2008 ASA QPRC
Contributed Session Abstracts

THURSDAY, JUNE 5

8:30 – 10:00 AM

(CCS1) Contributed Session - Statistical Process Control

Title: Profile Monitoring Analysis Using Semiparametric Methods
Speaker: Abdel-Salam G. Abdel-Salam, Virginia Polytechnic Institute and State University
Co-Author: Jeffrey B. Birch, Virginia Polytechnic Institute and State University

Abstract: Profile monitoring is a relatively new technique in quality control best used where the process data follow a profile (or curve) at each time period. The majority of previous studies in profile monitoring focused on the parametric modeling of either linear or nonlinear profiles, with both fixed and random-effects, under the assumption of correct model specification. Our work considers those cases where the parametric model for the family of profiles is unknown or, at least uncertain. Consequently, we consider monitoring profiles via two methods, a nonparametric method and a semiparametric procedure that combines both parametric and nonparametric profile fits, a procedure we refer to as model robust profile monitoring (MRPM). We speculate that both methods will be robust to the common problem of model misspecification. Also, we incorporate a mixed model approach to both the parametric and nonparametric model fits. As a consequence, it is speculated that both the nonparametric method and the MRPM method will result in charts with good abilities to detect changes in Phase I data and have simple to calculate control limits. The new methods should provide greater flexibility and efficiency over current parametric methods used in profile monitoring that rely on correct model specification, an unrealistic situation in many practical problems in industrial applications.

Speaker: Jim Alloway
Title: Visual Teaching Aid for Control Charts and Capability Measures

Abstract: Control charts are the fundamental tool for managing and improving processes, but many students are intimidated by the classroom presentation. To reduce this apprehension and provide a more hands on approach, a unique teaching aid is introduced. Students collect data and plot it on a special surface. They begin with a simple time series plot, then progress to a run chart, and finally a control chart as they collect more data. We show how special cause variation is more reliably detected as we progress through these three charts.

Most students have difficulty distinguishing between control limits and specification limits. This teaching aid places the voice of the customer on one axis, the voice of the customer on a second, and then creates a third axis where the VOC and VOP meet to form measures of process capability. This approach addresses the admonition to never display control limits and specification limits on the same chart. Short term capability measures can be determined visually with this approach.

Speaker: Xuan Huang, University of Massachusetts - Amherst
Title: Model-Based Multivariate Monitoring Charts for Autocorrelated Processes
(Joint work with Soren Bisgaard)

Abstract: Modern statistical quality control often involves simultaneously monitoring several correlated product or process variables. Hotelling's T^2 control chart is the standard tool used. However, this method assumes temporal independence and stationarity of the data, an assumption that is frequently violated. Consequently autocorrelation may seriously impact the performance or evaluation of the chart. For univariate process monitoring of processes that exhibit serial correlation, it has been proposed to use a special cause control chart based on plotting the residuals after fitting a univariate time series model. In this presentation we generalize this idea to multivariate time series data. Instead of using a Hotelling's T^2 control chart applied directly to the observed data, we propose applying the Hotelling's T^2 to the residuals after fitting a multivariate time series model. The Average Run Length (ARL) performance of these two methods are compared for a group of first order vector autoregressive models with different parameters. We conclude that the residual based method in most cases performs favorably relative to using Hotelling's T^2 chart on the raw data. However, since neither method seems uniformly superior a suggestion would be to combine the two to enhance the performance of Hotelling's T^2 chart. In parallel, a common cause chart on fitted data is also introduced to aid process adjustments.

