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Proposal for FY14 V&V Challenge Workshop

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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?

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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

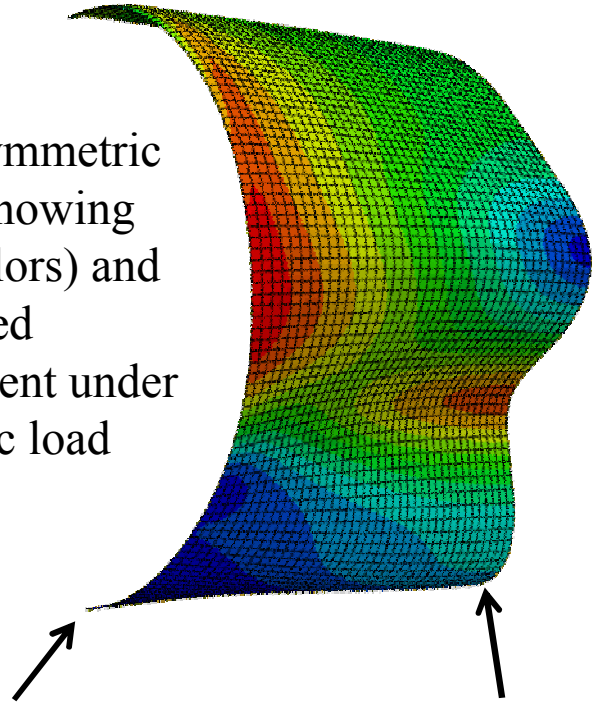
- "Aggregation" of uncertainty
  - Combine uncertainty of QoI due to multiple sources
  - Parametric uncertainty
  - Experiment-related uncertainty
  - Model form uncertainty
  - Numerical uncertainty
- Decision making with V&V/UQ information
- "Relevancy" of information throughout a hierarchy of analyses,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

Quarter symmetric cylinder showing Stress (colors) and exaggerated displacement under hydrostatic load



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

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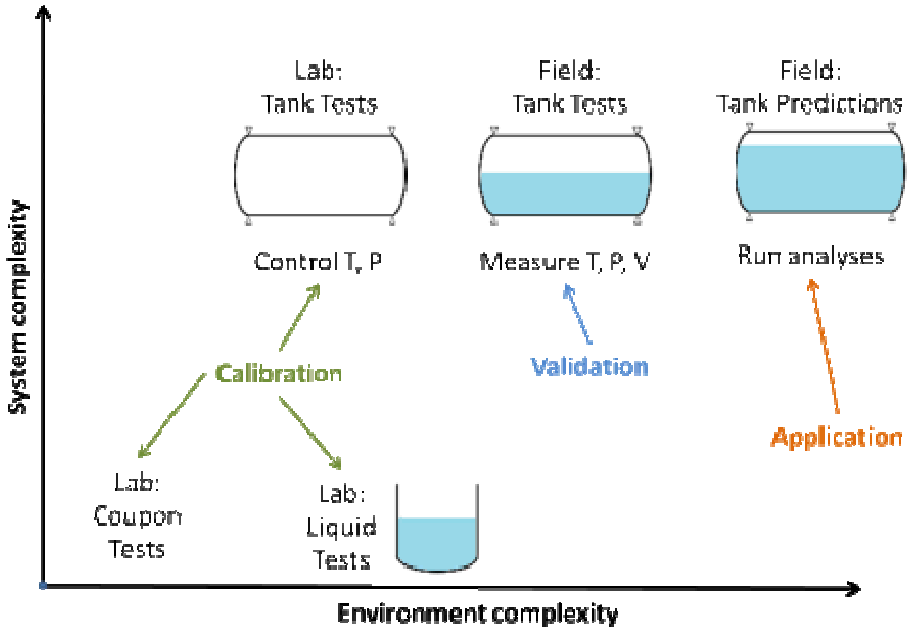
Problem Features

