INFORMS Roundtable Summer Meeting Agenda
July 19-20, 2015
Jackson Lake Lodge
Grand Teton National Park, Moran, WY
Theme: "Uncertainty Quantification"

Sunday, July 19

2:30 PM	***Meet in Jackson Lake Lodge Lobby***	
3:15 PM	***Outing: Jackson Lake Scenic Cruise***	***Colter Bay***

We will meet in Jackson Lake Lodge Lobby to take a shuttle bus to the Colter Bay Marina, 5 miles north. We will return to Jackson Lake Lodge by 5:30 pm.

http://www.gtlc.com/activities/marina-lake-cruise.aspx

6:30 PM	***Reception***	***Sunset Terrace***
7:30 PM	***Dinner***	***Trapper's Room***
9:30 PM	***Adjourn***	

Monday, July 20

7:00 AM	***Breakfast***	***Trapper's Room***
8:15 AM	***Roundtable Introductions***	***Wrangler/Prospector/Homesteader (WPH)***
8:30 AM	***The Role of Uncertainty Quantification in Predictive Models***	***WPH***

We increasingly rely on mathematical and statistical models to predict phenomena ranging from nuclear power plant design to profits made in financial markets. When assessing the feasibility of these predictions, it is critical to quantify uncertainties associated with the models, inputs to the models, and data used to calibrate the models. The synthesis of statistical and mathematical techniques, which can be used to quantify input and response uncertainties for simulation codes that can take hours to days to run, comprises the evolving field of uncertainty quantification. The use of data, to improve the predictive accuracy of models, is central to uncertainty quantification so we will begin by providing an overview of how Bayesian techniques can be used to construct distributions for model inputs. We will subsequently describe the computational issues associated with propagating these distributions through complex models to construct prediction intervals for statistical quantities of interest such as expected profits or maximal reactor temperatures. Finally, we will describe the use of sensitivity analysis to isolate critical model inputs and surrogate model construction for simulation codes that are too complex for direct statistical analysis. All topics will be motivated by examples arising in engineering, biology, and economics.

Ralph C. Smith, North Carolina State University, Department of Mathematics

Dr. Smith received his PhD in Applied Mathematics from Montana State University in 1990. Following a three-year postdoctoral position at the Institute for Computer Applications in Science and Engineering (ICASE) at NASA Langley Research Center, he was an Assistant Professor in the Department of Mathematics at Iowa State University. Dr. Smith joined the North Carolina State University faculty in 1998, where he is presently a Distinguished Professor of Mathematics.

Dr. Smith is Editor-in-Chief of the SIAM book series on Advances in Design and Control and is on the editorial boards of the SIAM/ASA Journal on Uncertainty Quantification, the Journal of Intelligent Material Systems and Structures, and Dynamics of Continuous, Discrete and Impulsive Systems B. He is co-author of the research monograph, *Smart Material Structures: Modeling, Estimation and Control* and author of the books, *Smart Material Systems: Model Development and Uncertainty Quantification: Theory, Implementation, and Applications*. His research areas include mathematical modeling of smart material systems, numerical analysis and methods for physical systems, Bayesian model calibration, sensitivity analysis, control, and uncertainty quantification.

9:30 AM Quantifying Uncertainty: A Primer WPH

Uncertainty quantification (UQ) is broadly defined as the process of characterizing, estimating and reducing uncertainty or variability in complex processes in the physical sciences, biological processes, engineering applications and even into high dimensional financial models. The increased reliance on mathematical and statistical models for modern research and development and for advancement of scientific discovery necessitates appropriately quantified uncertainties. When properly understood, these uncertainties facilitate more informed decision making (inference). In this tutorial, we address basic approaches to the quantification of a wide variety of information sources, including deterministic mathematical modeling of complex systems, stochastic statistical models of physically conducted experiments, and potentially highly valuable (and variable) subject matter expert judgement. The approaches discussed often lend themselves to Bayesian approaches for the quantification of uncertainty because of the inherently updatable nature of the paradigm. An additional benefit of Bayesian approaches in an UQ setting is the ability to move from retrospective estimation of uncertainty to prospective prediction of uncertainty in physical processes. We illustrate the approaches with applications in high throughput manufacturing and materials science alloy formations.

Shane Reese, Brigham Young University, Department of Statistics

Dr. Reese received his Ph.D. in Statistics from Texas A&M University in 1999. Following a four-year research scientist position at the Los Alamos National Laboratory, he was an Assistant Professor in the Department of Statistics at Brigham Young University. He is currently the Melvin W Carter Professor of Statistics at Brigham Young University.

