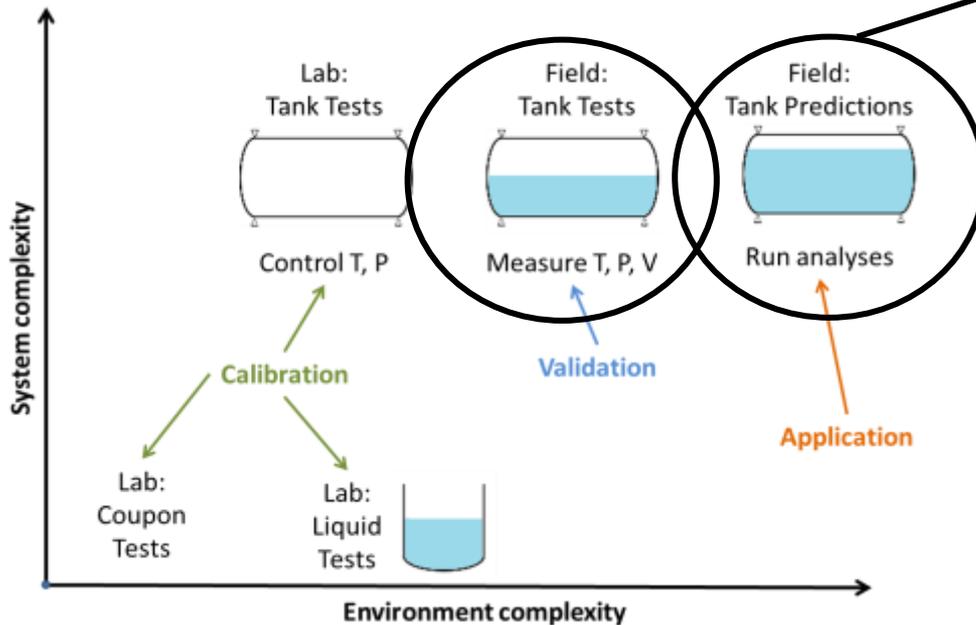
el”
stem model
Mild conditions
xtreme conditions
el”

- Calibrate liquid property
- Calibrate failure threshold
- Calibrate material model

Domains: Calibration Validation Application

The Story → V&V Hierarchy

- Intended Use: Predict Probability of Failure at a range of temperatures
- Establish credibility of models →



Domains: Calibration Validation Application



System Model Features

- Runs quickly → Not limited by methods
- Physically intuitive
 - Pressurized vessel + Liquid load → Displacement & stress
- Non-ideal convergence behavior
 - Interesting **solution verification** problem
- Many parameters, nonlinear responses
 - Non-trivial **UQ** problem
- Modeling limitations
 - Calibration of parameters w/ known **model form error**
- Sub-models
 - Material properties
 - Liquid properties



More Details

- Multiple “levels” of complexity
- Physics level
 - Temperature dependent liquid and material properties
 - Multiple models → **Model form uncertainty**
 - Measurement limitations, Variation in materials
 - **Epistemic, parametric uncertainty**
 - **Aleatoric, parametric uncertainty**
- System level (Full tank)
 - Combine all sources of uncertainty → **Aggregation**
 - Use the V&V hierarchy to organize multiple analyses
 - **Make a decision**



Problem Statement

- Calibration
 - Characterize uncertainty in the model parameters
 - Calibrate some or all model parameters
- Validation
 - Compare given tank test data with predictions
- Prediction
 - Probability of failure under two scenarios
- QoI's are specified, **V&V hierarchy is specified**
- All data will be supplied from a hidden “truth” model
- Tank model will be supplied, with multiple meshes

