Invited Session Abstracts

Tuesday, June 5

Invited Session 1A
Tuesday, 1030am-Noon
Title: Multivariate Methods for Quality Improvement
Organizer: Connie Borror, Arizona State University
Chair: Connie Borror, Arizona State University

A Bayesian Approach to Change Point Estimation in Multivariate SPC
Steven E. Rigdon, Southern Illinois University Edwardsville
Rong Pan, Arizona State University

A Bayesian procedure is developed to estimate the time of a change in the process mean vector for a multivariate process. In addition, we can infer simultaneously which variable(s) had a change in mean value, and the value of the changed mean. All three problems (change point time, variables that shifted, and new values for the shifted variables) are addressed in a single statistical model. Markov chain Monte Carlo methods, through the software WinBUGS, are used to estimate parameters of the change point models. To identify the mean shift in a process with more than two variables, we propose a branch-and-bound search algorithm so that MCMC can be carried out with a predictable computing time in each search step. The search process is automated using R. A simulation study shows that the Bayesian approach has similar performance compared to the MLE in terms of identifying the true change point location when non-informative prior is assumed; however, it can perform better when proper prior knowledge is incorporated into the estimation procedure. The Bayesian approach provides full posterior distributions for the model and change point, which can contain information that is not available in a likelihood analysis.

Assessment of Demerits and an Ordinal Alternative
Justin Chimka and Qilu Wang, University of Arkansas

Demerits control is the traditional tool for monitoring defects of different severity with a single chart. It requires arbitrary assignment of numerical values to the ordinal scale and therefore is theoretically flawed. Opposed to demerits we assess its errors with respect to an alternative based on the proportional odds model.

A Control Chart Based On a Nonparametric Multivariate Change-Point Model

Mark Holland, Medtronic
Douglas Hawkins, University of Minnesota

Phase-II statistical process control (SPC) procedures are designed to detect a change in distribution when a possibly never-ending stream of observations is collected. Several techniques have been proposed to detect a shift in location vector when each observation consists of multiple measurements. These procedures require the user to make assumptions about the distribution of the process readings, to assume that process parameters are known, or to collect a large training sample before monitoring the ongoing process for a change in distribution. We propose a nonparametric procedure for multivariate phase-II statistical process control that relaxes these requirements.

Invited Session 1B
Tuesday, 1030am-Noon
Title: Reliability for Complex Systems
Organizer: Alyson Wilson, Institute for Defense Analysis
Chair: Christine Anderson-Cook, Los Alamos National Laboratory

Estimating Go Probabilities from Impact Accelerated Tests
Brian Weaver and Scott Vander Wiel, Statistical Sciences Group, Los Alamos National Laboratory

To ensure the safety of procedures that involve high explosives (HE), detonation probabilities are estimated for accident scenarios in which HE is assumed to suffer impacts from an anvil released from various heights. Additionally, the HE is placed on various thicknesses of a supporting material that is used to soften the impact from the anvil. These tests report the height the anvil was dropped, the thickness of the supporting material, and whether the HE detonated or not. We discuss the use of such drop tests for estimating the height for a 1% Go probability when the supporting material has a nominal thickness.

Assuring End to End Availability of Complex Systems
Abhaya Asthana, Software and Solution Reliability, Bell Labs CTO

Service unavailability represent real operating expenses to service providers via costs associated with loss of brand reputation and customer good will, higher maintenance-related operating expenses, liquidated damages and expenses of reporting major outages to governmental agencies. To ensure that suppliers deliver the end-to-end service availability and quality expected by service providers, new capabilities are required to model, measure, and evaluate the robustness and effectiveness of the complex systems over their lifecycles. The purpose of the Design for Availability framework we have developed at Bell Labs is to achieve these key quality expectations through a proactive process to both *drive* and *assess* the availability of a solution as a whole. It is a multi-release process that builds upon the Design for Reliability process for software and systems, focusing on inter network element (multi-vendor) and end to end interactions. The multi step process includes: setting targets, generating requirements, analyzing and budgeting, modeling end to end architecture, ensuring conformance via diligence on constituent network elements, validation and verification through network level robustness and stability testing. Finally, analyzing field outage data to fine tune the architecture and reliability models. The DfA framework with best in class practices helps set appropriate customer expectations, identify design weaknesses, and recommend roadmap for network evolutions.

Meta-Analysis for the Assessment of Defense System Reliability

Laura Freeman, Operational Evaluation Division, Institute for Defense Analyses

System reliability is of paramount importance to the transport, weapon, and command systems acquired by the Department of Defense. Often these systems have rigid reliability requirements because of the importance of reliability to safety. It can be cost prohibitive to conduct full up system tests to determine reliability in the operational environment. Therefore, testers often need to consider data from multiple testing phases, which can occur in vastly different environments. Meta-analysis combines the results of several studies into one analysis but has traditionally been applied to normally distributed data. This talk proposes a meta-analysis approach to estimating reliability. Two case studies demonstrate potential benefits and pitfalls of the suggested analyses.