Title: Improving the Applications of Sequential Sampling Methods to Entomological Problems and other Areas
Speaker: Payal K. Shah, Department of Statistics, University of California - Riverside
Co-Author: Daniel R. Jeske, Department of Statistics, University of California – Riverside

Abstract: Wald's SPRT is widely used in pest management where the data is assumed to follow iid univariate one-parameter distributions. These restrictive assumptions are not met in practice. Data that we collected on a pest affecting the Citrus groves of the San Joaquin Valley in Central California demonstrates the need to account for covariates (e.g., the size of the sampling units) that are correlated with the number of pests. This complication introduces nuisance parameters and non-identically distributed observations. In this paper, we aim to address three things; first we would like to introduce to the field of Entomology the use of Bartlett's SPRT as a solution for handling nuisance parameters. Second, we propose to account for non-identically distributed observations by incorporating generalized linear models into a multivariate modeling framework for the covariates and pest count data. Finally, we compare our proposed approach of combining Bartletts SPRT with multivariate GLM's to Wald's SPRT under the fallacious assumption of univariate iid observations to quantify the advantages gained by utilizing covariate information.

Title: A kolmogorov-smirnov type statistic to test the randomness control chart data
Speaker: Dr. John L. Stedl, Professor of Information Systems, Chicago State University

Abstract: The great Edward Deming divided variation into two classes: common and special. Common variation is the natural underlying variation of the process, i.e., the randomness of the process; special variation is due to factors which are causing additional variation. Unfortunately, this signal is "buried" in the noise (common variation) and can be difficult to detect day to day. Control chart data pose the question: "Is it random?"

The August, 2007 issue of The American Statistician (pp 189-200) speaks to the heart of this issue in their reviews of Nassim Taleb's books: *The Black Swan: Impact of the Highly Improbable* and *Fooled by Randomness: The Hidden Role of Chance in Life and in the Markets.* One reviewer states that Taleb believes that the best rationale for why some events happened is truly randomness.

The Wald-Wolfowitz runs test is the default test nonparametric test for this purpose and is commonly found in statistical software packages, Minitab and StatTools for instance. My new test turns out to be a Kolmogorov-Smirnov (K-S) type statistic. In the time ordered sequence, values above the median are replaced with +1 and those below the median with -1, then graphing the corresponding sequence of partial sums. The test statistic is the maximum distance from the x-axis or appropriate center line if the number of +'s is not equal to the number of –'s. Large deviations above or below the center line suggest a lack of randomness in the data. Formally, one rejects the hypothesis of randomness if the plot reaches a maximum level k from the center line, where k is determined by fixing the type I error probability. The critical values turn out to be multiples of the K-S critical values.

THURSDAY, JUNE 5

10:30 AM – 12:15 PM

(CCS2) Contributed Session - System Analysis and Data Mining Methods

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Title: A Probabilistic Approach to Representing and Analyzing Uncertainty in Large-Scale Complex System Models
Speaker: Douglas L. Allaire, Massachusetts Institute of Technology
Co-Authors: Karen E. Willcox, Ian A. Waitz

Abstract: Numerical simulation is becoming increasingly widespread as a means to support decision-making and policy-making processes. Simulation models for such applications are often complex, involving many disciplines, many inputs, and long computation times. Inputs to such models are inherently uncertain, leading to uncertainty in model outputs. Typically, large-scale models that span many disciplines will involve probabilistic inputs, such as measurement error, as well as qualitative and subjective inputs that cannot easily be translated into precise probabilistic terms [1]. These two fundamentally different types of uncertainty are termed aleatory uncertainty, which is due to natural randomness, and epistemic uncertainty, which is associated with a lack of knowledge. For large-scale complex system models intended to support decision-making and policy-making processes, properly representing and analyzing both types of uncertainty is critical to both model development and the application of model results.

This paper presents a probabilistic approach to representing and analyzing uncertainty in large-scale complex system models intended to support decision-making and policy-making processes. A six-step approach is proposed that includes: 1. establishing the desired outcome of the analyses, 2. documenting assumptions and limitations of the models, 3. documenting inputs and outputs to the models, 4. choosing how to represent the uncertainty in each input, 5. analyzing the uncertainty, and 6. presenting the results.
The proposed approach brings together several existing methods such as Monte Carlo simulation, optimization, and global sensitivity analyses. The procedure is demonstrated for a large-scale complex system model that supports decision-making for aviation environmental policy scenarios.

