

ASQ STATISTICS DIVISION

Newsletter[©]

Volume 21, No. 2

Spring, 2003

Chair's Message

by Bob Mitchell



Congratulations!

Welcome to the Spring 2003 "pre-AQC" Statistics Division Newsletter. You have obviously successfully navigated the web to find us on ASQNet. Every effort has been made to ensure the accuracy of the email lists used to send your notification of and a link to the first STAT e-Newsletter. If you didn't get the email or postcard notice, please check your personal information with ASQ. If the information is correct and there is still a delivery problem please contact the Newsletter Editor or me. There will be no print version of this or future issues of the Newsletter. As a bonus feature, available to Statistics Division members only, a new paper written by Don Wheeler, "Good Data, Bad Data" is also available for download off the ASQNet server.

The Statistics Division e-Newsletter, along with links to special features, will be moved to the re-designed STAT website upon its completion – targeted for May 2003, in time for presentation and demonstration in our booth at the 57th AQC in Kansas City. If you're planning to attend the Annual Quality Congress this year please stop by our booth and say 'Hi' or drop by the hospitality suite to visit with the Officers, short course instructors, and AQC session presenters. In addition to showcasing

our new website, we will give away 5 sets of three books via drawing: Understanding Variation by Don Wheeler, Fourth Generation Management by Brian Joiner, and Switched-On Quality by John Guaspari. If you cannot join us in Kansas City, please feel free to visit our redesigned website in late May and offer us your feedback.

Other AQC events include:

Saturday, May 16 –

Tutorial: Those Darn Humans – Anticipating and managing natural organizational resistance.

Sunday, May 17 –

Tactical Planning Session with Dr. John Middleton
Tutorial: Improving Performance through Statistical Thinking.

Continued on page 3

Editor's Corner

by Karin Chu



Welcome to our new home on the Internet! To update you on the progress of the Division's new website, the web development committee is

currently working with the web designer on putting together a prototype of the new website, the prototype will be available at this year's AQC. So please be sure to stop by the Stats booth and give us your feedback on the new web.

Continued on page 3



Inside This Issue

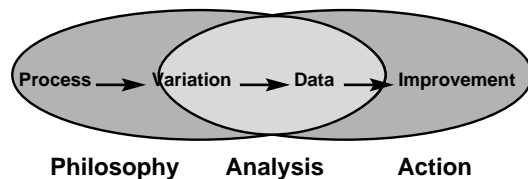
Chair's Message	1
Editor's Corner.....	1
W.J. YOUDEN MEMORIAL ADDRESS	
Reliability: The Other Dimension of Quality	4
Stat Division Sponsors Statistical Leadership Workshop.....	11
Tactical Planning Meeting.....	11
MINI PAPER	
Six Sigma, Measurement Systems, and the Hidden Factory.....	12
BASIC TOOLS	
Effective Six Sigma via Statistical Thinking	16
2003 AQC Statistics Division Schedule of Events	
AQC Statistics Short Courses	22-23
AQC Statistics Booth Activities.....	24
AQC Statistics Session	25
Open Positions	26
Letters to the Editor.....	27
Editorial.....	27
Gordon Research Conference Announcement	28
Statistics Division Committee Roster	29

MISSION

- Promote Statistical Thinking for quality and productivity improvement.
- Serve ASQ, business, industry, academia, and government as a resource for effective use of Statistical Thinking for quality and productivity improvement.
 - Our primary customers are Statistics Division members.
 - Other key customers are:
 - Management
 - Users and potential users of Statistical Thinking
 - Educators of the above customers
- Provide a focal point within ASQ for application-driven development and effective use of new statistical methods.
- Support the growth and development of ASQ Statistics Division members.

VISION

Statistical Thinking Everywhere
 Statistical Thinking Statistical Methods



DESIRED END STATE

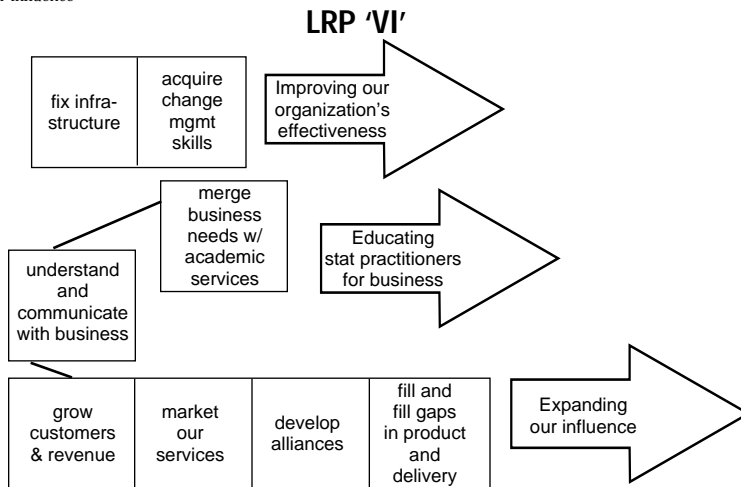
- Our members will be proud to be part of the Statistics Division.
- Our Division's operations will be a model for other organizations.
- We will be a widely influential authority on scientific approaches to quality and productivity improvement.

PRINCIPLES

- Our customers' needs will be continuously anticipated and met (i.e. Customer focused rather than customer driven).
- Our market focus for products and services is weighted as follows:
 - Greatest weight on intermediate level.
 - Nearly as much weight on basic level.
 - Much less weight on advanced level.
- Focus on a few key things.
- Balance short-term and long-term efforts.
- Value diversity (including geographical and occupational) of our membership.
- Be proactive.
- Recognize that we exist for our customers.
- View statistics from the broad perspective of quality management.
- Apply Statistical Thinking ourselves; that is, practice what we preach.
- Uphold professional ethics.
- Continuously improve.

STRATEGY

- Improve our organizational effectiveness
- Educate statistical practitioners for business
- Expand our influence



MEETING GROUND RULES

- Respect and listen to all participants.
- No speeches.
- No "side-bar" discussions.
- Decisions by consensus, if possible.
- We will be open and honest, even if it hurts.
- Support your ideas, don't defend them.
- We will delegate word-smithing to small groups.
- All help facilitate, although we will have a formal leader, facilitator, scribe, and timekeeper (including at breakouts).
- We will rotate scribes.
- We will keep a separate flipchart for To-Do's.
- Mission, Vision, Principles, Strategy, Ground Rules should be visible.

Disclaimer

The technical content of material published in the ASQ Statistics Division Newsletter may not have been refereed to the same extent as the rigorous refereeing that is undergone for publication in **Technometrics** or **I.Q.T.** The objective of this newsletter is to be a forum for new ideas and to be open to differing points of view. The editor will strive to review all articles and to ask other statistics professionals to provide reviews of all content of this newsletter. We encourage readers with differing points of view to write to the editor and request an opportunity to present their views via a letter to the editor. The views expressed in material published in this newsletter represents the views of the author of the material, and may or may not represent the official views of the Statistics Division of ASQ.

Criteria for Basic Tools and Mini-Paper Columns

Basic Tools

Purpose: To inform/teach the "quality practitioner" about useful techniques that can be easily understood, applied and explained to others.

Criteria:

- Application oriented/not theory
- Non-technical in nature
- Techniques that can be understood and applied by non-statisticians.
- Approximately three to five pages or less in length (8 1/2" x 11" typewritten, single spaced.)
- Should be presented in "how to use it" fashion.
- Should include applicable examples.

Possible Topics:

New SPC techniques
 Graphical techniques
 Statistical thinking principles
 "Rehash" established methods

Mini-Paper

Purpose: To provide insight into application-oriented techniques of significant value to quality professionals.

Criteria:

- Application oriented.
- More technical than Basic Tools, but contains no mathematical derivations.
- Focus is on insight into why a technique is of value.
- Approximately six to eight pages or less in length (8 1/2" x 11" typewritten, single spaced.)
 Longer articles may be submitted and published in two parts.
- Not overly controversial.
- Should include applicable examples.

General Information

Authors should have a conceptual understanding of the topic and should be willing to answer questions relating to the article through the newsletter. Authors do not have to be members of the Statistics Division.

Submissions may be made at any time to the Statistics Division Newsletter Editor. All articles will be reviewed. The editor reserves discretionary right in determination of which articles are published.

Acceptance of articles does not imply any agreement that a given article will be published.

CHAIR'S MESSAGE

Continued from page 1

Monday, May 18 –

Session M209: “Beyond Six Sigma/Lean” by Forrest Breyfogle and John Breckline.

7:30pm Council / Open Business meeting

On a more weighty issue, the ASQ BoD recently voted to approve a \$7 cost of living dues increase, but rejected an additional \$10 research and development increase. ASQ has held dues steady for three years and is still a good value as compared to other professional society membership fees. Yet concern exists among many division leaders about how this dues increase might impact their division membership. Most division membership fees are in the \$6 - \$10 range. I believe you'll agree with me that Statistics Division membership is a terrific value. Division membership gives you automated notification of recently published e-Newsletters filled with Case Studies, Mini Papers, and Basic Tools, plus special features like conference announcements, Chair's Message, Division awards and recognition, and other special notes. Currently, three regular Newsletters are published per year, but the electronic medium no longer

constrains us to Newsletter size or frequency. Division membership also provides discounted registration fees to the highly valued and well renowned Fall Technical Conference and associated FTC and AQC division-sponsored short courses. Statistics Division members also receive the single-topic focused Special Publication, and division members will continue to receive special access to cutting-edge information and publications, like the Don Wheeler “Good Data, Bad Data” paper. New member subscriptions receive all four Special Publications in their 'Welcome' packet - - a \$36 value all for just \$8.50 Statistics Division membership fee.

On a final note, your Statistics Division has received our ninth consecutive Level 3 “Top Achiever” recognition for division management excellence (McDermond Award). We continue to receive the highest level of achievement recognition for providing publications, conferences, tools and communications to our members. Please check out the “Call for Volunteers” for opportunities to join our dynamic, energetic, enthusiastic and vibrant leadership team!

EDITOR'S MESSAGE

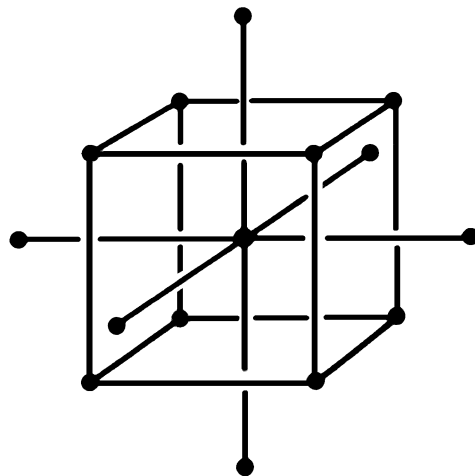
Continued from page 1

In the last issue we published the second and final installment of Davis Balestracci's article, “Statistics and Reality”. We received many feedback from the readers, via telephone, e-mail, and word-of-mouth. Most of you shared with us your experience with Six Sigma and thanked us for publishing this helpful piece. Some of you felt that the article was perhaps too critical on Six Sigma trainers and practitioners. In this issue, we have provided a selection of these communications as Letters to the Editor, as well as an editorial piece written by Davis.

As an introduction bonus for visiting the new e-newsletter, in this issue you will also find Don Wheeler's newest work, published exclusively by the Stats Division, “Good Data, Bad Data, and Process Behavior Charts”, just follow the link provided on the ASQ website, under the Stats Newsletter.

By the time this issue of the Newsletter has reached you, hopefully our troops overseas will have come home safely. Take care & talk to you next time.

Karin



RELIABILITY: THE OTHER DIMENSION OF QUALITY

W. J. Youden Memorial Address

*by William Q. Meeker
Department of Statistics
Iowa State University*



William Q. Meeker

W. J. Youden. It is a pleasure to be here today to give this address in remembrance of the life and the work of W.J. Youden. I was in my third year of college and in my first statistics course in the spring of 1971, when Jack Youden passed away. It was two years later, in a course on experimental design, where I first heard Youden's name.