Invited Session 1C
Tuesday, 1030am-Noon
Title: What's New in Fractional Factorial Designs?
Organizer: Bobby Mee, University of Tennessee
Chair: Bobby Mee, University of Tennessee

Examples of Efficient Design with Minimal Aliasing
Bradley Jones, SAS and Universiteit Antwerpen

For some experimenters, a disadvantage of the standard optimal design approach is that it does not take into account the aliasing of specified model terms with terms that are potentially important but are not included in the model. For example, an optimal design for a first-order model may unnecessarily alias main effects and interactions. Designs so generated may be globally optimal for estimation of the primary effects of interest, yet have undesirable aliasing structures. This talk introduces the concept of alias optimal design and provides a number of examples showing their advantages in practice.

Compromise Blocking Schemes for Two-Level Fractional Factorial Designs with Clear Two-Factor Interactions
Hongquan Xu, UCLA

Experimenters often face the practical problem of choosing good fractional factorial designs and blocking schemes when the experimental units are heterogeneous. Minimum aberration blocked designs in the literature do not always meet the practical need when some two-factor interactions are required to be estimated clearly. A two-factor interaction is clear if it is neither aliased with any main effect or any other two-factor interaction nor confounded with any block effect. A factor is clear if any two-factor interaction involving it is clear. Motivated by a real problem, we consider compromise blocked designs with maximum number of clear factors and construct such blocked designs with 32 and 64 runs. Theses compromise blocked designs are often different from minimum aberration blocked designs. Some of these compromise blocked designs also have the maximum number of clear two-factor interactions.

Double Semifolding 2^(k-p) Designs

David Edwards, Virginia Commonwealth University

Commonly used initial screening experiments are resolution III and IV 2^(k-p) designs that necessarily alias lower-order effects. The addition of another fraction to an initial experiment may therefore be needed to resolve ambiguities involving aliasing. The choice of follow-up experiment is often made based on the results of the initial experiment and/or objectives of the experimenter. When many interactions involving a number of factors are considered likely and it is difficult to determine which effects should be de-aliased, then the experimenter is likely faced with the objective of de-aliasing as many lower-order effects as possible. Foldover (requiring as many runs as the initial experiment) is one of the most widely used techniques for selecting such a follow-up experiment. However, semifolding (adding half of a foldover fraction) often permits estimation of as many terms as a foldover. In this talk, we examine the addition of two semifoldover fractions to an initial experiment (termed double semifolding) as a means of estimating even more effects. Properties of this follow-up strategy will be discussed as well as "optimal" choices based on several design criteria. Finally, the use of this technique will be examined in the context of partial replication for follow-up experiments.

Invited Session 2A
Tuesday, 4pm-530pm
Title: Customer Care
Organizer: Terry Callanan, Carestream Health
Chair: Terry Callanan, Carestream Health

Improving Customer Satisfaction Using a Proven Data-Driven, Customer-Centric Methodology
Jeff Miller, Senior VP Client Experience, 3 Day Blinds

Improving customer satisfaction is or should be one of the main objectives of companies. An improvement in customer satisfaction will result in many positive outcomes, including: increased referral business, thus increasing sales while reducing marketing costs; reduction in warranty and service recovery costs; improved employee satisfaction; reduction in training expenses; and lost market share.

Using a data-driven, customer-centric approach will provide the information necessary to improve your products, services or processes, and therefore enhance the customer experience. Actual data from 2 companies will be provided to illustrate the improvement that can be realized by using this approach.

How to Take a Fortune 200 Company and Make Satisfaction and Loyalty Matter
Jim Bampos, VP Customer Quality, EMC^2 Corporation

The talk will focus on how a product focused company recognized the importance of managing the Total Customer Experience (TCE), while continuing to grow at a record pace. The discussion will emphasize how to ensure the stakeholders of customer experience are true partners in every aspect of the relationship. Also covered will be the closed-loop process; data collection, ties to financial performance, and sharing results, and impact with the entire company. Presentation Topics will include: Total Customer Experience, EMC Stakeholders, Voice of Customer Program, EMC Transformation, Customer Journey Map, EMC Challenges, EMC Best Practices, and Unified Analytics Platform.

Cumulative Logistic Regression Models with Ordinal Explanatory Variables: Application to Customer Care Metrics
Li Guo and Daniel Jeske, University of California – Riverside
Terry Callanan, Carestream Health

Most discussions for ordinal data analyses have suggested the use of a cumulative logistic regression model. Largely ignored in these discussions is the modeling technique for dealing with ordinal independent variables. One solution to this problem is to represent the ordinal covariate by dummy variables. This strategy, however, may yield unordered parameter estimates, which contradicts intuition. The purpose of this talk is to illustrate, using a substantive example in customer care, the challenges presented when fitting a cumulative logistic model with ordinal predictors. A novel algorithm for fitting a constrained cumulative logistic regression model is then introduced. Detailed information about implementing the proposed algorithm in SAS is then presented.

Invited Session 2B
Tuesday, 4pm-530pm
Title: Modern Reliability for Field Analysis
Organizer: Ming Li, GE Global Research
Chair: Ming Li, GE Global Research

Balancing Multi-Level Reliability Models to Maximize Service Contract Profitability
Brock Osborn and Kati Illouz, GE Global Research

In order to be most effective in services applications, reliability models should take a multi-level approach. This involves viewing the system hierarchically and analyzing the data in multiple contexts. This presentation will explore both the theoretical and practical aspects of this approach to services modeling and will provide examples of its application in various business settings.

