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Collaboration on Uncertainty Analysis: Sandia's Perspective

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Sandia's position and interests

- Sandia has acknowledged and advocated the importance of uncertainty treatment for several decades and are **strongly supportive of any collaboration** in this field
- Sandia was the lead laboratory for two large nuclear waste repository performance assessments (WIPP and Yucca Mountain), in which uncertainty analysis (UA) and sensitivity analyses (SA) were a key component for demonstrating safety confidence
- Currently, we would like to focus our effort in three areas, described in more detail in the following slides:
 1. **Presenting the current conceptual and computational approach developed at Sandia**
 2. **Sharing new techniques and testing their effectiveness**
 3. **Promoting the use of UA and Sensitivity Analysis SA for complex systems**

1. Presenting our current conceptual and computational approach for uncertainty treatment

- Sandia has developed a sampling-based methodology and computational approach to incorporate aleatory and epistemic uncertainty into analyses for complex systems, such as geologic repositories for heat-generating waste
- A special issue of Reliability Engineering System Safety (RESS) has been published in 2000 to present the approach used for WIPP¹ – Another one on YM has just been published in 2014²
- We would like to **share our expertise** via short courses, peer review publications and conference participation and presentations
- We are also eager to **learn in return** from exchange and comments as well as comparison with approaches used by our German counterpart

1 “The 1996 Performance Assessment for the Waste Isolation Pilot Plant” **Reliability Engineering and System Safety** Vol. 69, Numbers 1-3 (2000)

2 “Performance Assessment for the proposed High-Level Radioactive Waste Repository at Yucca Mountain, Nevada ” **RESS** Vol. 122 (2014)

<http://www.journals.elsevier.com/reliability-engineering-and-system-safety/special-issues/>

Summary of Sandia's expertise and interest on uncertainty treatment

- **High Level characterization of complex system:** Separation of aleatory and epistemic uncertainty.
- **Uncertainty characterization:** probabilistic approach, evidence theory (Dempster-Shafer), ...
 - **Distribution construction:** construction via expert elicitation, frequentist approach, Bayesian updating
- **Sampling techniques:** Simple Random Sampling, Latin Hypercube Sampling, Importance Sampling, Reliability Methods (DAKOTA package)
- **Uncertainty Analysis:** estimate of output uncertainty and characterization via statistics over time or at selected time-step/condition.
- **Sensitivity analysis:** correlation and regression (parametric and nonparametric) techniques at selected time-steps or over time

2. Sharing and testing new uncertainty and sensitivity techniques

- As the interest in UA/SA grows among the scientific community, more sophisticated and promising techniques will be developed
- We are regularly working on developing, learning and testing new techniques
- Techniques we are particularly interested in include:
 - **Non-parametric regression (“smoothing”) techniques** such as locally weighted regression and recursive partitioning regression¹. We would like to test them more formally, mainly on results from past WIPP and YM analyses.
 - We would be interested in testing the methods presented by D. A. Becker at the 3rd US-German workshop on Salt² such as the **change of variables**.
- We thought also that some **technical exchanges** to exchange idea and **define benchmark testing** would be beneficial to all parties.
See next slide on RESS special issue

1: CB Storlie and JC Helton (2007). [Multiple Predictor Smoothing Methods for Sensitivity Analysis: Example Results](#). *Reliability Engineering and System Safety* **93** (1), 55-77.

2: D.-A Becker (2012) **Investigations on Sensitivity Analysis of Complex Final Repository Models – 3rd US-German Workshop on Salt Research, Design and Operations**, Albuquerque NM, (Oct. 2012)

Information available in the YM special issue

Reliability Engineering and system safety vol. 122 (2014)

- Description of several techniques to handle both aleatory and epistemic uncertainty in a computationally efficient way: each scenario (nominal, early failure, seismic, igneous) offered different perspective in treating aleatory uncertainty
- Uncertainty and Sensitivity Analyses have been applied on an extensive set of data (radionuclide concentrations in various barriers, radionuclide mass released at different barrier boundaries, dose rate in the biosphere, etc.). Stepwise linear regression was not always successful in explaining the variance in the output of interest. **Good basis as a benchmark testing tool for new sensitivity analysis techniques.**

3. Promoting the use of UA and SA in complex systems analyses

- We are strong advocates of promoting uncertainty analysis (UA) and sensitivity analysis (SA), not only within the radioactive waste management community, but in any research and application field dealing with complex systems:
 - The development of special issues has had greater impact than single articles in the past. We recommend considering **organizing any collaboration as a collection of suitable articles that could be published as a special journal issue** (with a generic title such as “Uncertainty Management and Sensitivity Analysis in Repository Safety Analysis”.) RESS Editors in Chief have always been supportive of such initiatives
 - We also think that **articles published in other fields** dealing with complex systems involving uncertainty (nuclear power plant, petroleum engineering...) are important to broaden the perspective.
 - Finally, it is important to **train future generations**, especially considering that many university programs do not have a strong emphasis on uncertainty characterization and analysis in real world situations. Therefore, we fully support development and **teaching of courses at university levels, as well as giving short courses and workshops** (such as the SAMO summer school)