There, I learned about latin square designs and then about Youden square designs. Youden square designs is a term that was coined by R.A. Fisher to describe the results of Youden's novel ideas in the area of designing experiments with balanced incomplete blocks. Jack Youden is probably best known for this and his other work in experimental design. What is less well known is that this early work, like much of Fisher's work, was motivated by experimental work in the agricultural sciences. Jack Youden spent the early years of his career at Boyce Thompson Institute for Plant research in Yonkers, NY. Youden published his balanced incomplete block methods in a 1937 paper with the title "Use of incomplete block replications in estimating tobacco mosaic virus." Part of the message in my presentation today, which is elsewhere supported by similar historical evidence, is that most statistical research with impact and lasting value had its roots in the applied sciences, including engineering.

During his years at the National Bureau of Standards (now the National Institute of Standards and Technology) Jack Youden had a profound effect on the development of statistical methods. Among many other things, he developed and popularized statistical methods for conducting interlaboratory studies. These methods continue to be in wide use around the world. The American Statistical Association has an annual reward, in honor of Jack Youden, in the area of interlaboratory testing.

Background. A substantial amount of the practical experiences that I have had during my career has been in the area of Reliability. I have had the good fortune to have worked with a large number of outstanding

industrial statisticians as well as other scientists and engineers.

During the three summers when I was a graduate student, I had an internship at General Electric Corporate Research and Development Center (Now General Electric Global Research Center), working on projects under the supervision of Gerry Hahn and Wayne Nelson. I have continued to benefit over the years from collaboration and interaction with Gerry, Wayne, Necip Doganaksoy, Roger Hoerl, and others at GE. From 1978 to 1992, I spent the better part of each summer working for the quality/reliability organization (the actual name of the department changed a number of times over this period of time) at Bell Laboratories, learning first hand about statistics, quality and reliability from such experts as Blan Godfrey, Jeff Hooper, Ramón León, Mike Tortorella, Vijay Nair, Michele Boulanger, Mike LuValle and various other scientists and engineers too numerous to mention here. My presentation today, based on these and other experiences, will describe the relationship between quality engineering, reliability engineering, and statistics. There will be some links to the life and work of Jack Youden.

Reliability. Today's manufacturers face intense global competition, pressure for shorter product-cycle times, stringent cost constraints, and higher customer expectations for quality and reliability. This combination raises some formidable engineering, managerial, and statistical challenges.

The usual textbook definition of reliability reads something like "the probability that a unit will survive until a given point in time under specified use conditions." A more appropriate definition is "the probability that a unit will survive until a specified point in time under encountered use conditions." The point is that the environment in which a product operates is a critical factor in evaluating a product's reliability.

Condra (2001) states "Reliability is product performance over time." This implies that good quality is necessary but not sufficient! One major difficulty and major contrast between quality and reliability is that reliability can be assessed directly only after a product has been in the field for some time; accurate reliability

Continued on page 5

W.J. YOUDEN MEMORIAL ADDRESS

Continued from page 4

prediction presents a number of technical challenges.

Reliability is an engineering discipline. Statistical methods are, however, important tools for reliability engineering. Historically, most statistical effort has been on the development of methods for assessing reliability. Much engineering effort is (correctly) focused on reliability improvement. Only recently have statisticians begun to have an impact on improving reliability.

Engineering functions that affect reliability. In product design, engineers have the following responsibilities (among others):

- Define product requirements
- Design the product
- Verify product design
- Improve the design to assure product robustness.

Then there is a parallel set of steps for manufacturing process design. The ideas presented here will generally apply to both product engineering and process design. After manufacturing begins, there are generally on-going efforts to

- Improve quality and reliability through design changes
- Reduce costs through design changes
- Maintain quality in production (e.g., through process monitoring).

Collectively, these efforts might be called “continuous improvement.”

Robustness. Robustness is an important, widely known (at least among statisticians working in the area of quality), but still under used, concept in quality and reliability. Robustness can be defined as the ability (for a product or a process) to perform its intended function under a variety of operating and environmental conditions (including long-term wear or other degradation). Operationally, the challenge is to design a product or process such that it will be robust to the expected environmental “noises” that a product/process will encounter in its manufacture or operation and to do this in a manner that is economically efficient.

The operational/technical ideas behind robustness derive from the important engineering ideas that were brought to us by Genichi Taguchi. Taguchi suggested a strategy, based on ideas of statistically designed experiments that can be used to improve product or process design by reducing the transmission of variability. The important concepts have been refined and explained by individuals and in places too numerous to mention here, but include the book-length treatments by Phadke (1989), Grove and Davis (1992), Wu and Hamada (2000), and Condra (2001).

Engineering design can be viewed as a complicated

optimization problem (although I am not sure how useful it is to do so, given our inability to quantify all of the inputs and especially intangible costs). Given this view, I have often wondered, in conversation with statisticians who work in industry, whether the tools of robustness would be useful for a product or process design that already had been very well engineered (and thus was already very close to optimum). I have been assured, almost uniformly, that few, if any, such designs exist, although clearly this must be product and industry specific.

Quality and reliability. Figures 1 through 4 illustrate one view of the relationship between quality and reliability. Suppose that the distributions represent some arbitrary product characteristic (e.g., the resistance of a resistor), which will cause degradation of customer-perceived performance (e.g., decreased signal-to-noise ratio) if the characteristic is near or outside either of the specification limits. Figure 1 reflects barely acceptable 3-sigma quality.

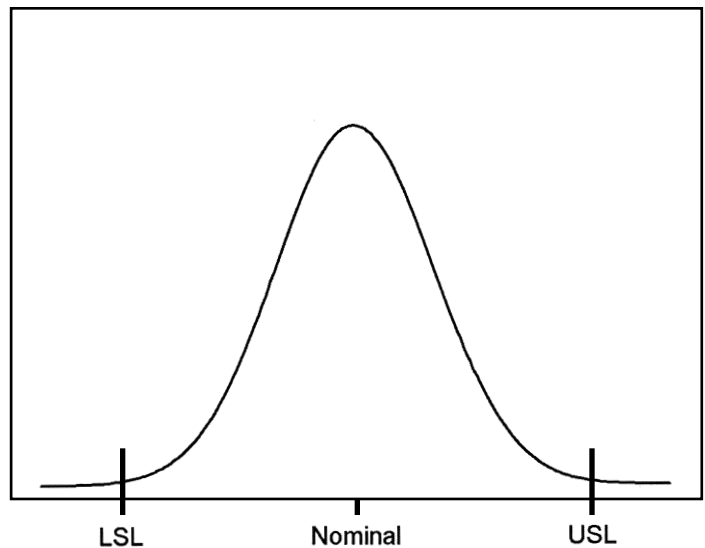


Figure 1. Three-sigma quality

Although the customers whose product is near the center of the distribution may be happy with their product's performance, those closer to the specification limits are less than fully pleased. Over time, as illustrated in Figure 2, there will be drift caused by wear, chemical change, or other degradation, moving more and more customers toward or outside of the specification limits---causing serious reliability problems.

Continued on page 6

W.J. YOUDEN MEMORIAL ADDRESS

Continued from page 5

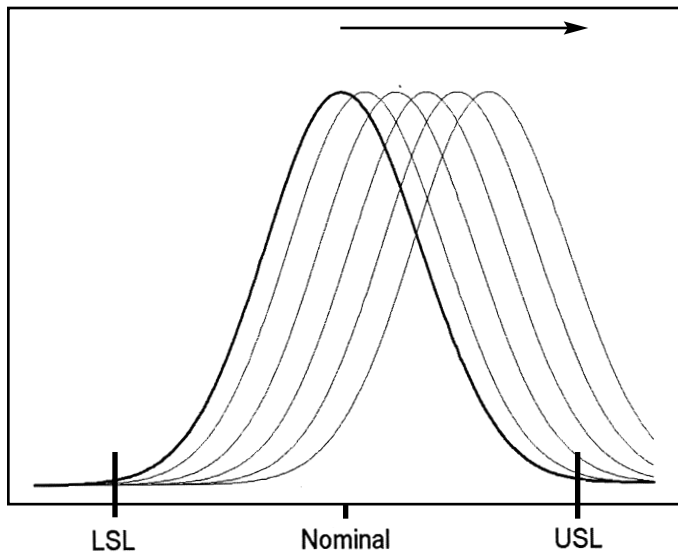


Figure 2. Drifting three-sigma quality

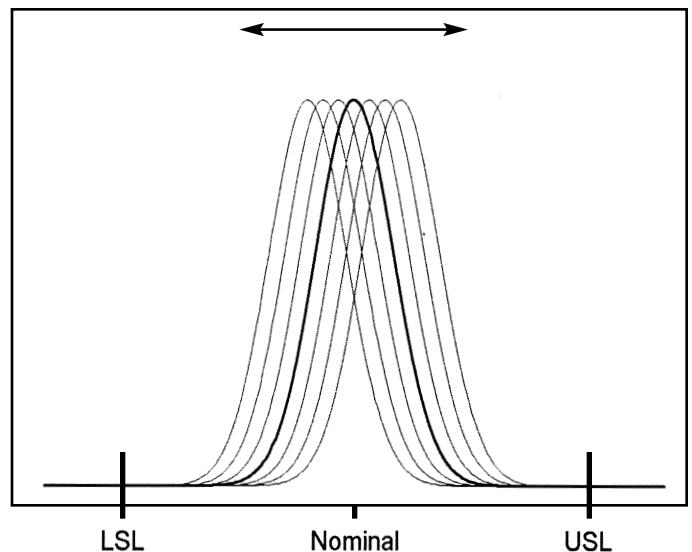


Figure 4. Drifting six-sigma quality

Figure 3 contrasts good quality and poor quality.

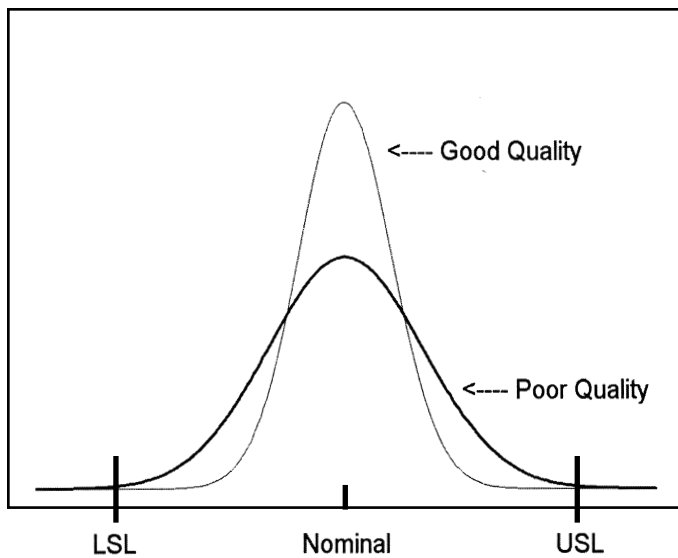


Figure 3. Good and bad quality

As illustrated in Figure 4, with good quality, even with expected drift over time, customers will, generally, continue to have good performance---quality over time or high reliability.

As with quality, we see that variability is the enemy of reliability. Examples of important sources of variability are manufacturing (including raw materials), environmental conditions (e.g., stresses), and customer use rates. Reduction of input variability and reduction in the transfer of input variability to customer perceivable variability are important goals for engineering design.

Reliability demonstration versus reliability assurance. Managers, for example, need information about reliability before making product-release decisions. Potential customers need information reliability before deciding to purchase a product.

Traditional reliability demonstration is essentially a statistical hypothesis test. It answers the question “do the data provide enough evidence to reject the null hypothesis that reliability is less than the target.” For example, using minimal assumptions (including a go-no-go assessment), to demonstrate that reliability at time t_0 hours is 0.99, with 90% confidence, requires testing at least 230 units for t_0 hours with zero failures. To have just an 80% chance of passing the test requires that the true reliability be approximately .999! The required sample size can be reduced, to some degree, by making certain assumptions (e.g., about the form of the failure-time distribution).

It might be feasible to run such large tests for a material or a low-level component. For a complicated, expensive systems or subsystem, however, such traditional reliability demonstration tests are not practicable. Reliability assurance is the alternative.

Continued on page 7

W.J. YOUDEN MEMORIAL ADDRESS

Continued from page 6

Reliability assurance is a procedure based on reliability modeling and combining information from various sources. Inputs to a reliability assurance procedure for a system would generally include knowledge of

- System structure (how components fit together and interrelate).
- Possible failure modes and their effect on system operation.
- Reliability of individual components and interfaces (including software).
- Knowledge of how the product will be used as well as the environment or environments in which the product will be used.
- Benchmark design information from similar, competing products.