Integrated Reliability Centered Maintenance Programs for the Designs of Power Plants
I-Li Lu, Boeing Research & Technology

In nuclear fusion power plant development, a RCM based program can be integrated in the design to ensure safety requirements are met with efficient process that minimizes maintenance costs. The key concept for achieving the goals is to develop a RCM based estimating model that helps break the big technology change into manageable pieces of known value, and iterating the process. The iterative process helps assure that any missteps are minor and can be recovered from quickly and at minimal cost. We illustrate how we may utilize concepts in statistics to assist physicists and business groups to establish program goals as well as objectives, provide solutions, and guide their reliability programs to comply with regulatory requirements.

Photodegradation Path Modeling and Analysis with Nonlinear Mixed Models
Yili Hong, Virginia Tech
William Q. Meeker, Iowa State University]

Photodegradation caused by ultraviolet (UV) radiation is a primary cause of failure for coatings, as well as many other products made from organic materials exposed to sunlight. Other environmental factors including temperature and humidity also have effect on the degradation process. Identifying a physically motivated model that can adequately describe the degradation path is an important step in service life prediction of such coatings. The model should also incorporate the effects of explanatory variables such as, the UV spectrum, UV intensity, temperature and humidity. In this paper, we use a nonlinear mixed model to describe the data because the degradation path is nonlinear function of time. Random effects are also used to account for unit-to-unit variability. The parameters in the model are estimated by maximum likelihood approach. The effects of the explanatory are extensively studied. The developed method is applied to accelerated laboratory test data for a specific coating, in which spectral UV wavelength and intensity, temperature, and relative humidity are controlled over time. We also extend our model to allow for time-varying covariates and apply the method to outdoor test data where the explanatory variables are uncontrolled.

Invited Session 2C
Tuesday, 4pm-5:30pm
Title: Design and Analysis of Computer Experiments
Organizer: Peter Qian, University of Wisconsin - Madison
Chair: David Edwards; Virginia Commonwealth University

Gaussian Process Enhanced Importance Sampling
Keith R. Dalbey and Laura P. Swiler, Sandia Labs

Importance sampling is a biased sampling method used to sample random variables from different densities than originally defined. These importance sampling densities are constructed to pick "important" values of input random variables to improve the estimation of a statistical response of interest, such as a probability of failure. The samples taken from the importance density must be appropriately weighted so that the resulting statistical estimates are unbiased. Conceptually, importance sampling is very attractive: For example one wants to generate more samples in a failure region when estimating failure probabilities. In practice, however, importance sampling can be challenging to implement efficiently, especially in a general framework that will allow solutions for many classes of problems. We are interested in importance sampling as applied to computationally expensive finite element simulations which are treated as "black-box" codes where we may not have much prior knowledge about the multivariate importance density.

We present an importance sampler that is used after an initial set of Latin Hypercube samples has been taken. The importance sampler uses a Gaussian process surrogate. The approach is adaptive in the sense that the Gaussian process suggests additional sample locations for simulator runs to help refine a failure probability estimate. The Gaussian process estimator is used in the calculation of the importance density, and a mixture model is used to combine information from the sequence of Gaussian process emulators developed in the algorithm. In this paper, we present the approach, discuss implementation details, provide the results for some test problems, and demonstrate the approach on a case study.

Fitting the Gaussian Process Model to Optimize Predictive Capability
Kathryn Kennedy, Arizona State University

Gaussian process modeling is a common metamodeling methodology applied to computer experiments, particularly attractive because as an interpolator it guarantees that the model will match the observed output at each of the observed points. Typically the models are fit using maximum likelihood estimation (MLE), which may not always provide for a good predictive model. An alternative method of model estimation has been proposed that will use an iterative search, with the goal of setting the correlation parameters to values that minimize the sum of the squares of the jackknife residuals. The resulting method will not necessarily be less computationally intensive, but may provide a better fit to the data and improve the predictive capability of the model. This criterion makes intuitive sense, because rather than optimizing the fit of the model to the data you already have, the algorithm would help to optimize the fit for new data. Given that the goal of the fitted model is often to act as a surrogate for the simulation model, optimizing the predictive ability is an attractive prospect. The algorithm will be tested and compared to traditional MLE fits, under scenarios where MLE is known to perform well and where it has fallen short.

Samurai Sudoku-Based Space-Filling Designs
Peter Qian, University of Wisconsin - Madison

Samurai Sudoku is a popular variation of Sudoku. The game-board consists of five overlapping Sudoku grids; for each of which several entries are provided and the remaining entries must be filled subject to no row, column and three-by-three subsquare containing duplicate numbers. By exploiting these uniformity properties, we construct a new type of design, called a Samurai Sudoku-based space-filling design, intended for ensembles of multiple computer models. Such a design can be divided into groups of subdesigns such that the complete design, each subdesign and each overlapped portion achieve maximum uniformity in both univariate and bivariate margins. Examples are given for illustrating the proposed designs.