- 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

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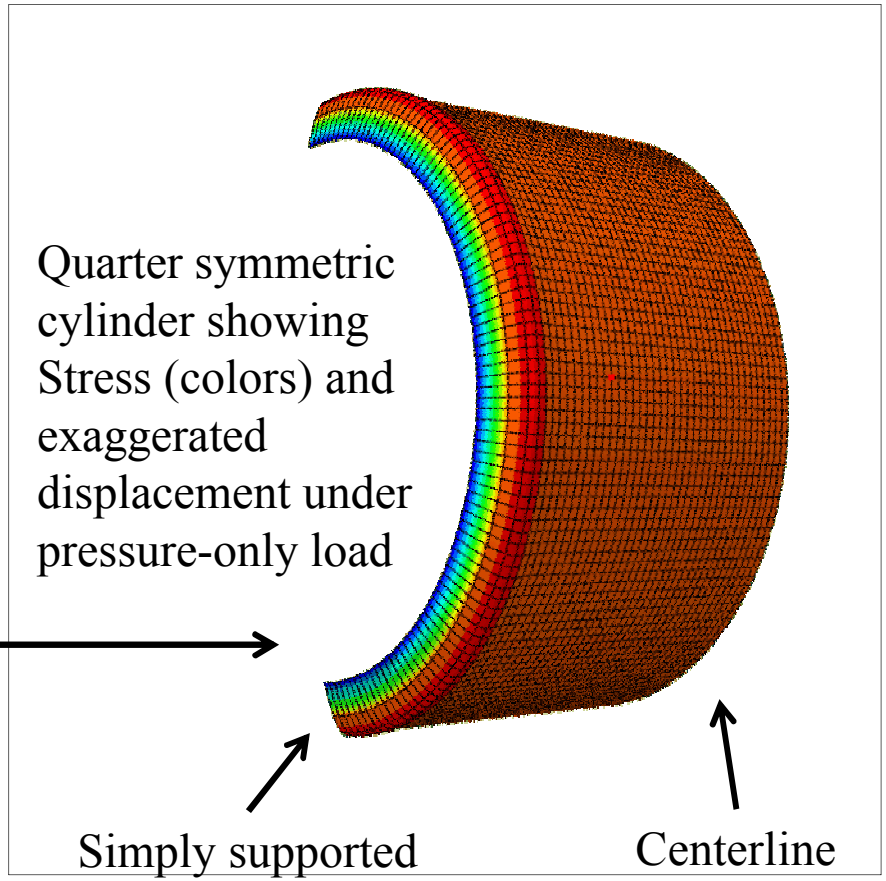

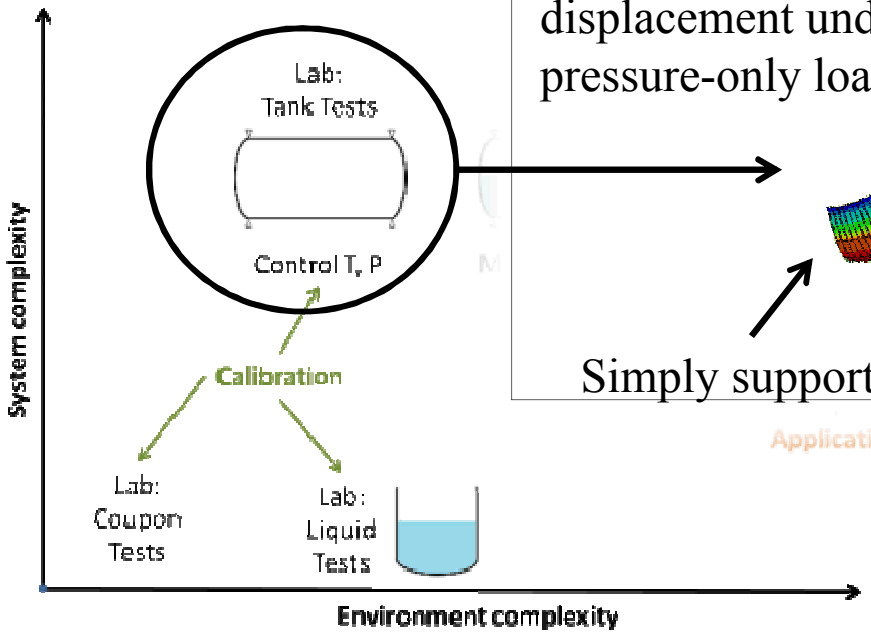

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stem model
Mild conditions
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Application

→Calibrate liquid property
→Calibrate failure threshold
→Calibrate material model