[1] Lawry, J., Miranda, E., Bugarin, A., Li, S., Angeles Gil, M., Grzegorzewski, P., Hryniewicz, O. *Soft Methods for Integrated Uncertainty Modeling,* Springer 2006.

Title: Partitioned Partial Least Squares
Speaker: Stina W. Andersen, PhD student, Industrial Engineering Department, Arizona State University
Co-author: George Runger, Dept. of Industrial Engineering, Arizona State University

Abstract: It is common to use Partial Least Squares to predict and monitor data from manufacturing processes such as batch fermentation processes. However, difficulties may arise when Partial Least Squares is applied to large data sets with correlated predictor variables of varying significance. In this presentation we will show how Partial Least Squares can be applied to such data and present a new modified approach based on a partition of the predictors that addresses some of the issues.

Title: The Efficiency of Logistic Regression Compared to Normal Discriminant Analysis under Class-Conditional Classification Noise
Speaker: Yingtao Bi, Department of Statistics, University of California - Riverside
Co-Author: Daniel R. Jeske, Department of Statistics, University of California – Riverside

Abstract: In many real word classification problems, class-conditional classification noise frequently deteriorates the performance of a classifier that is naively built by ignoring it. This paper compares the misclassification error rate of one popular generative classifier, Normal Discriminant Analysis (NDA) with the corresponding discriminative classifier, Logistic Regression(LR) under class-conditional classification noise. We show that, contrary to the widely held perception that the LR approach is more robust than the NDA approach, this robustness advantage does not extend to class-conditional classification noise contexts.

Title: Validation Of A High Throughput Microarray System
Speaker: Shu-Pang Huang, principal biostatistician, Bristol-Myers Squibb Co.

Abstract: Microarray based expression profiling experiments are typically performed with minimal automation and with arrays handled individually. While microarray washing and scanning are often automated, the most labor intensive steps, labeling and hybridizing, continue as manual processes. The handling of individual microarrays reduces throughput potential while simultaneously increasing variation in sample handling. Here we assess the performance of a new high throughput microarray system. The system is comprised of three components: an automated workstation for target labeling, hybridization set up, and array washing, a high resolution scanner and a new high throughput array plate (GeneChip HT Array) consisting of 96 microarrays in the standard SBS microtiter plate format. We show that automated labeling is more consistent compared to the manual process. Gene expression values measured with the HT Array plates are consistent with single cartridge values, but with smaller array to array variation. Calibration experiments employing defined mixtures of RNA demonstrate that expression values are internally consistent across HTA arrays. Taken together, this new system offers a robust platform for higher throughput gene expression profiling.

Title: A Three-Class Neutral Zone Classifier Using a Decision-Theoretic Approach with Applications
Speaker: Hua Yu, Department of Statistics, University of California - Riverside
Co-Author: Daniel R. Jeske, Department of Statistics, University of California – Riverside

Abstract: Neutral zone classifiers allow regions of neutrality to account for cases where the data is too ambiguous to have adequate confidence in assigning a specific predicted class. In this paper, we propose a three-class neutral zone classifier as a model extension for a previously derived two-class scenario. The neutral zone classifier is derived by modifying the traditional Bayes classifier using a generalized decision-theoretic framework in which the cost of an incorrect classification is weighed against the cost of remaining neutral. We assume that a power transformation exists such that the underlying class distributions can be modeled as two-component mixtures of normal distributions. Applications in medical diagnosis, safety evaluation and biology are discussed. The proposed neutral zone classifier is illustrated with a microbial community profiling example.

