Client Services

Sigma Science Inc.

The services offered by Sigma Science Inc. have multiple components integrated into a cohesive framework. These components are *customized* for each Client. In most cases only some of the components are applied at any given time. Typical components include, but are not limited to:

1. Client Assessment
2. Leadership & Infrastructure Development
3. Engineering/Support Training and Short Course offerings
4. Master Development
5. Internal Sustainability (Self-sufficiency)

Using this deployment framework, we have been successful at driving cultural changes throughout organizations while generating significant financial and productivity results. These successes have largely been due to:

- Support and involvement of management at multiple levels;
- Selection of projects based on financial impact, operational opportunity and organizational feasibility;
- Provisions for an improvement framework applicable across business segments and functions;
- Matching of employee abilities and organizational positions to training levels;
- The linking of business objectives to project activity; and
- Integrating the methodology with other initiatives.

Sigma Science offers both on-site (in-person) and remote training and consultation services.

Developing an Internally Sustainable Program: The Components

These components are not serial in the deployment of Sigma Science® throughout the organization. For example, leadership training may continue throughout the deployment lifecycle.

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Client Assessments

Assessments are designed to link key business opportunities and management objectives to actionable project work. Site assessments help us to develop a deeper understanding of the organizational needs, the nature of processes and products, potential candidates for training, and the organization's expectations. It also ensures program efforts are in direct alignment with management objectives and other corporate initiatives. Additionally, site assessments provide us needed insights in order to customize and refine the training materials to best meet the needs of the individuals and the organization.

Leadership & Infrastructure Development

An integral factor in determining a program's success hinges on providing the management team with a solid understanding of Sigma Science. Our program includes training targeted for both senior level management and the mid-level managers (project managers) who will be sponsoring projects and selecting candidates for training.

The implementation of the methodology varies across organizations depending on organizational philosophy, strategy, and the nature of the processes. These elements are covered further in the following papers: *Six Sigma Deployment Strategies*[1], *Six Sigma on Business Processes: Common Organizational Issues*[2], and *Six Sigma on Continuous Processes: How and Why It Differs*[3]. No matter what the implementation strategy is used, senior and mid-level leadership must be responsible for ensuring efforts are sustained and certain failure modes are addressed so knowledge gained can be effectively utilized in moving the organization into the future.

[1] Sanders, D. and Hild, C. Discussions of Strategies for Implementation of Six Sigma, *Quality Engineering,* 12(3) 303-309 (2000).
[2] Sanders, D. and Hild, C. Six Sigma on Business Processes: Common Organizational Issues, *Quality Engineering,* 12(4), 603-610 (2000).
[3] Hild, C., Sanders, D. and Cooper, T. Six Sigma on Continuous Processes: How and Why it Differs, *Quality Engineering,* 13(1), 1-9(2000-01).

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Executive Leadership Training (1-2 Days)

The senior executive course typically includes a conceptual overview, discussion of metrics, roles and responsibilities of the various levels of the organization, importance of integration of initiatives, examples of typical projects, common failure modes, and potential outcomes. The content clearly demonstrates the power of Sigma Science methodologies as applied to various aspects of the business.

The goal of this is to provide clear program leadership and support within the organization to drive sustainable results.

Project Management Training (2-3 Days)

Operations-level managers are primarily responsible for the selection of individuals to be trained and the projects to be worked. Project leaders and operations managers are positioned to ensure that the organization takes advantage of the process knowledge gained as a result of the project work.

This training provides an overview of the tools, but more importantly addresses issues such as project selection and candidate selection. It also includes a discussion of our training model and the role of managers during Sigma Science deployment. During the training, we address any business specific issues and discuss the behaviors and disciplines required of mid-level management to support long-term gains from the newly acquired knowledge. Only through the support at these levels will culture change be driven. This phase continues throughout the implementation process.

Because operations-level management is so critical we believe there should be at least one management class per wave of Engineering courses. This course is taught prior to (approximately one month) the Engineering level training to optimize results of the project work.

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Support, Engineering, Short Course Offerings and Project Support

Support (e.g., 2 week workshop over 2-3 months)

Support Functional Training is designed to equip a larger number of individuals in the organization with the basic Sigma Science tools. Support Functions apply their knowledge to develop initial understanding of processes, measurements systems and current data collection techniques. In addition, they develop a set of questions and theories about improving the processes. It is an option for technical managers to attend this training instead of the Project Managers workshop.