Wednesday, June 6

Invited Session 3A
Wednesday, 1030am-Noon
Title: Applications of SPC to Survival Analysis
Organizer: Emmanuel Yaschin, IBM
Chair: Bill Woodall, Virginia Polytechnic Institute

Monitoring Time to Failure Events
Stefan Steiner, University of Waterloo, Waterloo, Canada

Monitoring medical outcomes is useful to help quickly detect performance deterioration. Previous methods have incorporated the risk adjustment needed to allow for patient heterogeneity, but have focused mostly on binary outcomes, such as 30-day mortality after surgery. However, in many applications survival time data are routinely collected. In this talk we describe an updating exponentially weighted moving average (EWMA) control chart to monitor risk-adjusted survival times. The updating EWMA (uEWMA) operates in continuous time so as to always reflect the most up-to-date information. The uEWMA can be implemented based on a variety of survival time models and can be set up to provide an ongoing estimate of a clinically interpretable average patient score. The efficiency of the uEWMA in detecting process changes is shown to compare favorably to competing methods.

Guaranteed Conditional Performance of Control Charts via Bootstrap Methods
Axel Gandy, Imperial College, London, United Kingdom

To use control charts in practice, the in-control state usually has to be estimated. This estimation has a detrimental effect on the performance of control charts, which is often measured for example by the false alarm probability or the average run length. We suggest an adjustment of the monitoring schemes to overcome these problems. It guarantees, with a certain probability, a conditional performance given the estimated in-control state. The suggested method is based on bootstrapping the data used to estimate the in-control state. The method applies to different types of control charts, and also works with charts based on regression models, survival models, etc. We show large sample properties of the adjustment. The usefulness of our approach is demonstrated through simulation studies.

On Monitoring Survival and Warranty Data
Emmanuel Yashchin, IBM Research Division, Yorktown Heights, NY, USA

We discuss situations where data correspond to a sequence of lifetime tests with censoring. Data structures of this type arise in a number of applications, such as reliability testing and warranty analytics. One of the key problems is detection of unfavorable changes in parameters of the underlying lifetime distribution. In this talk we discuss this problem in the framework of the likelihood ratio tests. The issues we address include charting, design of control procedures and alarm prioritization. We discuss applications related to reliability monitoring of computer components.

Invited Session 3B
Wednesday, 1030am-Noon
Title: Modern Methods for Finding Clusters in Data
Organizer: Ery Arias-Castro, University of California – San Diego
Chair: Xinping Cui, University of California – Riverside

Scalable Detection of Anomalous Patterns with Connectivity Constraints
Skyler Speakman, Edward McFowland III, and Daniel B. Neill, Carnegie Mellon University

We present GraphScan, a novel method for detection of arbitrarily-shaped connected clusters in graph or network data. Given a graph structure, data observed at each node, and a score function defining the anomalousness of a set of nodes, GraphScan can efficiently and exactly identify the most anomalous (highest scoring) connected subgraph. Kulldorff's spatial scan statistic, which searches over circular regions, has been extended to include connectivity constraints by the flexible scan statistic (FlexScan). However, FlexScan performs an exhaustive search over all connected subsets: its run time scales exponentially with the neighborhood size k, making it computationally infeasible for $k > 30$. Alternatively, the Upper Level Set (ULS) scan statistic scales to large graphs but is not guaranteed to find the highest scoring subset. We demonstrate that GraphScan is able to scale to graphs an order of magnitude greater than FlexScan, while still identifying the highest scoring subgraph. We examine the detection power of GraphScan using simulated disease outbreaks injected into real-world Emergency Department data. Our results demonstrate that GraphScan improves detection power by accurately identifying irregularly shaped clusters, and can scale up to much larger regions than FlexScan, requiring under a minute of computation time for each day of data.

Clustering on Longitudinal Data Using Penalized Splines and Pseudo Likelihood
Xinping Cui, Nigie Shi and James Borneman, University of California – Riverside

This work is motivated by a study to identify and characterize associations between microorganisms and human health and disease processes for which the numbers of multiple operational taxonomic units (OTU) are measured over time for multiple subjects. It is of great interest to identify clusters of OTU showing similar changes over time since they may represent organisms that are working in a coordinated manner to perform the functional process. Combining penalized splines and pseudo likelihood method, we developed a generalized-linear-mixed model based clustering procedure. We examined the accuracy of parameter estimation and clustering through simulation studies and demonstrated satisfactory result.

Co-clustering Spatial Data Using a Generalized Linear Mixed Model with Application to Integrated Pest Management

Zhanpan Zhang, Daniel R. Jeske, Xinping Cui, and Mark Hoddle, University of California – Riverside

Co-clustering has been broadly applied to many domains such as bioinformatics and text mining. However, model-based spatial co-clustering has not been studied. In this paper, we develop a co-clustering method using a generalized linear mixed model for spatial data. To avoid the high computational demands associated with global optimization, we propose a heuristic optimization algorithm to search for a near optimal co-clustering. For an application pertinent to Integrated Pest Management, we combine the spatial co-clustering technique with a statistical inference method to make assessment of pest densities more accurate. We demonstrate the utility and power of our proposed pest assessment procedure through simulation studies and apply the procedure to studies of the persea mite (*Oligonychus perseae*), a pest of avocado trees, and the citricola scale (*Coccus pseudomagnoliarum*), a pest of citrus trees.