He has been an Associate Editor of the Journal of the American Statistical Association, Technometrics, Communications in Statistics, and Chance Magazine. He is co-author of the book *Bayesian Reliability*. He is an elected Fellow of the American Statistical Association. His research areas include statistical modeling in materials science, statistical approaches for combining information across various sources, Bayesian model calibration, National Security statistics, and sports statistics.

10:30 AM Break WPH

11:00 AM Combining Information for Uncertainty Quantification WPH

The challenges of "big data" and "data science" are often described in terms of the "4 V's": Volume, Velocity, Veracity, and Variety. This talk focuses on variety and how it interacts with uncertainty quantification. Data collection and curation is expensive, and we want to be sure to use "all available" information to support decision making. This talk illustrates the benefits of using statistical models to combine multiple sources of information to assess systems and quantify uncertainty. In addition to system assessment, we also consider how using multiple sources of information can help with subsequent test planning. Although practitioners often use "assuring" and "demonstrating" performance synonymously, statisticians distinguish between demonstration and assurance testing. A traditional demonstration test is essentially a classical hypothesis test, which uses only the data from the current test to assess whether the quantity of interest meets or exceeds a requirement. Many modern systems, such as communication devices, transportation systems and military weapons, are highly reliable and extremely complex. For these systems, demonstration tests often require an impractical amount of testing. In response to this, we can consider an assurance test as one that uses additional supplementary data and information to reduce the required amount of testing. The additional data and information may include appropriate models; earlier test results on the same or similar devices; expert judgment regarding performance; knowledge of the environmental conditions under which the devices are used; benchmark design information on similar devices; computer simulation models; and prior knowledge of possible failure modes. I will illustrate these ideas with case studies.

Alyson Wilson, North Carolina State University, Statistics Department

Dr. Alyson Wilson is a Professor in the Department of Statistics and Principal Investigator for the Laboratory for Analytic Sciences at North Carolina State University. She is the coordinator of NCSU's Data-Driven Science cluster, which focuses on the development of interdisciplinary collaborations between statistics, mathematics, and computer science to develop leadership in data science. Prior to joining NC State in 2013, Dr. Wilson was a Research Staff Member at the IDA Science and Technology Policy Institute in Washington, DC (2011-2013), where she helped provide research support to the White House Office of Science and Technology Policy and the Office of the Secretary of Defense. Before her move to Washington, Dr. Wilson was an Associate Professor in the Department of Statistics at Iowa State University (2008-2011). From 1999-2008, she was a Project Leader and Technical Lead for Department of Defense Programs in the Statistical Sciences Group at Los Alamos National Laboratory. In this role, she developed and led a portfolio of work in the application of statistics to the reliability of conventional and nuclear weapons. Dr. Wilson continues her collaboration with Los Alamos as a Guest Scientist. From 1995-1999, Dr. Wilson was a senior statistician and operations research analyst with Cowboy Programming Resources, where she planned, executed, and analyzed U. S. Army air defense artillery operational evaluations.

Dr. Wilson is a Fellow of the American Statistical Association and an elected member of the International Statistical Institute. Wilson has served on numerous national panels, including the National Academy of Sciences (NAS) Committee on Integrating Humans, Machines, and Networks (2012-2014) and the NAS Committee on Mathematical Foundations of Validation, Verification, and Uncertainty Quantification (2010-2011). She is the former Reviews Editor for the Journal of the American Statistical Association and the American Statistician and a former Associate Editor for the Journal of Uncertainty Quantification. She is a founder and past-chair of the American Statistical Association's Section on Statistics in Defense and National Security. In addition to numerous publications, Dr. Wilson has co-authored a book, *Bayesian Reliability*, and has co-edited two other books, *Statistical Methods in Counterterrorism: Game Theory, Modeling, Syndromic Surveillance*, *and Biometric Authentication* and *Modern Statistical and Mathematical Methods in Reliability*. Dr. Wilson received her Ph.D. in Statistics from Duke University, her M.S. in Statistics from Carnegie-Mellon University, and her B.A. in Mathematical Sciences from Rice University.

12:00 PM ***Lunch*** ***Trapper's Room***

1:15 PM Uncertainty Quantification for Complex Systems WPH

A hallmark of modern society is the inter-dependence between many of its constituents and the complexity of its failure modes. In many instances, such as encountered following the Deepwater Horizon oil spill, or the Fukushima Daiichi nuclear accident, a complex interplay between natural, man-made, and societal factors augmented the event itself with socio-economic and political factors on a global scale. A cursory look at the current grand challenges facing today's global society indicates a rising trend in this class of problems at the interface of science, technology, nature, and human well-being. Understanding and characterizing extreme events in such settings require added attention as the complexity of interactions is likely to yield emergent phenomena and non-convex safety sets. Furthermore, in such situations, it is typical that relevant data is acquired using several modalities to which different levels of credibility may be attached. Even knowledge about various components of these complex system is often accumulated along different logical paths which may include causality, functional dependence or correlational studies with longitudinal or cross-sectional surveys.