All participants are required to bring a minimum of one project to class. Support projects are smaller in scope than Engineering projects, and are often chosen to align directly with or provide the foundation for Engineering projects.

Support training is delivered with a hands-on methodology to ensure rapid tool application and immediate generation of business results. Support training is also used to identify individuals that are willing/capable of continuing on to Engineering training. The continuation toward Engineering certification requires an additional 2-3 weeks depending on the individual.

Engineering (e.g., 4 weeks over 5 months, six 3-day sessions over 6 months)

The Engineering training is an advanced, more technical program ranging from four to eight months in length (training elements). While this course does teach your people very advanced tools and techniques, the training is **not** tool driven. The appropriate application of any tool or method is preferable to the sequential, repetitive use of a standardized set of tools. Hence, an effective program develops the candidates' critical thinking skills while they build proficiency in the tools.

To successfully learn the methods, application of the thinking and tools is necessary. Therefore, the training is designed to facilitate the use of tools between training weeks (e.g., one week of training and project reviews followed by three weeks of project work). Project reviews and site visits (mentoring) are an integral part of the development of

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critical thinking and the appropriate application of concepts and methods. Especially for the first sets of individuals through the program, site support is essential. The first few are pioneers of a sort—ambassadors of the new methodology. Their success is critical to the growth of the Sigma Science initiative.

The frequency and periodicity of site visits is based on the rate of project work and the needs of the individual candidates. Phone, e-mail and internet support is used appropriately between classes and site visits to provide a consistent communication between the instructors and the candidates. As Master Candidates (see next section) are developed, this aspect of the work becomes increasingly internal to the organization.

As previously stated, the specific contents are customized to the needs of the organization and its processes or products. However, the core methodologies are covered in most Sigma Science Inc.'s programs. These core methodologies can be grouped into four categories:

I. Critical Thinking
   - Scientific Method
   - Thought Maps

II. Process & Product Description (Mapping)
   - Process/Product Maps, Relationship Diagrams
   - FMEA & Statistical Tolerancing

III. Sampling (without manipulation)
   - Numerical Evaluation of Metrics (NEM)
   - Measurement Systems Evaluation (MSE)
   - Sampling Strategies, trees and Components of Variance (COV) Studies

IV. Sampling (with Manipulation)
   - Factor Relation Diagrams (FRD)
   - Design of Experiments (DOE)
   - Experimenting in a Noisy Environment

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Our material is continually updated and is supported by papers we have written specifically designed to illuminate both fundamentals and advanced topics historically difficult to teach. In addition, we continually develop new modules and tools to support the business needs. Details of the tools and examples of cross-industry customization are provided elsewhere.

Short Course (specially designed support classes)

This course is not designed to replace the Engineering or the Support training, but to investigate specific portions of processes to support aggressive organizational goals.

Its primary objective is to provide individuals with the ability to critically assess the information available/not available in existing databases and to be able to better understand process variation via critical sampling and data collection.

Thus, the project goals should be directly aligned with this objective. It is expected that individuals in the classroom should be able to generate critical process questions via analysis of their existing data sets, to understand the nature of the variability of critical process parameters, and to strategically sample the process in order to be able to answer specific questions. Hence, typical project scope will include:

- Evaluating/developing new measurement processes;
- Developing thought maps for particular process areas (the analysis of historical data sets should generate better process questions that, in turn, provide guidance in new ways to collect data on the process);
- Process mapping areas of the process believed to be critical for obtaining output parameters;
- Development of sampling plans to understand dominant sources of variation;
- Collecting new data to confirm or invalidate current theories about causes of variation.

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Development of Masters (12-18 month program)

An important component of the deployment strategy is the development of Masters. These are individuals who are capable of applying intensive and diversified process improvement techniques to achieve greater efficiency and effectiveness no matter *what* the process type. Sigma Science Inc. will provide technical modules, suggested readings, and evaluation of technical skills & teaching methods that potentially lead to recommendation of certification as a Master. The Master Candidate's (MC) organization will provide the opportunity for the MC to participate in the development process and evaluation of performance to include interaction with members of the organization and business results. The MC will design, in conjunction with us, a twelve to eighteen month development process and document that process in a Personal Development Plan. This plan may build on existing plans, must be detailed, measurable, contain milestones, and tentative schedule of key events.