Domains: Calibration Validation Application

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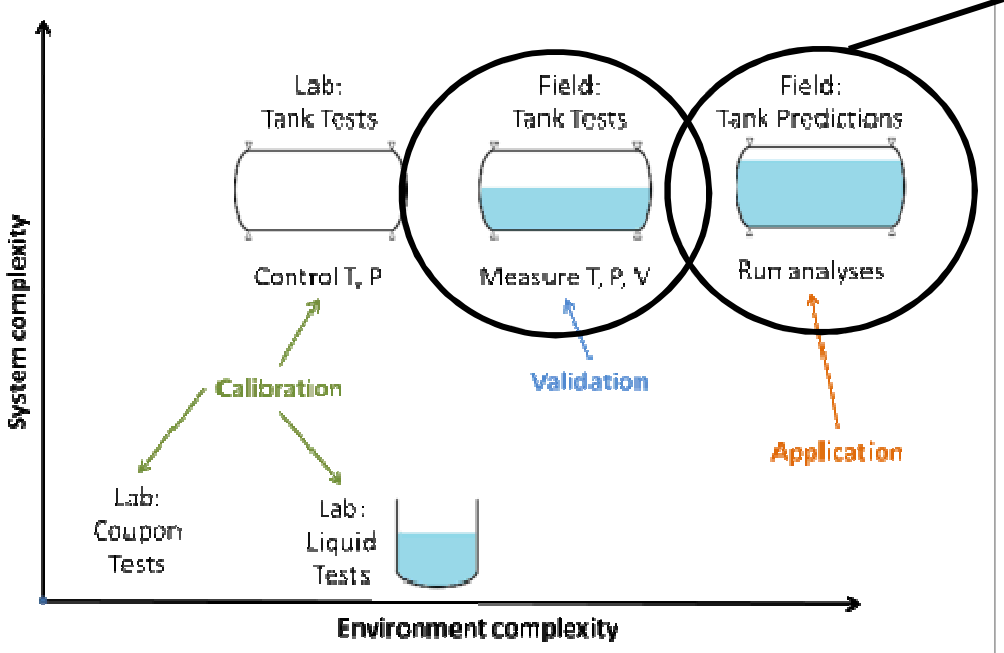
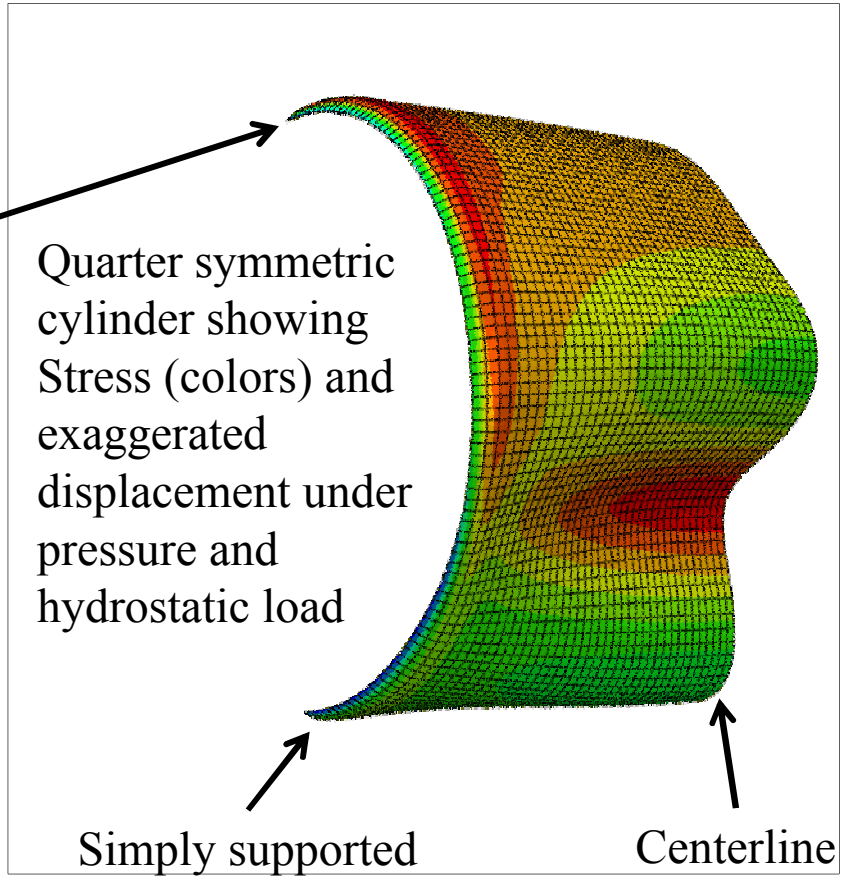
The Story → V&V Hierarchy

