Proposal for FY14 V&V Challenge Workshop

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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 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 Story

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**V&V Hierarchy**

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Domains: Calibration  Validation  Application

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

Simply supported  Centerline

→ Calibrate liquid property
→ Calibrate failure threshold
→ Calibrate material model
The Story → V&V Hierarchy

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

Domains: Calibration  Validation  Application

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

Simply supported  Centerline
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 \(\rightarrow\) Model form uncertainty
  – Measurement limitations, Variation in materials
    • Epistemic, parametric uncertainty
    • Aleatoric, parametric uncertainty
• System level (Full tank)
  – Combine all sources of uncertainty \(\rightarrow\) 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](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