Internally Sustainable Program & Beyond

Sigma Science Inc. provides informal support to Engineers and Masters as long as requested at no cost to the organization. These long-term relationships with individuals provide guidance and assistance beyond the formal organizational engagement.

Projects

As we discuss in *Common Myths About Six Sigma*[4], one difference between most Six Sigma initiatives and preceding quality improvement efforts is that work is organized around projects and project completion. Ideally, the projects flow down from business strategies and provide a connection between senior and lower-level management.

[4] Hild, C., Sanders, D., Common Myths About Six Sigma, *Qual. Eng.*13(2), 269-276 (2000-01).

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The strengths of a project focus are:

- The removal of uncertainty concerning where management wants work directed;
- Required practice in application of the Sigma Science concepts and tools while undergoing training (thus, promoting more critical thought and appropriate tool usage);
- A strengthened understanding of the need for a combination of good process and engineering knowledge and statistical thinking; and
- The development of an appreciation for the strengths and limitations of the methods learned.

On the other hand, certain characteristics of project work can help shorten the life of a Sigma Science initiative if not managed properly. First, the nature of project work is of finite duration. Individuals often conclude, "I've finished my Sigma Science project, so I'm returning to my normal work". As a result of short-term focus on specific projects, the organization may undergo the usual burst of improvement only to eventually return to status quo. Often, the selection of project objectives by management restrict the investigators to narrow or inflexible paths of work, not allowing for sequential evolution of investigative direction based on the knowledge acquired. Finally, project orientation often focuses the work on the problems themselves and not on the processes that cause the problem.[i]

We recommend that the Sigma Science projects are handled and reported in the manner that current projects are handled and reported. Concurrently, managers are educated and required to change the manner in which they ask question and direct work in their respective organizations.

Training in a Multi-Industry Environment

Every process and business, and thereby project, is unique and the skills needed by the Engineer can be different dependent upon the nature of the process and the objectives of the project. In order to achieve sustainable gains/improvements, flexibility in programs is necessary. The degree and nature of the flexibility is dependent upon:

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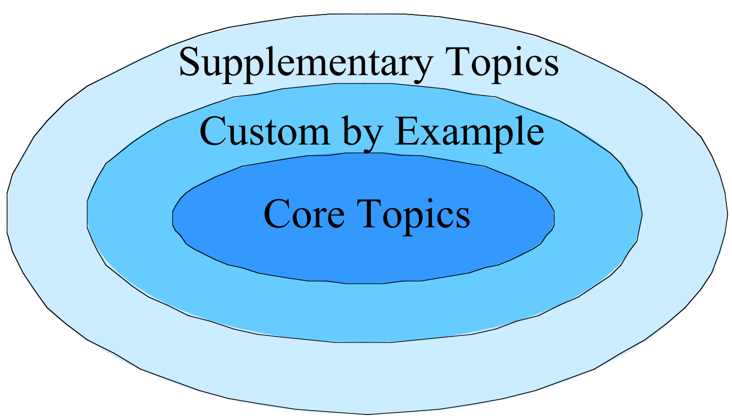
- **The type of processes**—for example, continuous, chemical processes often require multivariate methodologies and service processes typically need survey development skills.
- **The needs of the organization**—for example, an organization that is primarily needing to drive a common focus on process improvement across the entire organization may need more a more basic tool set combined with good motivational sessions. On the other hand, an organization that needs to resolve critical product failures whose effects have been mitigated without discovery of underlying causes will need advanced statistical tools combined with excellent engineering skills.
- **The nature of change needed to achieve sustainable gains in process/product performance**—for example, if the existing process structure is incapable of achieving the desired level of change in a critical response, then process redesign and lean manufacturing principles are necessary.

"To believe that one specific tool set applies everywhere or across every issue is to ignore fundamental differences…."[5]

Our programs are designed using a 3-tiered approach to content customization as shown below:



Some tools and training elements are universally applicable, since they represent the fundamental tools that are useful in any process, regardless of the industry type. These tools represent roughly 70% of the Sigma Science tools. For these core tools, we

[5] Ibid.