Structured programs for design for reliability. The concept of reliability demonstration is not new. In 1990, a team at ATT Bell Laboratories published a handbook, ATT (1990), describing a suggested procedure for “Reliability by Design.” More recently, Design for Six Sigma (or DFSS as implemented at GE) has the DMADV steps: Define, Measure, Analyze, Design, Verify. There are, of course, other similar company-specific reliability improvement programs that mandate the use of upfront analysis to provide a degree of assurance that a company’s product will have the needed level of reliability. Simple web searches for “Design for Reliability” and “Reliability by Design” turned up hundreds of hits. Design for Reliability generally implies the use of up-front analysis and testing (as needed) in product and process design to eliminate problems before they occur. This is in contrast to the traditional Build, Test, Fix, Test, Fix... approach that is implied by the “reliability growth modeling” approach to reliability management.

Failure modes and reliability prediction. Design for Reliability requires careful consideration of product (process) failure modes. Broadly, failure modes can be classified as those that are anticipated and those that are unanticipated. Generally a reliability model will reflect only the anticipated failure modes and it is the anticipated failure modes that engineers focus on (although it can be argued that design for product robustness will help to prevent even unanticipated failure modes). Usually it is the unanticipated failure modes that cause the most serious reliability problems. It is for this reason that an important component of any reliability by design program should have as one of its goals to discover and eliminate potentially important failure modes as early as possible. Tools for identifying failure modes include engineering knowledge and previous experience, failure modes and effects analysis (FMEA) in up-front design, highly accelerated life testing (known as “HALT” tests wherein

prototype subassembly units or systems are subjected to higher than usual operating/environmental conditions in order to shake-out design weaknesses), and early feedback from the field. Some products undergo “beta testing,” where early-production units of a product are released for use, preferably in a high-use, customer-friendly environment (e.g., testing washing machines in a laundromat).

Generally, the longer that it takes to identify a failure mode, the more expensive it is to fix it. This implies that it is poor practice to rely on data from the field to discover potential failure modes and that considerable effort in this direction is needed early in the design process.

In many applications, engineers try to use a predictive model that will provide at least a rough idea of a product’s reliability in the field. Although widely practiced, the development and use of reliability models is controversial. To some degree this is because of numerous examples where such models were developed and trusted for making important decisions, but then were, in the end, proved to be seriously inaccurate. A more constructive view of these failures is that they are important parts of the learning process for an important task.

Inputs to reliability models. As described above, the inputs for a reliability model include

- An identification of failure modes
- A system structure model in which there is a “component” corresponding to each possible failure mode and providing a description on the effect that component failure has on system failure
- A probability or statistical model providing information about the reliability of the individual components, as a function of the use environment.

In many applications the use environment will be dynamic, changing over time. For example, jet engines experience different amounts of high, medium, and low levels of stress and the effect of such “spectra” of stresses needs to be part of the reliability model.

Determining the needed inputs under stringent time and economic constraints is always a challenge. Typical sources of information (roughly in order of cost) are

- Engineering knowledge (e.g., values that can be found in handbooks).
- Previous experience
- Analysis based physical/chemical models that relate to failure (e.g. chemical kinetic models of degradation or finite element models to describe the effect of stress distributions on failure)
- Physical experimentation and accelerated testing.

Continued on page 8

W.J. YOUDEN MEMORIAL ADDRESS

Continued from page 7

When none of the usual sources of information provide the needed information to the desired degree of accuracy, engineers will typically build in conservative “factors of safety.”

A major challenge in the use of information from a combination of sources is in the development of methods to quantify uncertainty. One promising approach to this problem is the use of “responsible Bayesian methods.” I define “responsible Bayesian methods” to mean the use of Bayes methods in which only prior information with a firm basis is included in the analysis. An example of such a procedure is the Los Alamos National Laboratory PREDICT process. For more information, see www.stat.lanl.gov/projects/predict.shtml.

Distinguishing features of reliability models.

For reliability data analysis, the standard statistical models used in basic statistics courses need to be extended in various directions.

- The normal distribution is rarely used as a model for failure times (instead we use distributions for positive responses such as the lognormal and Weibull distributions)
- Simple moments estimators (mean and variance) and ordinary least squares rarely provide appropriate methods of analysis (instead simple graphical methods combined with maximum likelihood estimation for fitting parametric models are used)
- Model parameters and regression coefficients are not of primary interest (instead, failure rates, quantiles, probabilities are needed)
- Extrapolation often required (e.g., have one year of data, but want proportion failing after three years or have data at high temperatures and need to estimate a failure-time distribution at low temperature).

Reliability data.

Traditionally, most reliability data was failure time data, reporting the failure times for units that failed and the running times for the unfailed (censored) units. In many reliability studies of high reliability products, few or no failures are observed. In some applications it is possible to track degradation over time, providing useful information about reliability even if there are no failures. Meeker and Escobar (1998) illustrate and describe methods for analyzing both kinds of data. In other applications a sequence of recurrent events are observed on a sample of units (e.g., system repair or maintenance actions). Special “recurrence data analysis” methods have been developed for such data (see Nelson 2003).

Use of physical/chemical models in reliability engineering. As mentioned above, extrapolation is often required in reliability engineering/statistical analyses.

Extrapolation is always risky and the basis for extrapolation is generally large amounts of past experience or, preferably, the use of physical/chemical models that describe the physical failure mode mechanisms. Some failure models have been studied extensively over the past decades (for example fatigue in mechanical systems and many mechanisms that cause failures in microelectronics applications). Although the development of such models is challenging, expensive, and time consuming, once the models are available, they will often provide long-term benefits.

Warranty and reliability. Warranties are more related to marketing than reliability! In many industries (e.g., the automobile industry), warranty costs, relating to poor quality and reliability, are substantial. Warranty databases exist primarily for required financial reporting. More and more companies are beginning to recognize, however, that warranty data can be useful for:

- Feedback for the design of the next product generation
- Early warning of unanticipated field problems
- Establishing a connection with laboratory testing and environmental characterization.

Warranty data are messy and present serious challenges for proper interpretation and analysis. Warranty data directly reflect one important component of what is seen on a company’s bottom line (another important component, which is more difficult to measure, is customers and goodwill lost when a product has a reliability problem).

The role of the statistician on a reliability team.

Statisticians play an important role on a reliability team. For example, they

- Contribute to the understanding and modeling of variation
- Help fill in the gaps in engineering knowledge by designing experiments and interpreting results
- Help develop systems to ensure that the most meaningful information is obtained to assess reliability and proactively identify problems or potential problems.
- Use appropriate statistical methods to make the most effective use of field and warranty data
- Develop appropriate methods for combining information from different sources
- Develop methods for quantifying uncertainty (statistical and model)
- Develop methods (especially graphical methods) for the effective presentation of results.
- Work with other scientists and engineers in the development of appropriate deterministic or stochastic models for physical/chemical failure modes.

Continued on page 9

W.J. YOUDEN MEMORIAL ADDRESS

Continued from page 8

A current example: service life prediction for organic paints and coatings. I thought that it would be useful to describe a current project where an interdisciplinary team is using a modern approach to tackle a difficult problem in reliability. The project is being conducted at the National Institute of Standards and Technology (NIST). I have been serving as an advisor to the project.

The standard method for testing paints and coatings for effects of outdoor exposure is to send specimens to outdoor testing facilities (notably in south Florida and Arizona, for sunny humid and sunny dry conditions, respectively) and to have them exposed for periods ranging from months to years. Outdoor tests are expensive and take too much time. Manufacturers of paints and coating have been trying for decades, with little success, to develop useful accelerated testing methods that allow the rapid screening and assessment of the service life of potential new products. The tests that have been run have tried to mimic outdoor environments by “speeding up the clock” (using increased temperature, increased UV intensity and cycling more rapidly than the usual diurnal cycle). These tests are not reliable and often lead to conclusions that differ from those derived from the data that are returned from the outdoor testing laboratories! Speed-up-the-clock tests do not follow the basic principles of experimental design and thus provide little or no information about the fundamental mechanism leading to degradation and failure.

Jon Martin with the Materials and Construction Research Division, Building and Fire Research Laboratory at NIST is the project leader. Jon is leading a NIST consortium with a number of industrial partners and his NIST scientific staff (which includes chemists, materials scientists, physicists, and engineers). More details about the project can be found at <http://slp.nist.gov/coatings/cslpmain.html>.

The approach is to use careful experimentation and physical/chemical theory to understand the degradation mechanisms that lead to failure of paints and coatings, starting out with focus on a particular important industrial application. The laboratory experimental setup is based on the NIST SPHERE (Simulated Photodegradation by High Energy Radiant Exposure) technology. This technology, developed by NIST scientists, uses a large integrating sphere to provide a controlled source of UV radiation. There are 32 separate chambers attached to the sphere and within each chamber it is possible to independently control UV intensity, the UV spectrum, temperature, and humidity. Carefully designed experiments will be used to check and refine various mechanistic models for material degradation.

As part of the model development/verification process,

outdoor experiments are being conducted at sites in several different climates. At each site specimens are being exposed to actual outdoor conditions with monitoring of UV radiation intensity and spectrum, temperature, and humidity, and the resulting degradation (various physical and chemical measurements are being made for the specimens tested in both the indoor and outdoor exposure tests). Environmental realizations (time series of the environmental variables over time), when used to drive the physical/chemical model, should produce results similar to that seen in outdoor exposure.

Once physical/chemical model degradations are available for a product, it will be relatively inexpensive to obtain information needed to compare different proposed formulations and learn about the effect that different environments will have on reliability.

Trends in the use of statistics in reliability. The way in which statistical methods are used in reliability has been changing and will continue to do so. Some changes that we can expect to see in the future that will affect the use of statistics in the area of engineering reliability are

- More up-front problem definition and ensuring the most meaningful data are obtained during product/process design.
- More use of degradation data and models including stochastic models
- Increased use of statistical methods for producing robust product and process designs
- More use of computer models to reduce reliance on expensive physical experimentation
- Better understanding of the product environment (e.g., through the use of products outfitted with “smart chips”)
- The availability (through remote monitoring using sensors and modern digital communications) of real-time information on the operational and environmental state of operating systems.
- More efforts to combine data from different sources and other information through the use of “responsible Bayes” methods for combining information from different sources.

Academic involvement in manufacturing reliability problems. Manufacturing industries have interesting, challenging, technical problems in reliability. There should be more academic involvement in these projects. It would be beneficial for all to have more professors and their students involved in solving these problems. The benefits of such involvement would be

- The quality of academic research will improve with access to real problems
- High probability of research impact

Continued on page 10

W.J. YOUDEN MEMORIAL ADDRESS

Continued from page 9

- Cost-effective for industry
- Students and faculty will gain valuable experience
- Better industry/academic relationships.

It is possible (but sometimes challenging) to achieve these benefits while meeting the requirements of the academic institutions (that research should produce scholarly publications and that external funding is needed to support much of its research).

Facilitating academic involvement in manufacturing reliability problems. Academics will have to be anxious to get their hands dirty with the difficulties of real problems, including investment of time to learn the language and science of the relevant disciplines. Industrial sponsors (i.e., individuals) will have to invest the time needed to identify, help structure, and provide guidance for selected projects. In today's highly competitive environment, it is difficult for industry to commit time and money unless there is some reasonable expectation of benefits. Some possible approaches that can be used to develop fruitful partnerships between industry and academics include

- Student internships and opportunities for faculty visits to industry (Los Alamos National Laboratory has such a program) provide assistance to industry and valuable learning experiences for the visitors.
- The NSF GOALI (Grant Opportunities for Academic Liaison with Industry) program provides funding for academics (students or faculty) to visit industry and/or for industry employees to visit universities to participate in research projects.
- When benefits to industry are uncertain (as will often be the case), industrial funding for cooperative work may be difficult to obtain. In such cases it may be useful to academics to offer to do work for expenses only, at least until a track record has been established.

Concluding remarks. Statistical tools that were developed to control and improve quality (e.g., process monitoring and designed experiments) have been useful for improving both quality and reliability. Generally, however, special statistical tools that focus on reliability are needed. With continuing changes in technology, increasing scientific knowledge, and new sources of data and other information, many new interesting problems and challenges lie ahead. Statisticians will continue to have an essential role to play in the area of reliability.

Acknowledgements. I would like to thank Luis A. Escobar and Gerald J. Hahn for helpful comments on the slides for the original talk and this written version.