THURSDAY, JUNE 5

1:30 PM – 3:00 PM

(CCS3) Contributed Session - Design of Experiments

Title: Use of Mahalanobis Distance and Taguchi Methods to Improve Client Experience
Speaker: Rajesh Jugulum, Bank of America

Abstract: Combined approach of using the Mahalanobis distance and Taguchi Methods have been successfully applied in many applications across the globe that resulted in having better multivariate measurement systems besides providing huge savings for industries. In this presentation, it will be shown how this approach was applicable to develop a measurement scale to measure the client health. With the existing practice, the client health was decided based on about 50 attributes and classified into green (loyal), yellow (vulnerable) and red (at risk) groups of clients. The decisions were made based on client relationship manager's judgment without having any quantitative method and hence the current method for measuring client relationship health was seen as subjective and not able to identify/differentiate specific types of risk from the primary client risk factors. In this application the Mahalanobis distance was used to develop the measurement scale based on the above mentioned attributes and Taguchi methods were used to measure accuracy of the scale and to find the useful set of variables.

Title: Screening Designs with Reasonably-Balanced Projections
Speaker: Tim Kramer, Global Statistical Sciences, Lilly Research Laboratories
Co-Author: David M. Steinberg (Tel Aviv)

Abstract: Screening designs are useful in product development to quickly identify a few factors having relatively large impact on a response from a much larger set of factors. They are also useful in robustness studies to demonstrate that product performance is insensitive to a host of variables within specified ranges. Regular fractions of 2- and 3-level factorial designs are often used for screening designs and tables and properties of these designs are well-understood. This paper introduces a balance metric which is obtained by examining all possible projections of the design into one, two and three dimensions. This loss function is shown to be related to a projectivity measure and entropy. Standard fractional factorial screening designs are shown to be optimally-balanced relative to this measure.

A general strategy for constructing screening designs with reasonably-balanced projections is presented. Some example designs are given, including a design that was employed by the author in the pharmaceutical industry. Analysis approaches are described. SAS code is available to construct designs of arbitrary levels and runs.

Title: Response Plots for Experimental Design
Speaker: David J. Olive, Department of Mathematics, Southern Illinois University

Abstract: A response plot of the fitted values versus the response simultaneously displays the fitted values, response and residuals. The plot is also used to visualize the model and to check the whether the model is reasonable. The plot can be used to select a response transformation $Y = t(Z)$ since the plotted points will scatter about a line with unit slope and zero intercept if the transformation is reasonable.

Title: Nested Latin Hypercube Designs
Speaker: Peter Qian, University of Wisconsin-Madison

Abstract: Multiple computer experiments with different levels of accuracy become prevalent in practice. In this talk, I will introduce a new class of design called nested Latin hypercube designs as a suitable choice for these types of experiments. Such a design is defined to be a special Latin Hypercube design that contains a smaller Latin hypercube design as a subset. The proposed designs can accommodate any number of factors and are flexible in run sizes.

Title: Semifolding General Two-level Factorial Designs
Speaker: Po Yang, Assistant Professor, Dept. of Mathematical Sciences, DePaul University

Abstract: Semfoldover designs save half of the original runs comparing to corresponding full foldover designs. The new runs which are added to the original design are used to de-alias some effects. Some semifoldover regular designs have been considered in recent years. In this paper, we study various semifoldover designs which are obtained from general two-level factorial designs, regular or non-regular. The tools we use in this paper are indicator functions.

THURSDAY, JUNE 5

3:30 – 5:00 PM

(CCS4) Contributed Session - Design of Experiments 2

Title: A review of Dorian Shainin's variable search
Speaker: Nagesh Adiga M, Georgia Institute of Technology

Abstract: Dorian Shainin's quality tools have acquired widespread popularity in several industries worldwide. Variable search is one of the different tools proposed by Shainin, which has not received much peer review except Ledolter and Swersey (1999). In this paper, we perform a theoretical and emprical study of Shainin's variable search technique. Properties of the design generated by the variable search technique are discussed and compared with other screening designs. Situations where the variable search can perform better or worse than conventional screening designs are investigated using a theoretical approach and detailed simulation studies.