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present standard material that is customized by providing industry and function specific examples around the standard core.
Secondly, some industries and functions will require specific tools to most efficiently drive business results. Those specific topics will be limited to those areas of the organization where benefit can be derived. As mentioned before, these topics represent 30% of the total training content.

In addition to the material customization around a core as mentioned above, we will also conduct symposiums for program participants. In these symposiums we will present additional tools and methods that are not part of the core, but useful in project work in select areas. The delivery of material via symposiums gives those individuals with specific requests the ability to expand their knowledge while retaining the efficiency of the core program.

With this in mind, we provide three examples of integrated programs that we tailored to the needs of individual organizations. Within these programs, it is apparent that some of the tools are foundational in nature while others are more specific to the needs of the individuals and/or organizations. These examples do not cover all of the situations but are simply a sample of some common situations.

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<u>Situation 1:</u> Transactional, Business Process Training Content

The content was adjusted to meet the needs of both product development and marketing research in the same program.

Week 1	Week 2	Week 3	Individual Tracks	
			Product Design	Marketing Research
Overview: Philosophy of Sigma Science	The Nature of Variation: Special Cause/Common Cause Model	Measurement System Evaluation for Continuous Measurements	Design of Experiment (DOE)	Multi-variate Techniques
Critical Thinking: Thought Maps	Measurement Error in Attributes Data	Intro. to Control Charting	Full & Fractional	PCA
Process Characterization: Flowcharts, Process Maps, Relationship Diagrams, Spaghetti Diagrams	Developing Measurement Processes, Operational Definitions, NEM	Components of Variance (COV) Studies: Sampling Continued	Experimenting in a Noisy Environment	Cluster Analysis Survey Development Conjoint Analysis
Concept of Variation, Process FMEA	Sampling Strategies: The Art of Sampling to Get Answers	Attributes Measurement System Evaluation: Kappa & ICC Statistics	Regression	
Project Definition and Scope of Projects	Process Restructuring for Administrative Processes: Batch vs. Paced-to-Demand	Systems Flow Exercise and Simulation		
Project Descript.	Project Reviews	Project Work		

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<u>Situation 2:</u> Chemical Division of a Larger Organization

The content was adjusted to meet the needs of closed-loop, chemical processes with large quantities of on-line process data as well as prohibitive costs for equipment or process layout changes.

Week 1	Week 2	Week 3	Week 4
Overview: Philosophy of Sigma Science	Review of Week 1	Review of Weeks 1 & 2	Review of Weeks 1, 2, & 3
Critical Thinking: Thought Maps	Regression Analysis	PCA Control Model	Evaluating Noise in DOE
Process Characterization: P&ID Diagrams & Process Maps	Principal Component Regression (PCR) and Stepwise Regression Procedures	Partial Least Squares (PLS) Regression	DOE: Blocking Strategies
FMEA	Introduction to Multivariate Control Charting Methods: T^2 & Q	Crossed vs. Nested Sampling Studies	DOE: Evolutionary Operations (EVOP)
The Nature of Variation: Special Cause/Common Cause Model	Sampling Strategies and Sampling Trees	DOE: Full Factorials	DOE: Covariate Analysis
Introduction to Principal Component Analysis (PCA)	Components of Variation (CoV) Studies	DOE: Fractional Factorials	DOE: Fractional Factorials with Restrictions on Randomization and Factor Relations Diagrams (FRD)
Measurement System Evaluation (MSE) Numerical Evaluation of Metrics: NEM	Project Reviews: Thought Map & Process Map Development	Project Work & Reviews	Project Work & Reviews

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<u>Situation 3:</u> High Volume, Discrete Parts Manufacturing, Assembly and Refurbishment

In order to increase productivity and reduce the amount of scrap, the project work needed to focus on implementing fundamental manufacturing practices, reducing variation, and implementing one-piece flow. Hence, the training was designed to accommodate the needs of the organization.