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STAT DIVISION SPONSORS STATISTICAL LEADERSHIP WORKSHOP

by Roger Hoerl

The Statistics Division is sponsoring another Statistical Leadership workshop, to be held in conjunction with the American Statistical Association (ASA) annual meetings, known as the Joint Statistical Meetings. The workshop will be held on August 4th, 2003, in San Francisco. This workshop is a follow-up to the initial Statistical Leadership workshop sponsored by the Statistic Division, which was held last April in conjunction with Virginia Tech University. Based on the positive response from participants, a series of ongoing workshops are planned. What is the purpose of this workshop? Read from the workshop announcement below.

Many statisticians in consulting roles would like to enhance their impact on the organizations they consult with. While statisticians' contributions may be very significant, all too often the statistician is viewed as playing a supporting, rather than leading role, in project success. Similarly, the

statistician is often viewed as someone passively giving advice, or performing narrow technical tasks predetermined by others, rather than proactively making things happen and delivering results. Several changes are occurring in our environment that make this situation even more important for us to address. These include corporate downsizing and delayering, which make it more difficult to justify passive consultant roles in the organizational chart; the enhanced statistical education provided to others both in academia and business and industry (through initiatives such as Six Sigma), combined with the proliferation of easy to use statistical software, which in conjunction allow others to perform lower level statistical tasks traditionally done by professional statisticians; and the pervasive impact of the Internet, which now allows sophisticated data analysis to be outsourced to anywhere around the globe. The purpose of this workshop is to enhance the

effectiveness of statisticians in business and industry, or those consulting there, particularly as it relates to exhibiting leadership. The goal is to help statisticians transition from being viewed as passive consultants to being viewed as proactive leaders within their organizations. In preparation for this workshop, several senior business leaders, CEOs, and other executives were interviewed to obtain their insights into how statisticians can have more impact. These insights will be shared and discussed at the workshop. The attendees will participate in breakouts to determine specific changes needed, and how to go about making them happen.

For more information on the first workshop, see www.billparr.org/Leadership/index.htm. For information on the workshop to be held this August, see the ASA homepage at www.amstat.org, and look for postings on 2003 Joint Statistical Meeting continuing education offerings.

TACTICAL PLANNING MEETING

by Davis Balestracci

The Statistics Division Officer Tactical Planning Meeting scheduled for Sunday, May 18, during the AQC will be a live, three-hour audioseminar with Robert Middleton, a well-known marketing plan specialist. He uses an innovative approach whereby he will deliver the seminar, sent beforehand as a pdf file, via a high quality telephone hookup designed so that he can

interact with the participants.

Mr. Middleton's web site—www.actionplan.com—is worth checking out by Statistics Division members as well. It contains some outstanding free downloads. In particular, his "Marketing Plan Workbook" (24 pages!) is worthwhile for anyone. It asks the tough questions that will need to be answered for the survival of quality

professionals as their roles continues to transition.

Given today's business environment, the Statistics Division's objective is to market itself for maximum effectiveness both for its members and its participation within ASQ for the benefit of its members. We are excited about this opportunity and hope our members will benefit as well!

MINI PAPER

SIX SIGMA, MEASUREMENT SYSTEMS, AND THE HIDDEN FACTORY

by Bill Rodebaugh

Abstract:

In many companies throughout the chemical process industries, measurement systems play an important role both in determining the final quality of product, but also in allowing a Six Sigma program to achieve breakthrough performance. Many measurement systems are not up to these tasks. In order to understand the effectiveness of measurement systems, Six Sigma uses the measurement indices of %GR&R and P/T ratio as a part of the improvement strategy. Ineffective measurement systems may lead directly to an increase in “the hidden factory”. This hidden factory is quantified by a calculation of a Cost of Poor Quality or COPQ. Examples of the hidden factory caused by ineffective measurement systems are additional processing costs and loss of product value through unnecessary downgrading.

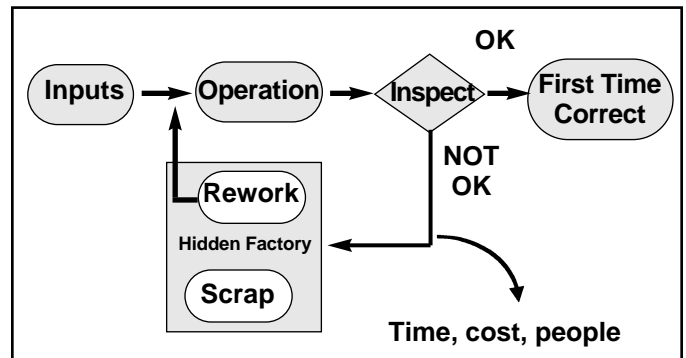
This paper initially defines how the measurement system is a part of the hidden factory. This paper will comment upon the basics of %GR&R and P/T ratio, will highlight the usage of Minitab to perform these analyses, will show examples of measurement systems in industrial applications, and will give suggestions on improving the measurement systems of an organization.

The key application from this work is to think of a measurement system as a process, not unlike any manufacturing process. Using the Six Sigma thinking, any process may be studied as a box with inputs and outputs. Study must be done to link poor measurement systems with poor manufacturing and inevitably poor financial performance. Black Belt and Green Belt project work can begin to improve the occasional measurement system. They cannot work alone. It will take a structured approach of evaluating performance of systems (measurement and sampling) correctly, and then developing a systematic procedure to improve performance. This system includes specific training, focused improvement roadmaps, and a project system similar to the system in Six Sigma organizations.

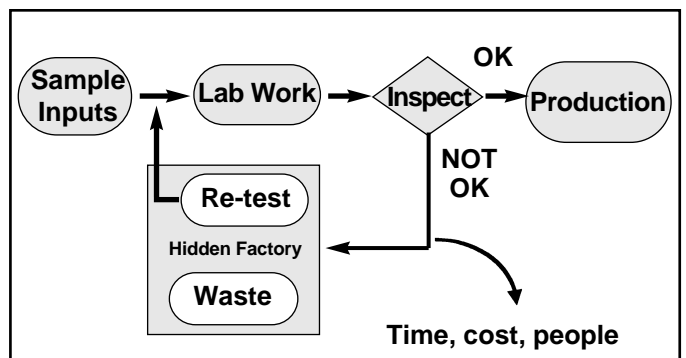
The Hidden Factory

The Hidden Factory concept is one that is taught early in the Six Sigma course work. It is that area of any process in which rework and non-value exists. If this area is cleaned, a large amount of the Cost of Poor Quality or COPQ of a process is also removed. Tangible

Hidden Factory issues include non-reworkable or scrap materials (materials that have lost their product value in processing), over-processed materials (materials processed with non-optimal yields and utilities), and over-analyzed materials (materials that are analyzed in-process even though the capability is high). The figure below describes the Hidden Factory.



In a laboratory setting, the hidden factory also exists. Here the implication of the Hidden Factory is in higher laboratory costs directly and in higher production costs indirectly. The Hidden Factory in a measurement system includes incapable measurement systems (purchased equipment that is incapable and unusable), repetitive analysis (measures that need to be repeated multiple times to achieve usable results, both process and measurement related), and variation issues (various noise issues that produce values that deliver unclear messages to production). The figure below describes this Measurement System Hidden Factory.



Continued on page 13

SIX SIGMA, MEASUREMENT SYSTEMS, AND THE HIDDEN FACTORY

Continued from page 12

The Hidden Factory Linkage

Not only are there quantifiable costs in the laboratory when the accuracy and precision of equipment and methods are unsatisfactory, but there are definable linkages between measurement systems and day-to-day production issues and between measurement systems and longer term Six Sigma improvement.

1. Production Environments generally rely upon in-process sampling for adjustment.
2. As Processes attain Six Sigma performance they begin to rely less on sampling and more upon leveraging the few influential X variables.
3. The few influential X variables are determined largely through multi-vari studies and Design of Experimentation (DOE).
4. Good multi-vari and DOE results are based upon acceptable measurement analysis.

Key Measurement System Indices

There are many components to the understanding of measurement system performance including: discrimination, stability, linearity, accuracy, and precision. While all of these pieces are critical to a good, long-term measurement system, accuracy and precision are reviewed mostly in measurement system analysis studies or Gage R&R studies. (It is the assumption to these studies that the discrimination of the instrument was acceptable when purchased, and that proper calibration and process range selection was made to allow issues with stability and linearity to be minimal).

The key metrics to describe a measurement system's accuracy and precision are the Precision to Tolerance (P/T) ratio and the %Gage Repeatability and Reproducibility (R&R).

The P/T ratio is equal to $5.15 * \text{MS} / (\text{Tolerance or USL-LSL})$.

The %Gage R&R is equal to $\text{MS} / \text{Observed Process Variation}$.

The MS as shown in the above equation is known as the measurement system. With the proper management and analysis of the study, the standard deviation of the measurement system can be quantified. In order to relate this value satisfactorily to the specifications and to the process, the width of the distribution needs to be discussed. With the P/T ratio, the MS, is multiplied by 5.15, which approximates 99% of the normal curve. This value is divided by the tolerance or more commonly for the Chemical Process Industries, by the range of the Upper and Lower Specification Limit. (There are some decisions that need to be made when there is either only an Upper or Lower Specification). The range of samples, which compose the test, defines the Observed Process

Variation. To ensure that the critical range is observed in the samples a certain length of time is needed to gather these samples so the process can vary fully, or some assistance can be given by analytical labs to "create" appropriate samples within the range.

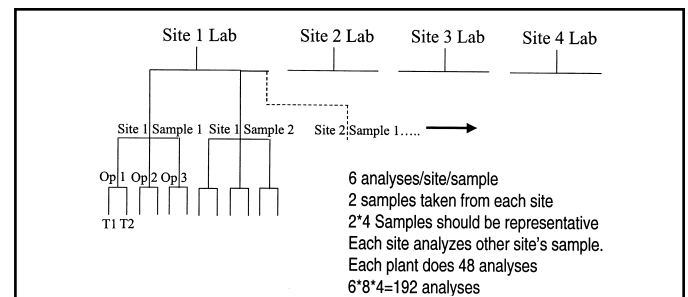
Acceptable values for these numbers are generally considered to be less than 30%. Lower values for %Gage R&R allow for clearer view within the process range. Lower values for the P/T ratio allow for clearer view of the disposition of good and bad product. The higher the amount of variation in a process that is due to measurement, the less capable a process appears.

Chemical Process Industry Example – W.R. Grace

As the Six Sigma program at W. R. Grace expands, the study of measurement systems and the impact of measurement systems upon processes becomes more important. As more and more processes are reviewed and improved via the Six Sigma methodology, additional clarity is necessary to define further improvements.

As part of a multiple site Six Sigma project, dealing with process yield improvement, an important measurement system was to be reviewed. Some improvements in the process had already been achieved during the Six Sigma project, but additional improvements were targeted. In this process there is a linkage between good process capability and good process yield. As noted before the clarity with which capability is viewed is dependent upon the adequacy of the measurement system. In order to get an acceptable understanding of the measurement system adequacy, a multiple site measurement system study was commissioned. The goal of this study was to explore issues with bias and with variation within and among labs. The variation study was important in order to understand the noise throughout the system and the bias study was important since capability comparisons were being made among the labs.

There are four sites in this study, and the measurement system study tree is shown below. Please note that the lab sites will be known as Site 1, Site 2, Site 3, and Site 4, and the variable under study will be known as CTQ1.



Continued on page 14

SIX SIGMA, MEASUREMENT SYSTEMS, AND THE HIDDEN FACTORY

Continued from page 13

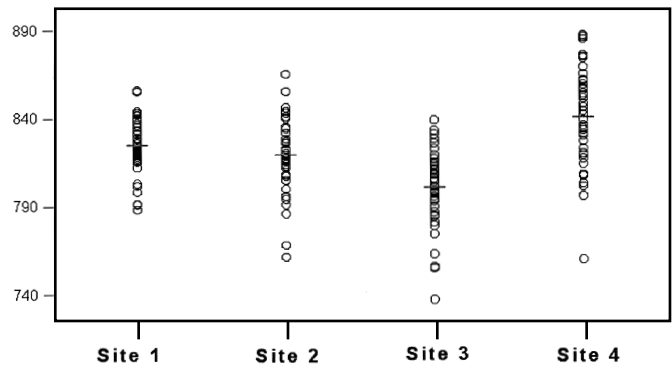
Formal Minitab analysis was performed using the Stat >> Quality Tools >> Gage R&R (Crossed) function. The crossed function was chosen since each operator at each site reviewed each sample. An overview of study results is outlined in the table below.