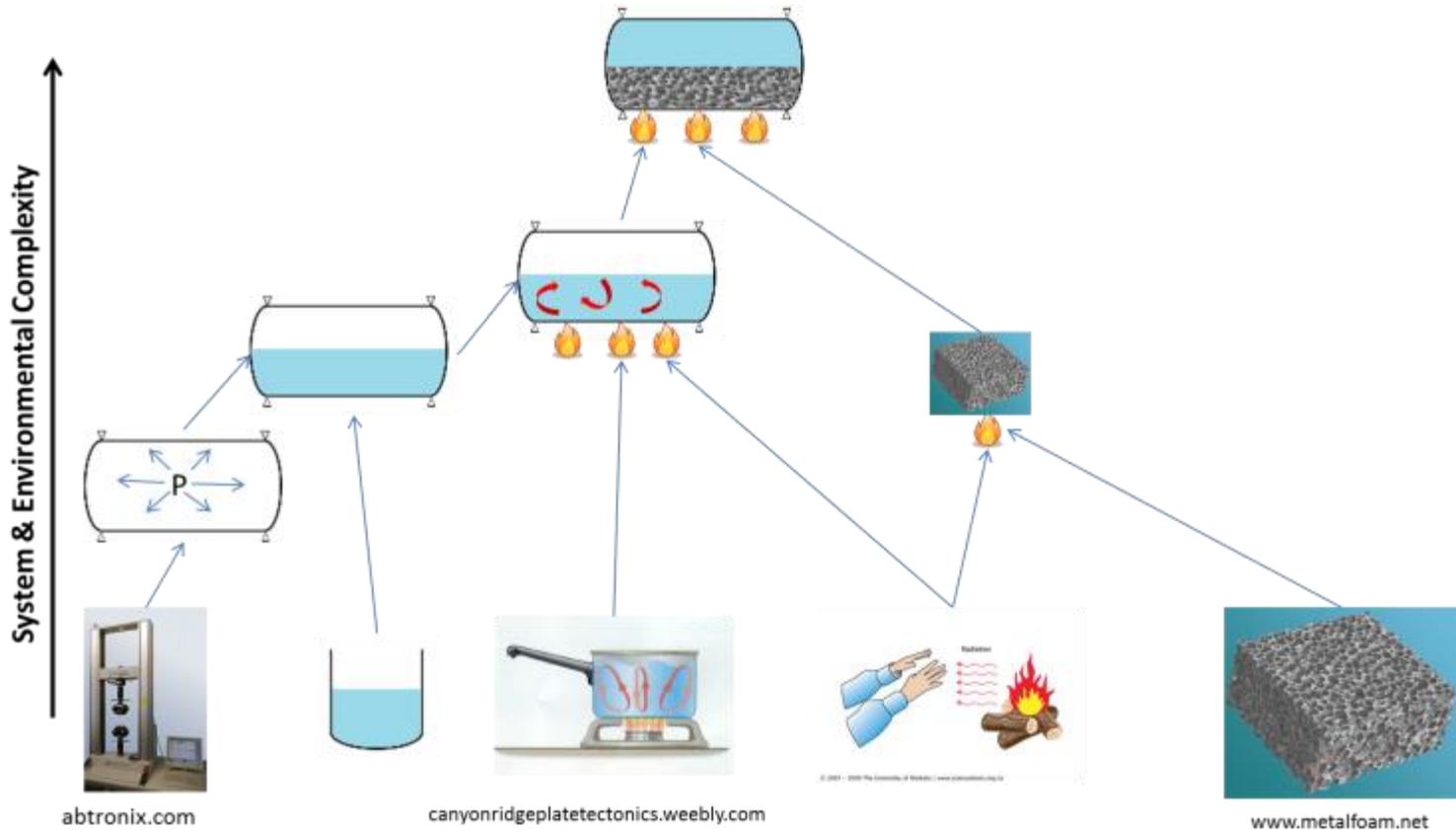


Expectations

- Development of uncertainty & statistical models required
- **NO development of physics models**
- Many choices: how to treat uncertainty, how many function evaluations, etc.
- No requirements on approaches
 - Supply references, suggestions, forum for discussion
- **MUST make an end decision based on prediction, uncertainty, credibility**

Context: Is this an interesting problem?

- Current V&V Hierarchy → 5 steps
 - Emphasize ideas for aggregation
- Big picture: Pyramid view of hierarchy





"Hidden" Features

Not explicitly asked for, to reduce problem scope

- Experiment-related uncertainty
 - Unknown Experimental Conditions
 - Imprecise measurements
 - How to propagate this to the QoI?
- Relevancy or “Rollup”
 - Info from Calibration, Validation, & Application domains
 - Is it all relevant?
 - Is the model valid (for intended use)?
 - Is the model useful?



Remaining work + Feedback Requested

- Finalize Scope
 - Problem could become unreasonably large
- Gauge community's interest level
- Determine schedule and venue
 - Fall 2013 – Announce workshop
- More Promotion
 - USNCCM (July) – nearly final problem statement



Goal of this workshop

- Pose a problem with many concepts
- Give participants choices
 - Analyze some vs. all of the pieces
 - How to model uncertainty
 - How to **aggregate** uncertainty
 - Make a final decision, informed by model predictions
- What is the impact of UQ/V&V choices?
- Provide different perspective from UQ community
- **Increase awareness, interest, innovation in V&V**



Contact Information

- Website: <https://share.sandia.gov/vvcw>
 - Still under development – Coming soon!
- Email: Coming soon
 - If interested in hearing more, send an email to be placed on a distribution list