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





Domains: Calibration Validation Application

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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

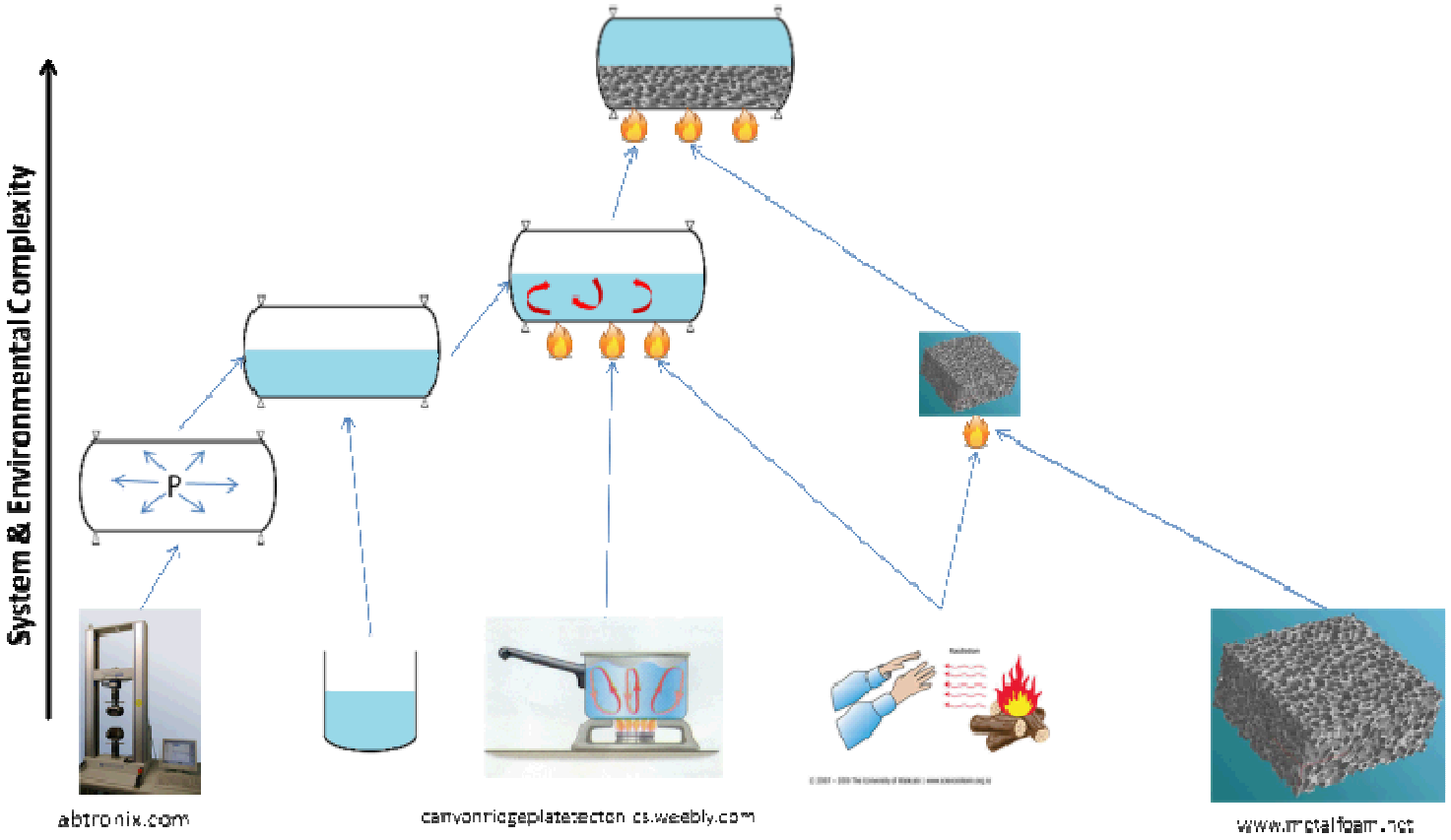
- Calibration
  - Characterize uncertainty in the model parameters
  - Calibrate some or all model parameters
- Validation
  - Compare given tank test data with predictions
- Prediction
  - Probability of failure under two scenarios
- QoI's are specified, V&V hierarchy is specified
- All data will be 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



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"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

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