Site	%GRR	P/T Ratio	R-bar	Equal Variances with Groups	Mean Differences (Tukey Comp.)
All	94.3 (78.6-100)*	116	16.05	No (0.004)	Only 1,2 No Diff.
Site 1	38.9 (30.0-47.6)	29	7.22	Yes (0.739)	All Pairs No Diff.
Site 2	91.0 (70.7-100)	96	17.92	Yes (0.735)	Only 1,2 Diff.
Site 3	80.0 (60.8-94.8)	79	20.37	Yes (0.158)	All Pairs No Diff.
Site 4	98.0 (64.8-100)	120	18.67	Yes (0.346)	Only 2,3 No Diff.

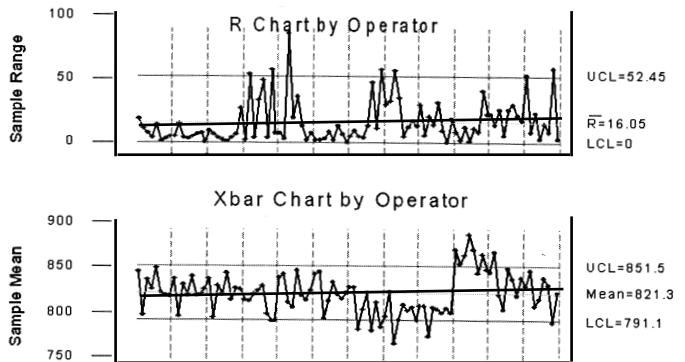
As seen in the previous table, this study highlighted several areas:

- Only Site 1, had a nearly acceptable % Gage R&R and P/T ratio.
- A partial confidence interval is quoted under the % Gage R&R in parentheses. This value is calculated only as a confidence around the \bar{MS} . The process standard deviation was kept constant in the calculation of the interval.
- The best R-bar was from Site 1. It was the only site where a repeated sample would be expected to be less than 17 units from the first sample.
- When reviewed as a collection of sites, at least one of the sites had differing variation.
- When reviewed as operators within the sites, all operators had the same variation.
- When observing the mean differences or biases:
 - Site 1 and Site 2 had no biases between them.
 - Site 1 and Site 3 had no biases among their operators.
 - Site 2 and Site 4 had at least one operator that showed a bias with the other operators.

The chart below shows the full range of samples and the mean of the samples per Site. This gives a good view of variation and bias among sites. It is possible to see how the range of readings in Site 1 is smaller than the other sites. Also, it is possible to see the higher mean for Site 4 and the lower mean for Site 3.



Another visual tool that aids in the data analysis is the X-bar R chart of all the data from each of the Sites. In this graph the range value is determined by looking at the repeated pair of each of the samples measured by each of the operators in each of the Sites. There are 96 values or 192/2 pairs of data shown on these two graphs.



The R Chart above shows an average Range of 16.05. This translates to control limits of 791.1 to 851.5 around the X-bar Chart mean of 821.3. Due to the high repeatability shown from sample to sample, a majority of the sample readings fall outside of these control limits. Only the lower readings from Site 3 and the higher readings from Site 4 are viewed outside of the control limits, or they are the only points that have enough signal to overcome the large amount of noise.

Linkage to the Hidden Factory

As seen in the prior analysis, there is a great amount of excess variation and bias within and among the sites under study. How does this condition impact the improvement targets of the project? How is this an example of the Hidden Factory? To answer these questions, a more detailed review of CTQ1's process in Site 2 will be undertaken.

Continued on page 15

SIX SIGMA, MEASUREMENT SYSTEMS, AND THE HIDDEN FACTORY

Continued from page 14

	R-bar	Notes	X-bar
Site 2 GR&R readings	17.9	Calc. By Subgroup	819.4
Site 2 2002 History	25.1	Calc. By Point-to Point	832.5

In the above table, a comparison of the samples analyzed by Site 2 is made with the actual values of materials produced by Site 2 in 2002. As an interesting check the Gage standard deviation divided by the product standard deviation is 71%. This compares to a %GR&R of 91% with a confidence interval of 70% to 100%. Regardless of the exact value, it is easy to say that an appreciable amount of the point-to-point variation of the process is due simply to measurement issues.

The economics of this project are straightforward. Each point increase in CTQ1 is shown as a gain in yield. At nominal production rates a 10-point increase in CTQ1, equates to a gain of approximately \$10,000. Due to the noise in the measurement system, it is difficult to quantify a step change of 10 points. Using an estimate of sample size at current noise levels and then at a reduction of noise by 70%, the amount of additional sample points needed to understand the change can be calculated. In the following table, two sample size outputs are shown. The standard deviation for the initial study was taken as the current point-to-point or R-bar variation. The cleaned standard deviation, without measurement variation, was calculated to be 30% or 100% - 70% of the original variation.

2-Sample t Test				2-Sample t Test			
Testing mean 1 = mean 2 (versus >)				Testing mean 1 - mean 2 (versus >)			
Alpha = 0.05 Sigma = 25.08				Alpha = 0.05 Sigma = 7.54			
Difference	Sample Size	Target Power	Actual Power	Difference	Sample Size	Target Power	Actual Power
2	2695	0.9000	0.9001	2	245	0.9000	0.9009
4	675	0.9000	0.9004	4	62	0.9000	0.9019
6	300	0.9000	0.9001	6	28	0.9000	0.9023
8	170	0.9000	0.9015	8	16	0.9000	0.9010
10	109	0.9000	0.9014	10	11	0.9000	0.9127
12	76	0.9000	0.9017	12	8	0.9000	0.9160
14	56	0.9000	0.9016	14	6	0.9000	0.9104
16	43	0.9000	0.9013	16	5	0.9000	0.9206
18	34	0.9000	0.9004	18	4	0.9000	0.9068
20	28	0.9000	0.9034	20	4	0.9000	0.9500

To see the difference of 10 points, the measurement system is adding nearly ten times the amount of samples to see the change. If the assumption is for one sample per day, there will be an additional three months of run time to see this change.

What are the benefits of this improved measurement system?

- Faster realization of financial benefits
- More trust in the laboratory numbers from Site 2, that may translate into further, better operation, including the ability to make faster process changes
- Additional Six Sigma tools, such as Design of Experiments, can be used with greater effectiveness.

Measurement Improvement in the Organization

This example is no doubt experienced throughout many sites and processes of companies in the Chemical Process Industries. Because of poor measurement systems, process control and optimization is limited. A focus on measurement system improvement can be undertaken which will analyze and target poorer measurement systems.

Key actions to improve measurement on an organization-wide basis include:

- Early Black Belt and Green Belt projects running %Gage R&R studies
- Reaching laboratory personnel with early Six Sigma training and participation in these Black Belt and Green Belt studies
- Later specific Analytical Green Belt training that is specifically tailored to the Analytical professional
- Corresponding project work led by Analytical Green Belts to study and improve measurement systems in the organization
- Development of an organization-wide database that holds all measurement system studies, and is available for review by Research and Development, Sales, and Manufacturing.

Regarding this measurement system, a Black Belt project was initiated that has led to immediate improvements. Detailed process mapping and other Six Sigma analysis have uncovered some inconsistencies in method. At the time of writing a secondary measurement system study has been undertaken, and improved results are anticipated.

It is critical as Six Sigma programs continue in many organizations that measurement system analysis is made a priority, possibly done early in the Six Sigma organizations. Failure to recognize measurement system problems will lead to a failure to improve processes and realize gains. It is also key to uncover the Hidden Factory with the measurement system. Each piece of unnecessary variation causes direct issues with the operability and efficiency of a laboratory and also affects the process that it is designed to view.

Reference:

Sigma Breakthrough Technologies, Inc., *Six Sigma Overview*, Black Belt Training Materials, Sigma Breakthrough Technologies, Inc., San Marcos, Texas.

BASIC TOOLS

“Effective Six Sigma via Statistical Thinking”

by Willis Jensen

Introduction

Six Sigma is enjoying its moment in the limelight due to the large number of “success stories” it has generated. One only has to pick up the latest issue of a business related magazine to find references to Six Sigma and the impact it is having on companies all over the world.

While first conceived and implemented in a manufacturing environment, its focus is expanding beyond manufacturing to other diverse applications, such as health care, finance, services, and government. There is even speculation that Six Sigma can help save lives in the war on terrorism. However, with all its success and media attention, those in the Six Sigma “trenches” are painfully aware that things are not always as rosy as they are sometimes made out to be.

My attempt to discuss both the positive and negative side of Six Sigma does not mean that I lack confidence in the Six Sigma methodology. On the contrary, I have seen tremendous success from applying the methodology and its associated tools. My motive is simply to aid in the continuous improvement effort. My own journey with Six Sigma is not free of challenges. However, I have become convinced that Six Sigma has the potential to transform the way businesses attack and solve problems. I have seen dramatic improvements in processes that have helped increase employee morale and build stronger customer satisfaction. I have seen the broader impact that Six Sigma can have on an organization, making it more data driven and focused on processes, instead of placing blame on individuals. It certainly has potential to help make “data-based decision making” more commonplace – even where traditionally it has been ignored. I sincerely hope that it does achieve its potential. I believe it can.

To fully achieve its potential, Six Sigma requires more than just “talking the talk.” It has to be done right. Effective utilization of Six Sigma requires much more than doing a bunch of training and christening a bunch of “belts.” It requires changing the mindsets of all the individuals involved. It involves a different way of thinking than what most people are accustomed to. Effective utilization of Six Sigma methodology requires outstanding use of statistical thinking.

Statistical Thinking

According to the Glossary and Tables for Statistical Quality Control: 3rd Edition published by the ASQ Statistics Division, statistical thinking is based on the three following principles:

1. All work occurs in a system of interconnected processes.
2. Variation exists in all processes.
3. Understanding and reducing variation are keys to success.

The principles of statistical thinking are straightforward and make a lot of sense. However, applying them to solve problems is a bit more difficult than it first appears. In my experience teaching people the principles of statistical thinking, I have learned that there is variability in how well people truly understand the concept.

An important thing to remember is that statistical thinking is a philosophy and does not have much to do with the traditional view of statistics. I often ask students what they think of when they hear the term “statistical thinking.” Most of the time, the answers have to do with the ability to analyze and interpret data. In fact, “statistical thinking” may be somewhat of a misnomer, a more accurate term in my view is “process-oriented thinking,” but I digress.

For more information about statistical thinking, there are a number of excellent articles and publications that have been published by the Statistics Division. For example, see the first and second special publications of the ASQ Statistics Division, or Improving Performance Through Statistical Thinking by Britz et al.

Six Sigma

While many may be familiar with the general idea behind Six Sigma, there are many different definitions. For example, Mikel Harry – widely considered one of the influential founders of Six Sigma at Motorola – put it this way:

“It is a business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction.”

George Eckes, an external consultant who helped implement Six Sigma at GE defined Six Sigma in two aspects: technical and cultural. The technical aspect deals with the well-known target of 3.4 defects per million units. The cultural aspect, which Eckes considers to be far more important, is one of continuous improvement or as he says, a “never-ending dissatisfaction with current performance.”

Continued on page 17

“Effective Six Sigma via Statistical Thinking”

Continued from page 16

Pande, Neuman, and Cavanaugh define Six Sigma as:

“A comprehensive and flexible system for achieving, sustaining and maximizing business success. Six Sigma is uniquely driven by close understanding of customer needs, disciplined use of facts, data, and statistical analysis, and diligent attention to managing, improving, and reinventing business processes.”

A recently published glossary in Quality Progress defines Six Sigma as:

“A methodology that provides businesses with the tools to improve the capability of their business processes. This increase in performance and decrease in process variation leads to defect reduction and improvement in profits, employee morale and quality of product.”

Because it encompasses so many different aspects, it would be difficult to create a single definition that everyone would agree with. Different people have different ideas about what it means. However, all these definitions have the same general idea – continuous process improvement. This has long been a part of other quality improvement efforts from the past.