Week 1	Week 2	Week 3	Week 4
Philosophy of Sigma Science Business Case Development Process Characterization: Process Maps, Spaghetti Charts, etc. Failure Modes & Effects Analysis (FMEA) The Nature of Variation: Special Cause/Common Cause Model Sampling Strategies Numerical Evaluation of Metrics (NEM) Measuring Processes Measurement System Evaluation (MSE) Critical Thinking Thought Process Maps	Philosophy of DOE Full and Fractional Factorial DOEs Experimenting in Noisy Environments Practical, Graphical and Quantitative Analysis Techniques Introduction to Factor Relationship Diagrams Project Reviews User Guides	Advanced Sampling: Nested, Systematic and Crossed Blocking Advanced Quantitative Methods ANOVA Case Studies and Project Reviews Product Delivery System Design (CONWIP to Kanban) Simulation Project Reviews User Guides Expansion	(Topics selected based on class needs) – Below is a partial list of topics to draw from Covariates Attribute and Ordinal DOEs Variation & Experimentation Factorial with Restrictions (Split Plots) Regression Analysis Ordinary Least Squares Application Curvature and RSM Capability and Statistical Tolerancing Diagnostics User Guides and Project Reviews

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Miller on Scientific Method: "Science is not any particular method or set of techniques. It is a way of reasoning. The standards are intellectual rather than procedural. The method of observation, formalization, and testing must vary with the nature of the problem".[6]

The following is a sampling of tools that may be delivered in support of project work. The tools are organized by Four Platforms.

Critical Thinking: the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, evaluating, and/or predicting information gathered from, or generated by, observation, experience, reflection, reasoning, communication, or sampling as a guide to belief and action.

Thought Map: an ongoing documentation of existing knowledge, the questions asked, the parallel paths of work needed to answer those questions, tools applied to answer questions, knowledge gained from work performed, and the direction of future work. The *thought map* is invaluable in any focused work effort in order to capture the multitude of questions that arise, the many possible paths that need to be considered in obtaining solutions, the work performed, and the solutions obtained.

Failure Mode & Effects Analysis (FMEA): a systematic method for identifying, analyzing, documenting and prioritizing potential failure modes, the effects of such failures on system performance and possible causes of failures.

Process and Product Description: Use of graphical techniques to identify and categorize variables for later investigation.

Process/Product Map: a tool that displays current process knowledge and is a supplement to many of the traditional process investigation tools. It enhances the usual flowcharts with the type of knowledge captured in Cause and Effect Diagrams. Graphically combining the knowledge typically depicted on a flowchart with that from a Cause and Effect Diagram, the Process Map overcomes the weaknesses of the two tools used independently. Additionally, the Process Map provides a clear understanding of the current state of process management by classifying each parameter as controllable or noise.

Sampling: a set of methodologies that combine the use of sampling strategies, sampling trees, and statistical process control (SPC). A proactive methodology, Sampling is used to discover dominant sources of variation in product or process and to thereby provide guidance and direction for work. Sampling is a discovery tool, whereby SPC has typically been taught as a monitoring tool.**:**

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[6] Miller, Edgar G. "Scientific Method and Social Problems", Science, 109: 290-291, March, 1949.

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Components of Variance (COV) Studies: methods to partition the overall process variation into portions assignable to causes at each of several levels. For instance, the total process variation might be attributable to a within piece component of variation, a between piece within lot component of variation, and a between lot component of variation. COV studies are used to evaluate the stability and magnitude of the various components of variation and therefore to provide focus for work to develop process knowledge.

Control Charts: Certain variations in process or product measures belong to the category of chance variations about which little can be done other than change the process or system that produced the data. This category of variation is the sum of the effects of complex interactions between many factors. It is the variation "built" into the process by current practices and managerial behaviors. Besides these "chance" variations, there are variations produced by "assignable" or special causes. These sources of variation can be isolated. Control charts are used to differentiate the variation.

Measurement System Evaluation (MSE): methodologies for identifying and quantifying the different sources of variation that affect a measurement system.

Sampling Trees: A graphical description of the relationship between "layers" of variables in a sampling plan. They describe the nature of the relationships; nested, systematic or crossed and are required for planning and analysis.

Sampling with Manipulation (Design of Experiment - DOE): efficient procedures for discovering relationships between independent factors (process parameters), such as temperature, pressure, time, speed, etc., and response variables (product parameters) such as size, variation, ductility, shrink, etc. The independent factors are varied in a specific fashion and the effect of these changes on the response measured. The fashion in which the independent variables are manipulated may be thought of as the experimental design.