Title: Prioritization of the Balancing Property and Full Estimability in Mixed-Level Designs
Speaker: Stefano Barone, Applied Statistics, University of Palermo, Italy
Co-Authors: Alberto Lombardo, Applied Statistics, University of Palermo, Italy

Abstract: In a recently published work, a new class of *Balanced Asymmetrical Nearly Orthogonal Designs* (BANOD2) was proposed, which can simultaneously estimate both first and second order effects of all factors, with a limited run size. The motivation for the new class lies in using the balancing property as a necessary precondition for several practical concerns arising in the experimentation field. A balanced design optimizes the use of experimental resources in technological experiments, may avoid misinterpretations in choice experiments of marketing research, and can relieve the experimenter from the arbitrariness in assigning the levels to factors. Furthermore the balancing property assures the minimum variance of first-order effect estimates. The BANOD2 designs have also the important characteristic of allowing for the estimation of all main effects and two-factor interactions in mixed-level experiments. In this work the optimality properties of this class of designs are reviewed and comparisons with other classes of competing designs prioritizing other statistical properties (e.g. D- and E-optimality, and projectivity) are stressed. Examples of application in several industry and service sectors are illustrated and a software interface for their generation, based on a heuristic algorithm, is provided.

Title: Creative Analysis Methods Applied to a Fractional Factorial Design to Resolve Inconsistent Results
Speaker: Janis Dugle, Abbott Nutrition
Coauthors: Christine Clinger, Marti Bergana, Jeff Boff, Abbott Nutrition

Abstract: This is an example of a well-designed experiment that did not follow the statistical 'rule book' for its responses, and the creative approaches that were used to pull a consistent story from the data. In the experiment, product developers chose to explore 5 ingredients to determine their effect on oxidative inhibition in an infant formula powder. A 2^(5-1) fractional factorial design with 3 center points (quasi-randomly assigned to 3 blocks) was used. The responses were 3 different analytical assays developed to measure some aspect of oxidation. In the analysis, we saw the following issues: the sums-of-squares were not clean (blocking constraints, missing data), the results of the near-saturated model did not display the hoped-for easy distinctions between effects that were 'keepers' and those that were noise; one of the largest sums-of-squares

was an interaction, and there was a large blocking effect. Finally, although the responses were correlated, the different models identified slightly different sets of terms as drivers of the responses.

To resolve these issues, Principal Components Analysis was applied to the responses. The components effectively separated the intended experimental result from the blocking effect, and summarized the 3 responses into a single oxidative score. The large interaction effect, comprised of two protein factors, was re-parameterized as a sum, and the resulting model showed a significant quadratic effect. In the end, all of the issues were addressed and robust recommendations could be given to the product developers.

Title: Bayesian Optimal Blocking of Two-Level Designs
Speaker: Lulu Kang, Ph.D student, Georgia Institute of Technology

Abstract: The presence of block effects makes the optimal selection of fractional factorial designs a difficult task. The existing methods use certain modifications of effect hierarchy ordering by giving more importance to treatment effects compared to block effects. There is no strong justification to those orderings and therefore, the optimality of such designs can be challenged. Here we propose a Bayesian approach to overcome this problem. The Bayesian approach is capable of developing designs that better satisfy the objectives of the experiment but at the same time without changing the effect ordering. This is achieved by postulating a prior distribution that satisfy the effect hierarchy principle and then proposing an optimal design criterion that gives more importance to the estimation of treatment effects. We apply our method to develop both regular and nonregular two-level designs. Several examples are presented to illustrate the advantages of the proposed method.

Title: Applications of DOE during Verification Stage
Speaker: Shari Kraber, Stat-Ease, Inc.

Abstract: Companies are gradually learning that design of experiments (DOE) can be a useful tool during the final verification stage of a product or process. Rather than just testing the extremes one factor at a time, a DOE can cover the expected range of production variation and confirm that the final production conditions will make product within specification. The underlying difficulty in this application is that the desired DOE finding is: NO significant effects. This talk will demonstrate how to confirm that the DOE chosen has correct power to detect effects IF they exist – the design must be large enough to find significant effects. After collecting the data, a variety of potential results are presented on half-normal plots and the interpretation of each case will be discussed.