This process improvement is achieved using the DMAIC (Define, Measure, Analyze, Improve, and Control) methodology. The “D” phase essentially defines the process to be improved along with its major inputs and outputs. The “M” phase measures the current level of performance in the process and ensures that the measurement system is adequate. This level is defined in terms of a key output of the process, often called a project Y. This project Y becomes a key metric and is useful in determining whether or not there has been an improvement in the process. The “A” phase analyzes the relationship between the key inputs of the process and its outputs. The “I” phase involves some form of experimentation (many times in the form of a DOE) to improve the process and verify the relationship between key inputs and outputs. The “C” phase involves placing controls for the critical inputs. This ensures that the improved performance level of the process can be sustained over time.

DMAIC uses many different tools for the various phases. Many are statistical in nature, like control charts, capability indices, measurement systems analysis, design of experiments, multi-vari analysis and others. These statistical tools can be used in all the phases. Other tools also play a strong role in DMAIC methodology; process maps, cause and effects matrices, failure modes and effects analysis, control plans and others. Use of these

tools to improve processes is not new; it has been part of past quality control programs. What is different about DMAIC is a stronger focus on maintaining the improved process through a control plan. In addition, it provides a strong link of the process to be improved and the strategic plan of the organization.

The overall goal of DMAIC is find the critical inputs, understand their relationship to the key outputs and then control them to maintain an improved level of performance in the process. If the methodology is used correctly, the improved process generally results in some financial benefit. This financial benefit is what holds such a strong allure to the business community. It is the reason for all the attention Six Sigma has received. Six Sigma has made a strong link between the use of the tools and financial results. It has done a good job of keeping in mind the real reason for any improvement program, that of making the organization better and more profitable. For more information on Six Sigma, see references 6, 7 and 8 in the bibliography.

Relationship between Six Sigma and Statistical Thinking

While companies tout Six Sigma as a methodology to save money and improve operational performance, the core philosophy behind any successful Six Sigma program is statistical thinking. The two should be inextricably linked to ensure that Six Sigma results are real and lasting.

The critical inputs that are diligently sought through DMAIC methodology are simply sources of variation in the process. The idea is to understand the sources of variability to improve and control the process. When correctly applied, DMAIC then becomes a formalized methodology for understanding and reducing variation - principle #3 of the definition of statistical thinking.

A Six Sigma program is doomed to fail if it only focuses on the financial results. Many Six Sigma programs have overemphasized a focus on cost reduction. If process improvement does not accompany that focus on costs, any realized financial gains will only be temporary. Processes will continue to perform at the same level. Remember the definition of insanity is doing the same thing we have always done and expecting different results. To get the fundamental, long-term savings, you have to focus on process improvement, not cost cutting. I have seen many cost cutting programs disguised as Six Sigma “process improvement” projects. While this may yield temporary financial benefits, it undermines the long-term success of the Six Sigma program.

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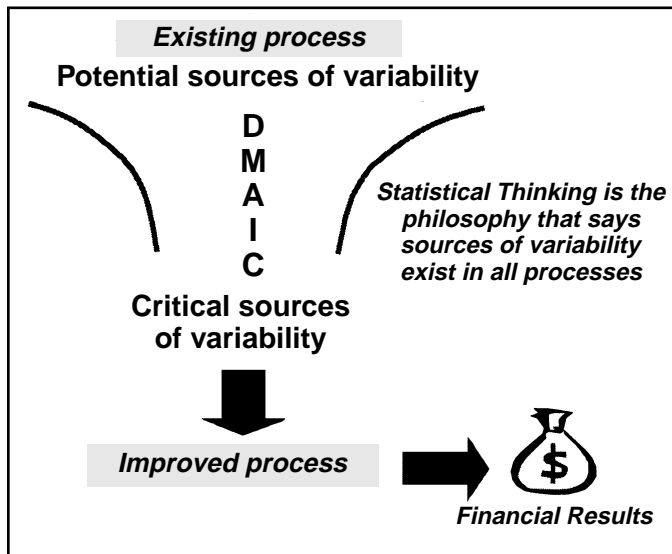
“Effective Six Sigma via Statistical Thinking”

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When adopting a philosophy of statistical thinking in conjunction with Six Sigma, the focus becomes fundamental process change. It moves us away from trying to massage the data to get the answers we want. Statistical thinking helps us to focus on sustainable, long-term improvements. It is very compatible with a philosophy of continuous improvement and Six Sigma methodology. In fact, it is necessary to ensure success.

In addition, Six Sigma complemented with the philosophy of statistical thinking adds a focus on only the most important sources of variability (the critical inputs). It helps us to reduce their negative impact. For any particular process, there are many different sources of variability. It is more effective to focus on those sources that have the most dramatic impact on the output. We can picture Six Sigma methodology as a funnel that acts to narrow the list from all the potential sources of variation to a manageable number. Figure 1 illustrates the concept.

Figure 1 – “The Funnel”



Examples

I would now like to show some examples of where failure to understand the principles of statistical thinking can have an impact on a Six Sigma project. Before doing so, I want to clarify that there are many reasons why a project may not be successful. These can be separated into two major categories (or levels) of failure: Deployment and Technical. See Table 1 below for some examples.

Table 1 – Examples of Six Sigma failures

Level of failure	Examples
Deployment	Lack of resources, No upper management support, Team dynamics issues, Resistance to change, Failure to link projects to strategic plan, No accountability for results, No champion support, Unclear project goal
Technical	Misapplication of statistical tools, Wrong interpretation, Wrong analysis, Not finding right critical inputs, Using wrong or bad measurement system, Failure to control process, Not using right metrics

Much of the Six Sigma literature focuses on the deployment level. As an example, Eckes lists 10 reasons why Six Sigma initiatives fail and how to avoid making those mistakes. Nine of them deal with deployment related issues. Only one deals with a technical issue – that of confusing special vs. common cause variation. Other Six Sigma literature has similar discussions (See #6 or #8 in list of references).

In the remainder of this paper, I will focus more on the technical failures that can occur when utilizing Six Sigma methodology. This choice of focus does not mean I think the deployment side of things is not important. Quite the contrary, I believe deployment failures must be addressed as soon as possible. They have been the downfall of many a Six Sigma program. The principles of statistical thinking can certainly be applied to handle the deployment issues. However, many practitioners of statistics deal more with the technical issues because of their technical background. That seems like a good place to start looking for applications of statistical thinking to Six Sigma.

Many technical failures could have been avoided had there been a thorough understanding of the principles of statistical thinking. The examples below highlight just some of the technical failures that I have seen. Certainly many more could be discussed here. Each one is followed by a key learning.

Example #1

A project was aimed at reducing relocation costs for employees. The team decided to use cost per relocation as their project Y. Because they were so focused on costs, they had a difficult time mapping the process. They had trouble applying DMAIC because they were not focused on the inputs and outputs of the process. The work

Continued on page 19

“Effective Six Sigma via Statistical Thinking”

Continued from page 18

of the team resulted in a series of cost cutting action items.

Short-term savings were accomplished by changes in company policies but there was no understanding of the process. However, they were not able to see the impact of those changes. The relocation process producing the costs is still the same. In addition, there is no understanding of the satisfaction level of the participants of the process. Those involved in the process still have the same problems they have always had.

An understanding of statistical thinking could have prevented this situation. The team would have focused on the process to be improved. More time would be spent on mapping the process and determining the key sources of variability in that process. This would result in a better understanding of the process and sustainable process improvement.

It is important with any Six Sigma project to use a project Y that focuses on the process. In other words, the project Y should be an output of the process. You will notice that in Figure 1, the financial benefit is off to the side. The financial result is not an output of DMAIC; it is a result of the improved process.

Learning – Do not use metrics that have \$ as the unit of measurement

Example #2

One project leader was struggling to figure out how to apply the principles to his project. After discussing the project with him, it became obvious that the team already had a solution in mind - outsourcing the manufacture of a particular product. By outsourcing, they felt like they could make the product with fewer costs.

In this case, DMAIC tools were being used, but the leader was simply going through the motions. The tools were not adding value to the project because they were not improving a process. They were just implementing a change. It was fruitless for the team to apply all the tools simply to say they had used them.

Statistical thinking helps to focus on the process and look at all possible solutions – or sources of variability. It reduces the number of “just do it” or “solution in mind” types of projects. It increases the number of things that a team can consider doing to reduce variability and improve processes.

Learning – Make sure you are trying to improve a process, not a “just do it” project or a “solution in mind” project.

Example #3

Some Six Sigma projects focus on the project Y at the expense of other metrics. For example, a completed project was not achieving its targeted level of performance. The reason? Fixing a problem in one area had caused problems in another area. The process was sub-optimized. The team did not consider the impact of their solutions on the other related processes.

This is a failure to recognize that all processes are part of a system, that is, they are interconnected. I applaud the choice of words in the definition of statistical thinking “All work occurs in a system of interconnected processes.” Sometimes we get caught up in the idea that all work occurs in processes that we forget how interconnected they really are.

Any Six Sigma project that strives to improve a process must be aware of the potential impact on other processes. This can be accomplished by using a good counterbalance metric. A counterbalance metric simply measures what could be negatively impacted by changes in the project Y. For example, if the project Y were to improve the production rate of a machine, a good counterbalance metric would be the measurable quality characteristics of the outgoing product.

Learning – Always include an appropriate counterbalance metric that is measurable.

Example #4

On another occasion, someone wanted my help to figure out how to do her statistical analysis in the Analyze phase. She had already completed the Define and Measure phases and had a list of key inputs to analyze. It turns out that she was doing the analysis correctly but was not getting any information from her results.

Upon further questioning, it was determined that the inputs were not controlled. They were simply “noise variables” and she had not come up with any way to improve the process. She had to go back to find other inputs that could be used to improve and control the process. With some rework of the results of the Define and Measure phases, she was able to find some controllable inputs. The controllable inputs allowed the project to achieve its goals and improve the process.

Continued on page 20

“Effective Six Sigma via Statistical Thinking”

Continued from page 19

Learning – Focus on the inputs that can be controlled or inputs that can mitigate the effect of noise variables.

Example #5

Two key components of DMAIC methodology are to present the initial capability and final capability of the project Y. The initial capability, occurring during the “M” phase, simply measures the current level of performance in the process. The final capability, occurring during the “C” phase, measures the new level of performance in the improved process. Many times this analysis is done with capability indices such as Cp and Cpk. However, the main tool should be simply a control chart. While capability indices can be useful, do not overemphasize them. For many non-manufacturing projects, the capability indices mean little because there are no customer specifications.

An effective project leader will always show a control chart of the data and refer to that chart frequently to show real improvement in the process. If a control chart cannot be created, it is either because the data was not collected or because the project is not really a process improvement project. If data was not collected in the past, the data collection should begin as soon as the project starts.

Someone who understands statistical thinking will have a strong focus on the control charts, the process view of the data. They recognize that control charts should be part of all Six Sigma projects.

Learning – Always plot the data for initial and final capability. Do a control chart of all the data in chronological order.

Solutions

To prevent these types of failures, the concepts of statistical thinking need to be taught, reinforced, and solidified in the minds of those involved in Six Sigma. Below are four solutions that will help in the effort to overcome some of the technical failures previously mentioned.

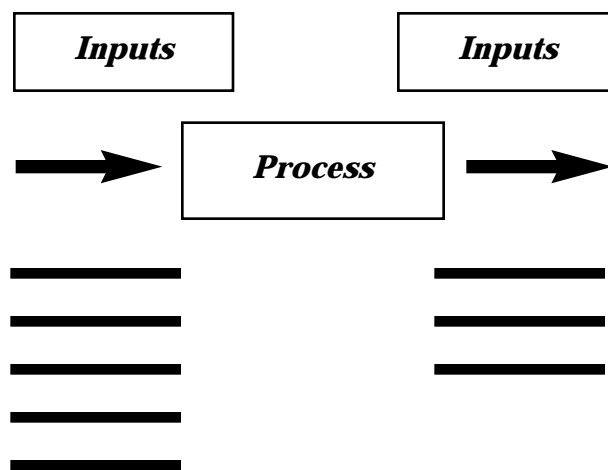
First, we must have greater care in defining the terms we use. One problem is that when we as statisticians talk about processes and variation, people sometimes have different operational definitions. To those not familiar with statistical thinking, the word process can mean something different. The dictionary has several different definitions for the word “process.” One is “something going on” and another is “a natural continuing activity or function”. However, the one that we want people to

understand is this one: “a series of actions or operations conducing to an end” (emphasis added). It is important to make sure that people understand that when we talk about a process, we are talking about a series or sequence of steps with inputs and outputs. It is ironic to think that there is variability even in the definitions of terms like processes and variation. However, it is important for us to be clear and consistent in our term usage.