A new perspective on characterizing the weight of evidence in observations, and a new way of transporting that evidence into inference and action is needed to simultaneously address the severe implications of failure and the limitation of resources typical in these problems.

This talk will address the development of predictions that are sufficiently credible for complex failure mechanisms. The challenge is one of understanding the constraints provided by the system, its interfaces and its observers while providing representations of data and of uncertainty that are robust enough to capture these constraints. These developments will be described using case studies that pertain to manufacturing and ultra-deepwater oil & gas exploration.

Roger Ghanem, University of Southern California, Departments of Aerospace & Mechanical Engineering and Civil & Environmental Engineering

Dr. Ghanem is Professor in the Departments of Aerospace & Mechanical Engineering and Civil & Environmental Engineering at the University of Southern California where he also holds the Gordon S. Marshall Professorship in Engineering Technology. He holds a PhD in engineering from Rice University with a focus on stochastic mechanics and had served on the faculty of SUNY Buffalo and Johns Hopkins prior to joining USC. Dr. Ghanem's research is in the general area of uncertainty quantification and predictive science. He has co-authored over 300 hundred articles on uncertainty quantification with applications to problems from across science and engineering and delivered several short courses on UQ to academia, industry and government labs. His recent research focus has been on uncertainty in coupled systems and multiscale systems, as well as model reduction in the presence of uncertainty. Dr. Ghanem is co-author of the NRC Report, *Assessing the Reliability of Complex Models: Mathematical and Statistical Foundations of Verification, Validation, and Uncertainty Quantification*, serves on the Executive Council of the US Association for

Computational Mechanics, and on the NRC National Committee for Theoretical and Applied Mechanics. He was founding member or chair for UQ committees in a number of engineering and mathematical organizations (ASCE, SIAM, USACM).

2:15 PM ***The State-of-the-Art in Uncertainty Quantification Algorithms*** ***WPH***

The field of Uncertainty Quantification (UQ) has experienced tremendous growth in the past decades, driven largely by the pressing needs of conducting UQ analysis in many disciplines. A salient challenge in UQ is the simulation cost, as UQ computations are often orders of magnitude more expensive than the baseline deterministic analysis. For complex systems on large scale, accurate UQ analysis has not been possible for a long time. In recent years, aided by the developments from the mathematics community, a large variety of efficient UQ algorithms have emerged. The newer methods enable practitioners to perform accurate UQ analysis for many complex systems for the first time, subsequently facilitating many important tasks such as risk assessment, reliability analysis and optimization, and decision making.

In this talk we will review the state-of-the-art in UQ algorithms, highlight a few widely used methods, and draw connections with some of the statistical tools. We will also overview the current challenges and shed light on the direction to tackle the challenges.

Dongbin Xiu, University of Utah, Department of Mathematics and Scientific and Computing Institute

Dr. Xiu received his Ph.D. in Applied Mathematics from Brown University in 2004. After post-doctoral studies in Los Alamos National Laboratory, Princeton University, and Brown University, he became an Assistant Professor in the Department of Mathematics at Purdue University in 2005. In 2009, he was promoted to Associate Professor with tenure, and then to Full Professor in 2012. In 2013, he joined the University of Utah, as a Professor of Mathematics and Scientific Computing and Imagining (SCI) Institute.

His research interests include UQ methods, optimization, high-order numerical schemes, multi-scale and inverse problems for complex systems. He is the author of the first graduate-level textbook on UQ: *Numerical Methods for Stochastic Computations, A Spectral Method Approach,* published by Princeton University Press in 2010. He is the inaugural Associate Editor-in-chief of the first journal on UQ: International Journal for Uncertainty Quantification, which started printing in 2011. He is also on the editorial board of SIAM Journal on Scientific Computing, Applied Numerical Mathematics. He is the recipient of the National Science Foundation CAREER award in 2007, on his work of Design and Optimization under Uncertainty. He received several teaching awards during his time at Purdue University.

3:15 PM ***Refreshment Break*** ***WPH***

3:45 PM	***Speaker Panel Discussion***	***WPH***
4:45 PM	***Adjourn***	
6:00 PM	***Reception***	***East Mural Room***
7:00 PM	***Farewell Dinner***	***East Mural Room***
9:00 PM	***Adjourn***	