FRIDAY, JUNE 6

8:30 AM – 10:00 AM

(CCS5) Contributed Session - Evaluation of System Properties

Title: Six Sigma implementation in the UK manufacturing SMEs: A multiple case-study analysis and key findings

Speaker: Jiju Antony, Director, Centre for Research in Six Sigma and Process Excellence (CRISSPE), Strathclyde Institute of Operations Management, Department of Design Manufacture and Engineering Management (DMEM), University of Strathclyde

Co-Author: Maneesh Kumar, Doctoral Student, Strathclyde Institute of Operations Management, Department of Design Manufacture and Engineering Management (DMEM), University of Strathclyde

Abstract: This paper seeks to investigate into the quality management practices prevalent in Six Sigma and non-Six Sigma small and medium-sized enterprises (SMEs) in the UK through a multiple case-study analysis. SMEs form the backbone of UK economy (99.9% of 14.3 million enterprises in UK are SMEs), contributing significantly in terms of employment (58.3%) and annual turnover (51.3%). The literature elucidates the benefits of Six Sigma in many large organizations, however its implementation in SMEs are still less evident. Therefore, the purpose of this research is to identify SMEs implementing Six Sigma and conduct a comparative analysis with ISO-certified organizations. Case-study protocol was developed to investigate into the following aspects of sample selected: organizational infrastructure; usage of tools and techniques; critical success factors (CSFs) of Six Sigma implementation; performance measures and; barriers to Six Sigma implementation. The research also makes an attempt at demystifying the myth that Six Sigma is applicable only in large organizations.

A case study based approach was used to capture the information on quality management practices within four UK SMEs. Two sample firms are implementing Six Sigma and other two SMEs are ISO certified. Mind genius software and content analysis was used to analyze the qualitative data generated from the four case study firms. There is a dedicated Six Sigma organizational infrastructure (i.e Black Belt, Green Belt, Yellow belt, Project Champion) in Six Sigma firms to execute projects and conduct continuous improvement activities, which is missing in ISO-certified firms. A significant difference in the usage of tools and techniques wass observed in Six Sigma firm against the ISO certified firms. The ISO certified firms rely more on the basic tools of continuous improvement for problem solving and rarely use the advanced quality tools and techniques. The application of advanced techniques such as failure mode and effect analysis (FMEA), Design of Experiment (DOE), hypothesis testing, to name a few, is prevalent in Six Sigma firms to resolve complex business problems. Finding from the case-studies elucidates that strong leadership, management commitment, communication, education and training was critical in driving any change within SMEs. Allocation of resources, middle-managers role, poor training and coaching were considered as impeding factors in making the change happen in sample firms. The performance in operational metrics [such as scrap rate, cycle time, on-time delivery, and yield] and strategic metrics [such as sales volume, profit margin, customer satisfaction] for SMEs implementing Six Sigma differs significantly from ISO certified companies. SMEs implementing Six Sigma are proactive and data driven, whereas ISO firms are operating in fire fighting mode. The analysis of case-study data indicated towards the trend of ISO SMEs being the foundation to embark on Six Sigma. The findings give an indication that Six Sigma is beneficial for all type of firms, irrespective of the size of the firm.

Title: A Statistical Approach to Quantifying the Elastic Deformation of Nanomaterials
Speaker: Xinwei Deng, School of Industrial and Systems Engineering, Georgia Institute of Technology

Abstract: Accurate estimation of elastic modulus of certain nanomaterials such as Zinc Oxide nanobelt is important in many applications. A recently proposed approach was to estimate elastic modulus from a force-deflection model based on the continuous scan of a nanobelt using an Atomic Force Microscope tip at different contact forces. However, the nanobelt may have some initial bending and it may shift or deform during measurement leading to bias in the estimation. In this work we propose a statistical model to account for these various possible errors. The proposed approach can automatically detect and remove the systematic errors and therefore, can give an accurate and precise estimate of the elastic modulus. The advantages of the approach are demonstrated through the application on several data sets.