Factor Relationship Diagrams (FRD): tools that assist engineers in understanding and making decisions regarding potential information content in an experiment and cost of that information relative to experimental run order and experiment size (experimental cost in terms of production time and possible scrapped units).

Ross' Rules of Analysis: Practical, Graphical and Quantitative

Regression Analysis: a set of methodologies used to determine the statistical relationship, if any, between variables in order to utilize the relation so that one variable can be predicted from the others. Regression, or ordinary least squares (OLS), empirically describes variation in a response variable (Y) based on a set of “independent variables” (x’s or y’s).

Diagnostics: A set of methods to determine the integrity of the data to be analyzed (tests for special cause, outliers, stability, etc.)

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Additional tools are delivered dependent on the nature of the situation. These tools include dealing with attribute data, data mining (PCA), non-manufacturing environments, etc.

<u>Software:</u>

We have conducted classes where the statistical package was JMP, SAS, Minitab, Statgraphics, Number Cruncher, and Design Ease. We do not focus our course on software packages so if you have a preference, we will work with you to use that. However, if you have no preference, we recommend JMP by SAS.

<u>General Company Information</u>

1.1 Company Business Background – Sigma Science Inc. (p.k.a Six Sigma Associates) was established in January 1993 to assist companies implement and utilize tools and techniques of Sigma Science, Scientific Method and Analytical Statistics to become more efficient and productive. I am the first independent consultant deploying Six Sigma. I have over 30 years of practical applications experience dealing with a variety of design, manufacturing/non-manufacturing environments and with a variety of process improvement techniques. I have been recognized by the American Supplier Institute (ASI), the Universities of Tennessee & Wisconsin, the Electronic Industries Association (EIA) and the Association Connecting Electronics Industries (IPC) for applications of continuous improvement techniques. In addition, I has been recognized by the American Society of Transportation and Logistics and the National Tooling and Machining Association for significant contributions. I has participated in ANSI, ISO & IEC standards development including IPC-PC-90 and ANSI/EIA-599. I have conducted workshops on statistical methods throughout Asia, Europe, North and South America. I have authored numerous articles on continuous quality improvement and have developed numerous courses on the tools and techniques of continuous improvement. I developed and cultivated the use of Process Mapping, Thought Mapping, Factor Relationship Diagrams, Ross' Rules of Analysis, the Ross metric and a host of other methods translating difficult statistical methods into practical engineering techniques. Clients have included AlliedSignal Aerospace, Whirlpool, Honeywell, Oakley, Electrolux, PPG, Abbott Labs, Tennant Company, Newell Brands, Weber, Lutron Electronics, Cytec Engineered Materials, Meggitt Electronics, Sanford, Milwaukee Tool, Jarden, Boston Scientific, USPC, Bell Helicopter, Endevco, Thermo King, Cytec Industries, General Electric, Guidant, Xerox, Toppan, Siemans, P&G, Texas Instruments, Georgia Pacific, Clayton, SmithKline Beecham, Brasmotor, MagneTek, Matsushita and ABB.

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1.2 SDWBE Ownership – Sigma Science Inc. is a small business as defined by the Small Business Administration (NAICS #541614, SIC # 4731, DUNS # 078098840).

1.3 About Bill Ross Founder and CEO–

Bill assists in the implementation and utilization of the tools and techniques of Sigma Science. I completed the ISO 9000 Lead Assessor examination, and was a volunteer Engineer for Education. Bill is a past member of the EIA Quality and Reliability Engineering Committee, the ANSI/ASC Z-1 Committee and the U.S. TAG's for ISO TC176, ISO TC69 and IEC TC56. Bill has a degree in Geochemistry from the University of Colorado and has completed graduate level studies in statistics at the University of Tennessee (McLean & Sanders) and the University of Wisconsin (Box, Bisgaard and Fung). Bill has been fortunate enough to work with and learn from Drs. Taguchi, Hogg, Mundel, Diamond, Wadsworth, Schilling, Johnson, Thyregod & Takahashi. (303.517.5579, statman@comcast.net).
I specialize in: Analytical Statistics, Critical Thinking, Scientific Method, Application of Statistical Thinking, Sampling and Design of Experiments.

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