Second, we must realize that statistical thinking (process-oriented thinking) is not natural. It may be easy to understand the words but to actually apply them is a completely different ballgame. It is a counter-intuitive at times. Our educational system teaches us deterministic principles, that there are facts and unchangeable things. The scientific method, in its pursuit of testing hypotheses and discovering new theories, encourages a deterministic mindset – that there is a fixed truth. For individuals to fully assimilate the principles of statistical thinking, they have to relax their deterministic beliefs. This can take some time getting used to.

A couple of things I have found, to help people learn and better understand the concept of a process, are the high-level process map and the fishbone diagram. An example of a high-level process map is shown in Figure 2. This process map is just a “50,00 foot view” of the process to be improved and includes a simple name. If you cannot give a name to the process, you will not be on the right track. Once the process is defined, you can talk about the major inputs and outputs of the process.

Figure 2 – High level process map

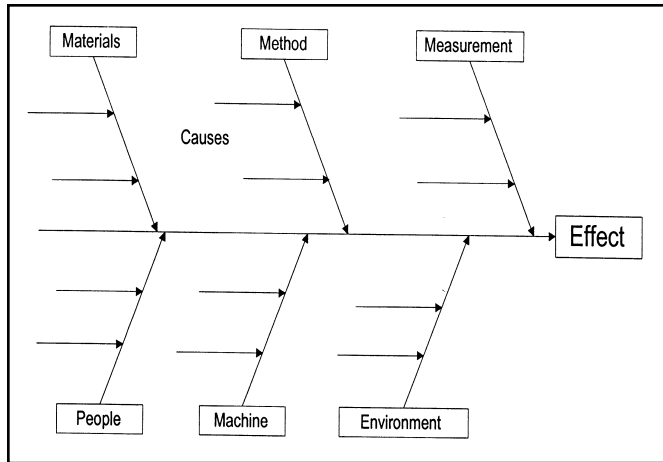


Continued on page 21

“Effective Six Sigma via Statistical Thinking”

Continued from page 20

Figure 3 – Fishbone diagram



With the high level view in place, you can then begin to talk about the specific steps of the process and talk in more detail about specific inputs and outputs.

Generally, a process map is created by first listing the steps and then listing the corresponding inputs and outputs. However, it may be helpful to first list the inputs (by way of the fishbone diagram) and then try to organize them into steps. The idea is to get people to think in ways they have not thought by considering all the potential inputs.

On one occasion, someone was having a hard time figuring out what to do next on her project. She had gone through the steps but had not really come up with improvements to make in the process. We went back to the beginning of her work and I found very few inputs on her process map. I encouraged her to do a fishbone diagram, which doubled the number of inputs. With the new inputs in hand, she learned that some of them were crucial to improving the process.

Third, improve Six Sigma training curriculum. Statistical thinking should be taught as the fundamental concept in any form of Six Sigma training curriculum. This should be done near the beginning of any training session before talking about any of the DMAIC tools. In addition, in any sort of training, we have to teach the purpose of the tools, and not just the tools. We have to de-emphasize the theory and calculations and focus on when and why the particular statistical tool should be used. I like to tell people to focus on the “spirit of the law” rather than the “letter of the law” when applying Six Sigma methodology. To learn the “spirit of the law” you have to provide examples, examples, and more examples. Supplementing training materials and instruction with a wide variety of examples help to solidify concepts of statistical thinking.

Lastly, we can be what Hahn has called the “Proactive Statistician.” This involves anticipating problems and seeking out solutions before the problems occur. This will be a big change for many of us who are used to the traditional “consultant” role of statisticians. It requires us to do more value added activities. It requires us to play more of a leadership role and take advantage of the opportunities before us.

Conclusion

Statistical thinking is fundamental to the success of Six Sigma. It plays a key role in bringing about true process improvement. Application of the philosophy of statistical thinking prevents many types of technical Six Sigma failures.

While the business culture is changing and the traditional role of statisticians is evolving, there is much to cheer. Six Sigma represents a powerful means to help a wider audience embrace and assimilate the principles of statistical thinking. That has to be a good thing. We should be excited about the role we can play in bringing about that change. We have a responsibility to ensure that we are really helping others better understand the rather chaotic world around us. This will ensure a better place for all of us.

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2003 AQC STATISTICS DIVISION SCHEDULE OF EVENTS

AQC STATISTICS SHORT COURSE

by Galen Britz

The Statistics Division is sponsoring a Pre-Conference Tutorial at the 57th AQC in Kansas City entitled "Improving Performance Through Statistical Thinking." The tutorial will be held on Sunday, May 18, 2003 from 8:00 am - 4:00 pm at the Kansas City Convention Center.

Improving processes is one of the most important jobs for all quality professionals. This tutorial is designed to:

- teach you how to use the concepts and methods of statistical thinking to improve organizational performance
- gain a common understanding of statistical thinking, and how it complements statistical methods
- examine levels for work (strategic, managerial, operational), comparing and contrasting how statistical thinking applies differently at each level. (Specific managerial and operational level processes will be provided.)
- develop ideas for how to use statistical thinking to improve results in your own organization.

Learning objectives are:

- Know how to apply statistical thinking to managerial and operational work
- Be able to determine how the concepts and methods of statistical thinking can improve results in you work environment
- Know how to apply statistical thinking in your role
- Encourage management to lead statistical thinking improvement efforts

Presenters are: Stu Janis - 3M, Tom Pohlen - 3M, Doug Hlavacek - Ecolab.

Costs: ASQ/AQP Members \$350, non-members \$450

You can register using the form in the program booklet sent by ASQ, by calling ASQ at 1-800-248-1948, or online <http://aqc.org>.

AQC STATISTICS SHORT COURSE

by Davis Balestracci

Title: “Those darn humans!” — *Anticipating and Managing Natural Organizational Resistance*
(All-day seminar)

Industry: Any

Level: Intermediate to advanced

Description

Regardless of the industry, most quality improvement efforts over the last 20 years have emphasized processes, tools, and good information—the “engine” of quality. However, the issues crucial to effective implementation that “fuel” this engine—cultural processes involving personal feedback, relationships, communication and, most importantly, people’s individual value systems—have been dealt with ad hoc, if at all, resulting in spotty ultimate effectiveness. Today’s unprecedented societal stress has also magnified the phenomenon created by these issues and first noticed by Joseph Juran in the 1950s—people’s natural resistance to change. Formal recognition and management of this as a process needing specific skills is necessary in today’s “bigger...better...faster...more...now!” business climate. Executives may no longer tolerate what they perceive as “analysis paralysis,” but “Culture eats strategic plans and best intentions for lunch!” At the conclusion of this talk, participants will be able to:

- Enact a crucial shift in their mindsets—changing themselves first—that will cause quantum leaps in their organizational effectiveness,
- Recognize, depersonalize, and manage the predictable anger, resistance, and ‘victim’ mindsets that accompany major organizational change efforts,
- Utilize a recognized effective model of everyday human behavior, “The Franklin Reality Model,”
- Facilitate two powerful group exercises to defuse organizational logjams typically encountered in implementing new change efforts,
- Redesign organizational training for greater effectiveness.

Davis Balestracci

Principal

Harmony Consulting

Phone: (623)-322-3328

e-mail: davis@dbharmony.com

Relation to Quality Profession and Development

Given today’s highly competitive business environment and the evolving role of Quality Professionals, the “survivors” will be those who can deal swiftly and successfully with the inherent, unintended frustrations of organizational psychology and resistance to the implementation of necessary performance improvements.

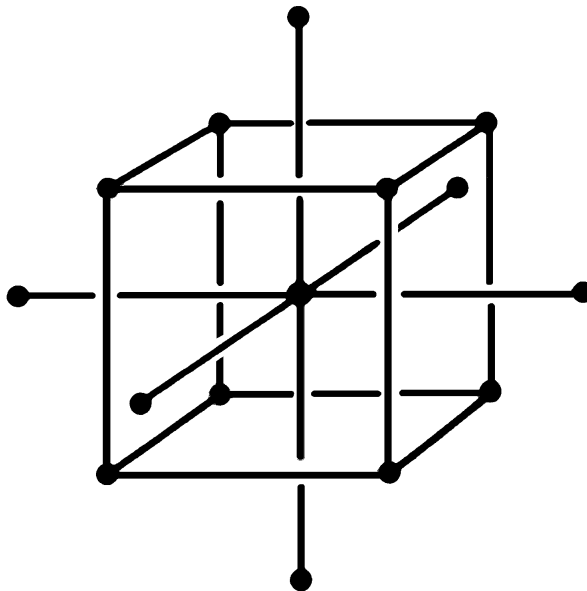
AQC STATISTICS BOOTH ACTIVITIES

by John Murphy

If you're going to AQC 2003 in Kansas City, plan to visit the Statistics Division booth to check out and provide your input of our new website currently under construction. We'll have hands-on demonstrations where you can explore the site and give us your feedback. In an effort to provide increased member value we are adding a new look and new features to our website such as improved navigation, file sharing, and discussion forums.

If you have friends going to the 2003 AQC who are not currently members of the STAT Division, but want to join, tell them to stop by the ASQ Megabooth at the Exposition Hall. As we have done for the past few Congresses, we will have copies of our popular, single-issue focused Special Publication Newsletters. This year we are handing out, free to everyone who stops by, our newest Special Publication: "Statistical Issues in Measurement" (Summer 2002) by Phil Stein. Anyone who joins the Statistics Division at the AQC will additionally receive all 3 previous Special Publications: "Statistical Thinking" (Spring 1996), "Data Sanity" (Summer 1998), and "Using the Power of Statistical Thinking" (Summer 2000).

Finally, we will conduct a drawing to giveaway 5 sets of three bundled books germane to the Statistics Division Body of Knowledge: Fourth Generation Management by Brian Joiner, Understanding Variation by Don Wheeler, and Switched-On Quality by John Guaspari.



AQC STATISTICS SESSIONS

BEYOND SIX SIGMA/LEAN

Session M209, May 19th, Monday 3:15 - 4:30 pm

Presenters: Forrest W. Breyfogle III, Smarter Solutions., Inc.
John Breckline, Nokia Internet Communications

Session Manager: John W. Jennings III, Quality System Innovations

Session Description: The session “Beyond Six Sigma/Lean” is a combination of a paper presentation by Forrest Breyfogle of Smarter Solutions®, and a case study by John Breckline of Nokia Internet Communications.

What companies will be around in ten years? The certainty of any response to this question has probably changed over the last year. Will your company face problems similar to Enron or K-Mart? Many companies need to readdress how they measure and make improvements within their organization. For survival companies need to replace fire fighting activities with a focus on fire prevention. Forrest’s presentation *‘Beyond Six Sigma/Lean: Methods to Ensure your Organization’s Health’* describes a methodology that helps companies improve their competitiveness and bottom-line. Described is a statistical based cascading measurement methodology that tracks an organization as a system, which pulls for the creation of improvement Six Sigma/Lean projects that are directly aligned with the needs of the business.

Alignment of business strategy, performance metrics, project selection, and resources is key to the collective, long-term success of Six Sigma. Management teams, champions and belts need to have a common understanding of this alignment to effectively select meaningful projects. John’s case study of a business support function, *‘Balanced Scorecards and Project Filters: Alignment for Success’*, explores the development of a Six Sigma project selection system based on flow-down from the strategic direction, to the creation of a Balanced Scorecard and criteria for a Six Sigma Project Filter, to the final selection of projects and assignment to Black Belts / Green Belts. The presentation will then close the loop in discussion of the metrics for Six Sigma performance within the function, measured on the Balanced Scorecard.

We look forward to having them share their experiences and expertise with us. We invite each of you to join us for a delightful, informative session on Monday, May 19, 3:15 – 4:40 pm.

Difficulty Level: Intermediate
Session Format: Paper/Case Study

OPEN POSITIONS

by Van Bowen

Opportunities for Participation

There are several opportunities for Statistics Division members to help the division leadership define and deploy our strategic and tactical plans. For additional information about each of these positions see: <http://www.asqstatdiv.org/opman-index.html>.