Invited Session 3C
Wednesday, 1030am-Noon
Title: Design of Experiments for Test and Evaluation
Organizer: Rachel Silvestri, Naval Postgraduate School
Chair: Doug Montgomery, Arizona State University

Sequential Experimentation with Cost-constrained Response Surface Designs
Brian Stone and Ira A. Fulton, Arizona State University

Custom experimental designs are commonly used when experimental constraints prevent the use of orthogonal designs or more standard alternatives. While many standard response surface designs such as the central composite design permit sequential experimentation, custom designs generated by software are not created to be run in multiple experimental stages. We present a methodology for creating a cost-constrained experimental design which can be built sequentially from a screening experiment followed by runs to estimate quadratic effects. The sequential experimentation custom design is constructed with a coordinate exchange algorithm. Multiple optimization criteria, which vary according to the purpose of a particular experimental stage, are evaluated using the Pareto front approach.

An Empirical Model Development and Data Validation Effort for Missile Fragment Flash Characterization
Raymond Hill, Air Force Institute of Technology

Fires in aircraft can be catastrophic; fire prevention is the design discipline focused on avoiding the catastrophes due to fires. Aircraft fires are generally examined in three areas of the aircraft: the engine bays, the dray bay areas, and the vapor spaces around the fuel tanks. A fire protection design engineer is currently limited in their analysis of fire effects when the cause of those fires is ballistic impacts, such as from missile fragments. Ballistic fragment impacts against aircraft can cause fire flashes both on the outside of the aircraft and, upon penetration of the aircraft skin, inside the aircraft fuselage. Modeling of the ballistic impact flash is insufficient and current design practice seems focused on expert opinion of a flash event. We discuss the data collection, data processing and model development of a impact flash characterization for both entry side and exit side (inside the aircraft) ballistic impact flashes. We also discuss model validation efforts based on live-fire test and future plans for model extensions. The model presented has been transitioned into the analytic suite of tools used by fire protection design engineers.

Quantifying Gains Using the Capabilities-Based Test and Evaluation Method

Eric J. Lednicky and Rachel T. Silvestrini, Naval Postgraduate School

Today's military operating environments are more operationally diverse and technically challenging. Fielding relevant weapons systems to meet the demands of this environment is increasingly difficult, prompting policy shifts that mandate a focus on systems capable of combating a wide threat range. The Capabilities-Based Test and Evaluation (CBT&E) construct is the Department of the Navy's effort to concentrate on integrated system design with the objective of satisfying a particular operational response (capability) under a robust range of operating conditions. One aspect of CBT&E is the increased employment of advanced mathematical and statistical techniques in the Test and Evaluation (T&E) process. This case study illustrates advantages of incorporating these invaluable techniques, Design of Experiments (DOE) and Modeling and Simulation (M&S), within the T&E process. We found through statistical analysis that the application of DOE concepts to the System Under Test (SUT) throughout three primary phases of T&E quantifiably improved the accomplishment of the selected response variable of interest.

Invited Session 4A
Wednesday, 4pm-530pm
Title: Bayesian Methods in Quality
Organizer: James Flegal, University of California – Riverside
Chair: Mark Holland, University of Minnesota

A Bayesian Comparative Analysis of Neuronal Point Processes
Sam Behseta, California State University, Fullerton

Neurophysiological studies often involve in-vivo examination of the spiking activity of neurons following various external stimuli. These investigations typically attempt to identify neurons that have condition-related differences among firing-rate functions; population-level differences across conditions; and neurons that exhibit interesting patterns of temporal difference across conditions. We discuss a series of Bayesian modeling strategies for point processes associated with neuronal firings, primarily to address the inferential problem of comparing neuronal spiking patterns.

Bayesian SPC for Autocorrelated Processes that are Subject to Random Jumps
Panagiotis Tsiamyrtzis, Athens University of Economics and Business, Greece
Douglas Hawkins, University of Minnesota

In this work we will provide a monitoring scheme for the mean of an autocorrelated process which can experience bidirectional jumps of random size and occurrence and has a steady state. Our interest focuses in the start up phase and short-run scenarios, where traditional SPC techniques fail to provide formal testing. Furthermore, we will provide a framework where prior information regarding the process can be employed. These will be achieved by adopting a Bayesian sequentially updated scheme that will allow inference in an online fashion. A real data application from the dairy business will illustrate the model capabilities.

MCMC: Can We Trust the Third Significant Figure?
James M. Flegal, University of California – Riverside

Current reporting of results based on Markov chain Monte Carlo computations could be improved. In particular, a measure of the accuracy of the resulting estimates is rarely reported. Thus we have little ability to objectively assess the quality of the reported estimates. We address this issue in that we discuss why Monte Carlo standard errors are important, how they can be easily calculated in Markov chain Monte Carlo and how they can be used to decide when to stop the simulation. We compare their use to a popular alternative in the context of two examples.