Speaker: Ying Hung, Georgia Institute of Technology
Title: Effects of Warpage on Fatigue Reliability of Solder Bumps: Experimental and Analytical Studies
(Joint work with Wei Tan, I. Charles Ume, and C.F. Jeff Wu.)

Abstract: Out-of-plane displacement (warpage) has been a major thermomechanical reliability concern for board-level electronic packages. Printed wiring board (PWB) and component warpage results principally from CTE mismatch among the materials that make up the PWB assembly (PWBA). Warpage occurring during surface-mount assembly reflow processes and normal operations may lead to severe solder bump reliability problems. In this research, the effect of initial PWB warpage on the low cycle thermal fatigue reliability of the solder bumps in plastic ball grid array (PBGA) packages was studied using experimental and analytical methods. A real-time projection moiré warpage measurement system was used to measure the surface topology of PWBA samples at different temperatures. The thermal fatigue reliability of solder bumps was evaluated from experimental thermal cycling tests and finite element simulation results. Three dimensional (3-D) models of PWBAs with varying board warpage were used to estimate the solder bump fatigue life for different types of PBGAs mounted on PWBs. In order to improve the accuracy of FE results, the projection moiré method was used to measure the initial warpage of PWBs, and this warpage was used as a geometric input to the FEM. The simulation results were validated and correlated with the experimental results obtained using the projection moiré technique and accelerated thermal cycling tests. An advanced prediction model was generated to predict board level solder bump fatigue life based on the initial PWB warpage, package dimensions and locations, and solder bump materials.

Title: Mis-specification Analysis of Linear Degradation Models
Speaker: Chien-Yu Peng, Ph.D. candidate, Institute of Statistics, National Tsing-Hua University
Co-Author: Sheng-Tsaing Tseng, National Tsing-Hua University, Hsin-Chu, Taiwan

Abstract: Nowadays, degradation models are widely used to assess the lifetime information of highly reliable products if there exists quality characteristics (QC) whose degradation over time can be related to reliability. The performance of a degradation model, obviously, strongly depends on the appropriateness of the modeling of the product's degradation path. In this paper, motivated by a laser data, we propose a general linear degradation path in such a way that unit-to-unit variation and time-dependent structure can be considered simultaneously. Following it, the product's mean-time-to-failure (MTTF) can be obtained under some regular conditions. Furthermore, we also address the effects of model mis-specification on the prediction of product's

MTTF. It shows that the effect of model mis-specification on product's MTTF predictions is not critical under the case of large samples. However, when the sample size and termination time are not large enough, a simulation study shows that these effects are not negligible.
Keywords: Degradation model; First Passage Time; Mean-Time-To-Failure; Model Mis-specification.

Title: Local-Functional ANOVA for Process Models, Mixture Models, and Deterministic Systems
Speaker: Joseph G. Voelkel, Center for Quality and Applied Statistics, RIT

Abstract: Consider an experiment to study the effects of *k* factors, at general settings $x_1, x_2, \ldots, x_k$. The factor levels can be fixed at pre-set levels in the experiment, but may exhibit variation from intended levels in the future. The $\{x_i\}$ include (a) control factors that may later be fixed, (b) control factors that may later vary within a tolerance, and (c) noise factors that may vary. We consider the case where the $\{x_i\}$ are continuous from either a process or mixture experiment that can be locally modeled by a quadratic function—the global model may be more complex. We first examine the total variance of the response *Y* induced by the variance of future $\{x_i\}$ settings. We find exact formulas (up to the quadratic approximation) for this variance in the process case. This includes as a special case the total uncertainty for deterministic systems often studied in engineering. We also find near-exact formulas for the mixture case under three different mixing scenarios.

We then decompose the variance into additive components due to each of the *k* factors and into non-additive portions induced by pairs of factors. We refer to this approach as local-functional analysis of variance or LANOVA, and provide several examples to illustrate its usefulness. We also compare this method to functional ANOVA.