Vice Chair - Products & Services:

This position is one that is being defined by the new needs and challenges of the web. As our products and services migrate to the electronic media environment, there is need to manage our products and services - both the migration to the web and the creation of new opportunities to our membership

Purpose: This position is key to developing and positioning our electronic offerings and exploring the possibilities of e-commerce. The Vice Chair position is intended as a division leadership development opportunity.

Membership Chair:

The Membership Chair is one of our most important positions. It requires innovation and an interest in tracking our membership and developing recommendations or strategies to recruit and retain division members. Again, this position is often used as a springboard to greater responsibilities within the Division and is a great grooming opportunity for future leadership positions. Corporate support is helpful.

Purpose: The Membership Chair promotes and monitors Division membership, coordinates Society promotional activities with the Division, and serves as Regional Councilor Coordinator to improve division effectiveness at the local section level.

Examining Chair:

Our current Examining Chair has served since we first achieved division status within ASQ in 1978, and is looking to groom his replacement. The Examining Chair is member of the division "Standing" Committee – positions required by the ASQ Division By-Laws.

Purpose: To facilitate the recognition of Division members who are qualified to achieve Society recognition as a Senior member, Fellow, or other Division or Society Awards.

Short Course Development Chair

The Short Course Development Chair assists the Chair and Chair-elect to identify short course instructors for tutorials usually offered at the AQC or FTC, but more importantly, looks for opportunities for the Division to sponsor short courses in other ASQ division/region/section conferences.

Purpose: To seek subject matter experts and the right instructors to develop and present new Short Course materials based on recent publications that support our mission and vision and in anticipation of member needs.

Additionally, there are some less demanding positions available. These positions provide a good means to become more involved in the operations of the Statistics Division.

Professional Society Liaison is a position that helps deploy the Statistics Division mission and vision by aligning with other professional societies and organizations.

Division Marketer is a position that was created as an outcome of our Baltimore Long Range Planning session (1997), and is an important member of the division Outreach Committee to help establish our business plan: identify markets, customers, competition, and unmet opportunities. The Marketer is a key position that seeks to align our membership recruitment and retention efforts to our product and service design process.

LETTERS TO THE EDITOR

Thank you for taking the time to publish the "Statistics and Reality - Part 2" Mini Paper in the American Society for Quality Statistics Division Newsletter, Winter, 2002 edition. I'm an instructor in Eastman Kodak's Six Sigma University. My primary responsibilities are in teaching and mentoring Kodak's Six Sigma Black Belt candidates. Your article struck deeply at many of the defects in statistical thinking and analysis that I see all around me every day.

Whether it's using historical data, collected under unknown or unknowable circumstances, or jamming the same data into software where using bar charts to show time series data, tabular displays of descriptive statistics, or sole reliance on hypothesis testing are mangled still further to answer poorly framed questions in the first place, or answering them using statistics gobbledegook and jargon for the unwitting, your article just hits home hard.

Thanks so much.
Peter Bartell

After reading "Statistics and Reality - Part 2" in the Winter 2002 issue of the ASQ Statistics Division Newsletter, I had to write. Mr. Balestracci describes a scenario where a "local statistical guru, a Six Sigma black belt" performs a dubious analysis of time-ordered data. It is clear the author has a strong personal bias against Six Sigma, but he really should stick to the facts, rather than offensive hyperbole. Any reasonably trained Six Sigma Belt, of any color, would plot time-ordered data on the proper control chart as the very FIRST step in analysis. In the future, perhaps you could exercise a measure of editorial constraint over such attempts to denigrate entire groups of people.

George Rommal, CSSBB
Senior Research Consultant and Master Black Belt
Homer Research Laboratories
Bethlehem Steel Corporation

EDITORIAL

by Davis Balestracci

Did These Two Folks Read the Same Article?

Yes, indeed they did—and each has valid observations. As a Division, we have been derelict in addressing the Six Sigma phenomenon in a way that benefits our members. We made the mistake several years ago of taking the "This, too, shall pass" approach while considering the blossoming issue of Six Sigma as somehow being "beneath" the Statistics Division—to our detriment and that of our members.

Our members are looking towards the Statistics Division leadership for help, and, as Chair-Elect, I want the membership to know that this is a particular interest of mine—anchoring a more fundamental "variation" mindset in work cultures while helping members develop the skills to facilitate this nothing less than *overwhelming* transition in the American quality movement—academic, industrial, service, administrative, and management. The days of us being a "statistical pharmacy" merely dispensing advice on "techniques" is long past!

I have no bias against Six Sigma per se, and my motivation in the previous article was not to "denigrate". Many of our members are "non-belted", have to experience just such analyses, and are at the mercy of, shall we say, less than competent Black Belts. For those of us who train in Six Sigma efforts, we must be aware of what our seminar participants *actually do* outside the classroom. I am reminded of a comment made by Eisenhower, "To an engineer in his office with pencil and paper, farming looks pretty easy."--which is how Six Sigma can appear to "Six Sigma University professors" if we're not careful!

I would highly recommend that all members of our Division become familiar with at least these three books:

- Joiner BL. *Fourth Generation Management: The New Business Consciousness*. McGraw-Hill, Inc., 1994, 289 pages [ISBN 0-07-032715-7]
- Langley GJ et al. *The Improvement Guide*. San Francisco: Jossey-Bass, 1996 [ISBN 0-7879-0257-8].
- Neave H. *The Deming Dimension*. Knoxville: SPC Press, Inc., 1990 [ISBN 0-9453-2036-1]

They predate Six Sigma, and, in my opinion, you will never look at Six Sigma training in the same way again after reading these.

I remember chuckling with other statisticians about how Brian Joiner had "sold out" when he came up with his "Joiner Triangle" in the mid-'80s. Its three corners were: Quality (which Henry

Neave in *The Deming Dimension* expanded to "Obsession with Quality & Reducing Waste"); Scientific Approach (the art of data-based decision-making); and All-One-Team (the need to work together using this philosophy).

Sound familiar? Joiner's point is that everyone needs to know this philosophy and have it be the way the organization does business—a "transformation" rather than the "project-based" format of Six Sigma. Many roads lead to Rome...

The Langley book (whose authors also include the respected statisticians Tom Nolan and Lloyd Provost) to me is an indispensable handbook for practitioners. It has a chapter that talks about 70 concepts of "waste" that is absolutely eye-opening! In thinking about some reactions we get in our efforts, I am reminded of a saying, "It's amazing how much waste can be disguised as useful work."

Neave's book was a revelation to me. One can consider it a "biblical concordance" to Deming's *Out of the Crisis* (a difficult read even for devoted Demingites). It reads like a novel and makes Deming's approach to quality unbelievably clear. Despite its age, Six Sigma probably owes more to Deming than you might think.

Something to remember is that a lot of initial Six Sigma successes are in getting processes to **where they should have been in the first place** – that is neither "improvement," nor will the savings continue at the current pace! These books will get you to the next step where the rate of improvement can be sustained.

I am excited about our upcoming web forum where we will have the opportunity to discuss such issues and share helpful resources. In closing, I would like to share with you some food for thought.

A minister friend of mine once demonstrated, when you are listening to a tirade, a good way to defuse your initial "hot button" reaction is by picturing yourself as holding up a sign that says to the person, "This is about YOU." Of course, should you choose to react in a similar manner, you may as well hold up a sign, "This is about ME." Remember this as we deal with the frustrating resistance inherent in being Six Sigma "agents"...and as we share on the upcoming Statistics Division web site forum!

Let's band together for the good of the Statistics Division and ASQ. Good luck and keep the feedback coming. We're listening!

GORDON RESEARCH CONFERENCE ANNOUNCEMENT

by Mary Beth Seasholtz

2003 Gordon Research Conference on Statistics in Chemistry and Chemical Engineering

July 27- August 1, 2003

Mount Holyoke College, South Hadley, Mass.

Chair: Mary Beth Seasholtz, mseasholtz@dow.com

Vice Chair: Tunde Ogunnaike, ogunnaik@che.udel.edu

Web Site: <http://www.amstat.org/sections/spes/GRC2003.htm>

The GRC on Statistics in Chemistry and Chemical Engineering focuses on new research directions in applied statistics and in the analysis of chemical phenomena. It has met annually for 50 years, drawing statisticians, chemometricians, chemists and chemical engineers from industry, government and universities around the world. Statistical interests typically lie somewhere between Technometrics and JASA, with the applied interests of the former and the technical depth of the latter. New methods of predictive modeling, experimentation, chemometrics, and quality are perennial favorites. Chemical interests range from analytical, organic, and environmental chemistry to chemical process monitoring/control.

Program

Title: Multivariate Curve Resolution Applied to Hyperspectral Images

Speaker: David Haaland, Sandia National Laboratories

Discussant: Paul Gemperline, East Carolina University

Title: Robust Multivariate Calibration

Speaker: Mia Hubert, Katholieke Universiteit Leuven, Belgium

Discussant: Robert Rajko, University of Szeged, Hungary

Title: Process Monitoring for Feedback Systems

Speaker: Joe Qin, University of Texas, Austin

Discussant: Barry Wise, Eigenvector Research, Inc.

Title: Bi-linear modelling with jack-knifing and interactive graphics: a versatile tool from the third statistical culture

Speaker: Harald Martens, The Royal Veterinary and Agricultural University, Denmark

Discussant: El Mostafa Qannari, Ecole Nationale d'Ingenieurs des Techniques Agricoles et Alimentaires, France

Title: Quantification and classification of Magnetic resonance Spectra with applications in medical diagnosis

Speaker: Sabine van Huffel, Katholieke Universiteit Leuven, Belgium

Discussant: Radka Stoyanova, Fox Chase Cancer Research Center

Title: Estimating the State of a System: the Moving Horizon Approach

Speaker: Jim Rawlings, University of Wisconsin-Madison

Discussant: Graham Goodwin, University of Newcastle, Australia

Title: Maximum Likelihood Multivariate Calibration

Speaker: Peter Wentzell, Dalhousie University, Canada

Discussant: Bhavik Bakshi, The Ohio State University

Title: Dynamic and Steady-State Process Investigations Using Functional Data Analysis

Speaker: James McLellan, Queen's University, Kingston Ontario

Discussant: Aaron Owens, DuPont Co.

Title: Are Mixture/Pooling Experiments Worthwhile for Drug Discovery?

Speaker: Jackie Hughes-Oliver, North Carolina State University

Discussant: Lei Zhu, GlaxoSmithKline

STATISTICS DIVISION COMMITTEE ROSTER

Voting Members of STAT Council

2002-2003

Committee	Name	Division Position	ASQ Member #	E-mail address	Telephone
OFFICERS					
	Bob Mitchell	Division Chair	613928	rhmittchell@mmm.com	651-736-8684
	Davis Balestracci	Chair-Elect	553773	davisbharmony@attbi.com	651-224-7804
	Marcey Abate	Treasurer	570469	mlabate@sandia.gov	505-844-9424
	Bill Rolfes	Secretary	44706	brrolfes@mmm.com	651-736-0731
STANDING					
Examining					
Chair	Bob Perry	Examining Chair	26025	rlperry@mmm.com	651-736-7371
Auditing					
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Chair	Jacob Van Bowen	Past Chair	969535	vbowen@richmond.edu	804-289-8081
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Co-Chair	Bill Rolfes	Secretary	44706	brrolfes@mmm.com	651-736-0731
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Voting Member	OPEN	Short Course Dev Chair			
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Voting Member	Karin Chu	Newsletter Editor	01392441	chukarin@wellsfargo.com	480-858-8951
Voting Member	Stuart Janis	Special Publications Editor	55532	sjjanis@mmm.com	651-736-4577
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Co-Chair	Marcey Abate	Treasurer	570469	mlabate@sandia.gov	505-844-9424
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Voting Member	Jim Lenhart	Web Master	1234146	jelenha@sandia.gov	505-844-5479
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STATISTICS DIVISION AMERICAN SOCIETY FOR QUALITY
c/o Karin K. Chu
MAC S4015-010
711 W. Broadway Road
Tempe, AZ 85282

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All communications regarding this publication, **EXCLUDING CHANGE OF ADDRESS**, should be addressed to:

Karin K. Chu, *Editor*
ASQ Statistics Division Newsletter
Phone: (480) 540-0902
Email: karinkchu@netscape.net

Other communications relating to the Statistics Division of ASQ should be addressed to:

Bob Mitchell
Bldg. 224-06-S-03, 3M Center
3M Company
Maplewood, MN 55144-1000
Email: rhmittell@mmm.com

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DEADLINES FOR
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