Invited Session 4B
Wednesday, 4pm-5:30pm
Title: Statistical Engineering – Case Studies
Organizer: Christine Anderson-Cook, Los Alamos National Laboratory
Chair: Peter Parker, NASA Langley

Statistical Engineering to Stabilize Vaccine Supply
Julia O'Neill, Merck

Reliable vaccine supply is a critical public health concern. Traditional statistical methods are being applied by manufacturers to improve the reliability of supply. The autocorrelation and variability inherent to biological processes present some special challenges. An example will be shared in which statistical engineering was applied to develop custom control and monitoring methods. For this vaccine, long-term variability has been reduced by one-third, with additional improvements underway. The stability of other manufacturing processes could be improved by applying the same analysis, standardization, and monitoring approaches.

Statistical Engineering Perspective on Planetary Entry, Descent, and Landing Research
Sean Commo, NASA Langley

Statistical engineering emphasizes developing and leveraging statistical methods and tools to help identify and solve large, complex problems. Within NASA, these large, complex problems are known as the agency's "Grand Challenges". Research in planetary entry, descent, and landing technologies is one of these challenges and is an expensive, resource-intensive endeavor that benefits from the rigorous approach of statistical engineering. This talk highlights the contributions of statistical engineering to the Mars Science Laboratory mission and more generally, planetary entry, descent, and landing research. For example, a new approach utilizing response surface methods was developed for characterizing a complex measurement system. In addition, we reflect on areas where early implementation of a statistical engineering approach can increase the overall impact of the highest level research objectives.

Modeling the Reliability of Complex Systems with Multiple Data Sources: A Statistical Engineering Case Study
Christine M. Anderson-Cook, Los Alamos National Laboratory

Estimating the reliability of complex systems with many parts and components often involves using multiple data sources, including expensive full system tests, as well as less expensive subsystem and component level tests. Using statistical methodology developed by the Statistical Sciences Group at Los Alamos National Laboratory, a process for estimating and predicting future reliability was developed. A multi-phase software tool, SRFYDO, was developed to make this process accessible and understandable to the system engineers who need to perform these analyses. In this talk, we present a short overview of the method, but focus on how the software was developed to incorporate multiple statistical tools with the goal of guiding engineers through an analysis.

Invited Session 4C
Wednesday, 4pm-530pm
Title: Measurement System Assessment
Organizer: Stefan Steiner, University of Waterloo
Chair: Joanne Wendelberger, Los Alamos National Laboratory

Assessing a Binary Measurement System with Varying Misclassification Rates
Stefan H. Steiner, Oana Danila, and R. Jock MacKay, University of Waterloo, Canada

Binary measurement systems (BMS) are commonly used as diagnostic tools in medicine and inspection systems in industry. Understanding their properties is essential to making correct decisions with these systems. In this talk we consider the situation where we wish to assess the BMS and estimate its misclassification rates and a gold standard measurement is available (only for the assessment). We propose an analysis of BMS assessment data using a random effects model that allows the misclassification rates to vary from part to part. This modeling approach is more realistic than the usual assumption that all good (bad) parts have the same misclassification rate since, in practice, there are usually some parts that are easy to correctly classify while other parts are more difficult. We consider both a standard plan where parts for the study are selected at random from regular production and a conditional sampling plan where we select at random only from parts previously failed.

Assessment of Automated Data Acquisition and its Effects on Bacterial Profiling
Todd Sandrin and Connie M. Borror, Arizona State University

The development of rapid and accurate methods to identify and characterize microorganisms is critically important in medicine, food safety and microbiology, counter bioterrorism, and environmental monitoring. Conventional methods can be time-consuming and not readily scalable to high-throughput applications. The use of matrix-assisted laser desorption/ionization (MALDI) time-of-flight mass spectrometry (TOFMS) has emerged as a promising tool to rapidly profile bacteria at the genus and species level and, more recently, at the sub-species (strain) level. Recently, it has been proposed that the MALDI approach can be enhanced with regard to reproducibility and throughput by automating data acquisition. In this presentation, we illustrate how automation can negatively affect the performance of this approach. Results of a reproducibility study comparing automation and two operators will different levels of experience are presented.

Assessing Properties of a Predictive Distribution Subject to Measurement Error

Brian Weaver, Los Alamos National Laboratory

When measurement systems are assessed, a measurement standard is used to determine a system's bias, its precision, or other quality characteristics. We define a measurement standard (standard for short) as an item whose true value is approximately known. The true value of a standard is not known perfectly and an uncertainty value is associated with it. With most measurement devices, this uncertainty can be ignored and the standard's value is assumed to known perfectly. For highly precise measurement systems, these uncertainty values associated with standard must be accounted for. In this talk we will assess calorimeters in servo mode (a highly precise system) by estimating a predictive distribution of a future measured value by accounting for not only the measurement error from the calorimeter, but also the uncertainty in the standard.

Thursday, June 7

Invited Session 5A
Thursday, 830am-10am
Title: Multivariate Quality Control
Organizer: J. Marcus Jobe, Miami University (Ohio)
Chair: J. Marcus Jobe, Miami University (Ohio)

New Nonparametric Multivariate CUSUM Control Charts for Location and Scale Changes
Xin Zhang, Jun Li, and Daniel R. Jeske, University of California – Riverside

With the manufacturing process becoming more and more complicated, there are many situations in which monitoring multiple quality characteristics is necessary. In most cases, these quality characteristics are correlated, so multivariate control charts are needed to monitor these quality characteristics simultaneously. Among different multivariate control charts, multivariate cumulative sum (CUSUM) control charts are the popular choice for detecting small and moderate changes in the manufacturing process. However, most of CUSUM procedures in the literature were developed under the multivariate normality assumptions, which is usually difficult to justify in practice. Therefore, nonparametric multivariate CUSUM procedures are more desirable. In this talk, we will present two new nonparametric multivariate CUSUM procedures based on the spatial sign and data depth for detecting location and scale changes. These two procedures can be considered as the nonparametric counterparts of the two parametric multivariate CUSUM procedures developed in Crosier (1998). We will discuss the properties of the two procedures and demonstrate their performance by comparing with the existing CUSUM procedures in a variety of simulation settings.

Modified M-estimates for Model-based Cluster Identification in Multivariate Control Charts
Karel Kupka. TriloByte Statistical Software

Frequent presence of unexpected values and outlying measurements has justified and supported the use and development of various robust methods and approaches in data analysis of technology and quality data (Tukey). One of the most used robust M-estimators (Huber) suggests an iteratively applied weight function to suppress influence of distant points in the sample space. The distance measure is usually based on some initial estimate of location. The convergence of iterative procedure may however depend on the initial estimate. Replacing this point estimate with some simple (e.g. normal or rectangular) distribution represented by a MC-generated set leads to a set of different locally optimal robust M-estimates with “local“ breakdown point higher than 0.5. This process can be viewed as a clustering procedure with cluster centers in the local M-estimates. It is shown that for certain values of the weight function constants the M-estimators split due to multimodality of the Huber object function. The cluster centers can be represented by univariate or multivariate M-estimates of location or generalized to coefficients of multiple linear regression models. Use of the procedures is demonstrated on the analysis of multivariate geometrical data from automotive industry.

An MCD and Cluster-based Monitoring Scheme for Retrospective Multivariate Individuals Process Data

J. Marcus Jobe. Miami University (Ohio)
Michael Pokojovy, Fachbereich Mathematik und Statistik, Universitat Konstanz, Germany

Multiple out-of-control points from individual multivariate process data significantly reduce the ability of the classical retrospective Hotellings T2 statistic to effectively detect an unstable process. To overcome this masking effect, we propose a computer-intensive cluster-based approach that incorporates the minimum covariance determinant (MCD) method of Rousseeuw with a multi-step cluster-based algorithm that initially filters out potential masking points. Compared to the most robust procedures, simulation studies show that our new method is usually better for two dimensions at detecting randomly occurring outliers as well as outliers arising from sustained shifts in the process location. Additional real data comparisons are given. Supplemental materials are available online.

Invited Session 5B
Thursday, 830am-10am
Title: Statistical Engineering – Successes and the Path Forward
Organizer: Christine Anderson-Cook, Los Alamos National Laboratory

QPRC Invited Panel: Statistical Engineering – Successes and the Path Forward

Panelists:

Connie Borror, Arizona State University
Bradley Jones, JMP Division of SAS
Peter Parker, NASA Langley

Statistical Engineering is defined as "the collaborative study and application of the tactical links between statistical thinking and statistical and discipline-specific tools with the objective of guiding better understanding of uncertainty in knowledge and decision-making to generate improved results to benefit the organization and/or society." Based on their experiences in academia, industry and government, the panelists will discuss examples of some of the key elements needed for successful implementation, as well as some of the important challenges that lie ahead for Statistical Engineering to emerge as a full-fledge discipline which complements the contributions of Statistical Science.

Invited Session 5C
Thursday, 830am-10am
Title: Biosurveillance
Organizer: Ron Fricker, Naval Postgraduate School
Chair: Daniel R. Jeske, University of California – Riverside

Digital Disease Detection
Taha Kass-Hout, The Centers for Disease Control and Prevention

BioSense 2.0 is a nationwide biosurveillance system designed to assist public health authorities with detecting and tracking disease outbreaks. It integrates data from health departments, hospital emergency departments, outpatient clinics, pharmacies, laboratories, and others, to provide insight into the health of communities and the country. Such timely data are vital and help guide decision making and actions by public health agencies at local, regional, and national levels. This talk will describe the BioSense 2.0 system, including its general architecture and algorithmic design, and it will discuss some of the open research questions and challenges in conducting near real-time disease surveillance.

Optimizing Biosurveillance Systems
Ronald D. Fricker, Jr., Naval Postgraduate School

An excessive number of false positive signals is a problem in many biosurveillance systems. This talk will describe a methodology for setting Shewhart chart thresholds that maximizes the system-wide probability of detecting an "event of interest" subject to a constraint on the expected number of false signals. Using this approach, public health officials can "tune" biosurveillance systems to optimally detect various threats. The approach is also relevant to industrial quality control.

A Comparison of Likelihood-based Spatiotemporal Surveillance Methods under Non-homogeneous Populations
Sung Won Han, University of Pennsylvania

Motivated by the applications in healthcare surveillance, this presentation discusses the spatiotemporal surveillance problem of detecting the mean change of Poisson count data under non-homogeneous populations. Through Monte Carlo simulations, we investigate several likelihood ratio-based approaches and compare them under various scenarios depending on the factors such as the population trend, the change magnitude, the change coverage, and the change time.

Invited Session 6A
Thursday, 1030am-Noon
Title: Robust Methods for SPC
Organizer: Karel Kupka, TriloByte Statistical Software
Chair: Karel Kupka, TriloByte Statistical Software

Robust Adaptive Control Charts
Gejza Dohnal, Czech Technical University, Prague, Czech Republic

To achieve better properties of sequential detection scheme in statistical process control, we use adaptive control charts with floating time period between inspections. In our design, we use a robust estimator for the next expected value of given process to determine next time point for inspection.

Diagnostics of the Robustied Least Squares
Jan Ámos Víšek, Charles University, Prague, Czech Republic

Previous research has addressed many topics concerning least weighted squares, instrumental weighted variables, and weighted total least squares. However, the basic problems of significance of explanatory variables or testing sub-models has not yet considered in heteroscedastic situations. That is the topic of the present contribution.

Computer Intensive Approach to the Evaluation of Cotton Yarns Complex Quality
Jiří Militký, Dana Křemenáková, Technical University Liberec, Czech Republic

One of the main tasks in characterization of the cotton yarn complex quality index is proper combination of individual yarn properties according to their usefulness in weaving mills. This index can be simply created based on the complex quality indices. The construction of this type of criterion by using weighting based on the Uster statistics is shown. The application is demonstrated on the example of rotor cotton yarns with different fineness and twist coefficients produced in Czech Republic. The influence of cotton fiber quality index on the quality index of cotton yarns is discussed as well.

Invited Session 6B
Thursday, 1030am-Noon
Title: Quality in Medical Sciences
Organizer: Alan Safer, California State University – Long Beach
Chair: Larry Bartkus, Edwards Life Science Quality Assurance

Demonstrating Changes in a Process
Larry Bartkus, Edwards Life Science Quality Assurance

A comparison will be made of Individual and Moving Range Charts, Exponential Weighted Moving Average (EWMA) Charts and CUSUM Charts. The advantages and disadvantages of the various approaches need to be understood in order to choose the most appropriate method when evaluating process data.

Capability Analysis for Balancing Cost with Quality
John A. Gomez, Beckman Coulter

There are many examples where Capability Studies and their associated indices such as Cpk and Ppk are used to understand a process's current and long term performance, to determine cost of quality, and to compare processes, equipment, and suppliers. It is very well known that "centering" your process, when possible, is the best way to quickly improve your capability and overall quality. But is that always the best decision? How can capability analyses be used to set targets, understand the cost of "higher" quality, and optimize process specifications to balance cost with customer expectations and regulatory requirements?
This talk will briefly explain process capability analyses and then cover a few case studies from the food and beverage industry as well as the medical device industry to highlight how this tool assisted in the optimization of fluid filling processes.

Design of Experiments for the Medical Device Industry
Larry Bartkus, Edwards Life Science Quality Assurance
Linda Howe Garriz, Alcon

There are many practical applications where good Design of Experiments can be used to resolve issues and optimize processes in medical device design and manufacture. An overview of case studies showing some practical applications will be presented here.

Invited Session 6C
Thursday, 1030am-Noon
Title: SmartGrid Reliability
Organizer: Meng-Lai Yin, California State Polytechnic University, Pomona
Chair: Allon Percus, Claremont Graduate University

Highly-Distributed Generation, Storage, and Automation in the Electric Utility Grid
Brian Hagerty, Claremont Graduate University

Improving the quality, efficiency, reliability and profitability of energy production depends on upgrading and integrating a number of advanced technology components in the evolving electric utility grid. In this presentation the effects of highly-distributed energy generation and storage located at the end-using customer's premises will be examined, as well as the role of demand-side automation of local generation and storage

Hybrid Optimization for Grid Design
Mark Wilson, San Diego State University

The development of a power system based on renewable resources requires an appropriately designed power grid. This has become increasingly important as the transfer from non-renewable to renewable energy sources has become widespread. We describe work performed as part of a 2010-11 Mathematics Clinic project with Los Alamos National Laboratory and Claremont Graduate University, optimizing the power grid design by minimizing the combined costs of transmission line placement and power loss. We present a hybrid approach for the optimization problem, combining the discrete method of genetic algorithms with a continuous Newton's method.

Optimizing Transmission Expansion for Renewable Energy
Son Doan and Aisha Najera, Claremont Graduate University

California's Renewable Portfolio Standard (RPS), requiring 33% of annual energy production to come from renewable sources, has spurred a boom in the construction of generation facilities. We have been working with Southern California Edison on the challenge of adapting the existing power grid to accommodate these renewable sources. Building on a model previously developed with Los Alamos National Laboratory, we address the problem of where to expand transmission capacity and build new substations while minimizing costs, maximizing efficiency, and meeting the RPS requirements.

Optimal SONET Ring Architecture for Best Reliability – A Modeling Approach
Meng-Lai Yin, California State Polytechnic University, Pomona

Synchronous Optical Network (SONET) technology can provide reliable networks, and SONET ring architecture has been widely applied in power grid communications. This presentation addresses the issues of finding optimal network topology, based on SONET ring architecture, for best reliability. Continuous time Markov models are constructed and the lessons learned are used to guide and develop heuristic algorithms.