EVIDENCE-BASED DECISIONS, SIX SIGMA AND MILLION DOLLAR BREAKTHROUGHS

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ABSTRACT

This highly interactive presentation delivers three benefits. 1) Participants will learn how and why vector analysis is foundation for the evidence-based decisions that power Six Sigma breakthroughs. Vectors accelerate Six Sigma ***D***efine, ***M***easure, ***A***nalyze, ***I***mprove, ***C***ontrol (DMAIC) project cycles into 30 days or less. 2) A health care case study shows how vector analysis, statistical evidence and a Crystal Ball simulation helped persuade a team of cardiovascular surgeons to embrace the million dollar breakthrough improvement known as off-pump Coronary Artery Bypass Surgery (CABG). 3) A manufacturing case study shows how an extrusion manufacturing plant used vector analysis and statistical evidence to cut material costs in half while doubling the speed of its throughput yield. The vector analysis Microsoft® Excel template attached to this paper can be immediately used by Black Belts and Master Black Belts to increase their effectiveness on the job.

1 THE MILLION DOLLAR EVIDENCE MODEL

Evidence—the backbone of million-dollar Six Sigma breakthroughs—is the product of a correct data analysis. Since 1920, a statistically correct analysis has consisted of a vector analysis applied to a data matrix. Very few people know this. Vector analysis, the unifying concept for Six Sigma power tools, is conspicuous by its absence from Six Sigma literature, certification exams, and the accepted body of Six Sigma knowledge. Nevertheless, vector analysis is the single most important tool in Six Sigma.

The model that serves as the foundation for vector analysis and statistical evidence is the three dimensional, Cartesian coordinate system (Figure 1). Crystal Ball® calls this model "Latin Hypercube" sampling.

Data matrix applications, also known as statistical software, use vector analysis framed in the "X, Y, and Z" model to calculate the standard deviation for a given set of data. Vectors are also the foundation for *F*-ratios, *P*-values, *t*-test values, *r* and r^2 values for correlation values, regression statistics, confidence intervals and most other decision statistics. By combining real-time data collection, evidence and three-dimensional financial simulation models Black Belts often discover they can accelerate their rate bottom line, improved financial results.

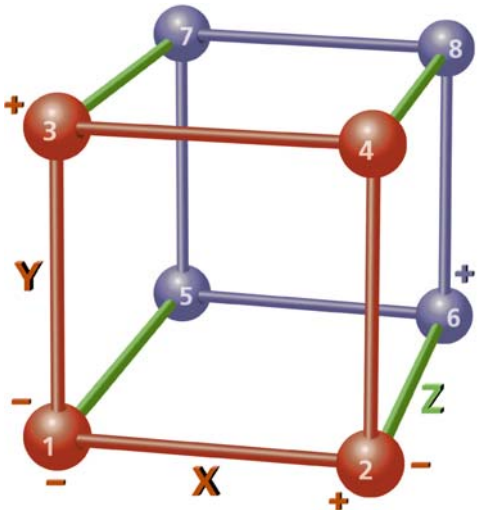

Figure 1: Many executives who hold a physical model of this abstract idea in their hands often find it easier to grasp the fundamentals of a correct analysis.

2 THE 15-MINUTE PH.D.

Surprisingly, it takes only about 15 minutes to teach people how to use vector analysis and evidence to make better quality decisions. Models that are fun to use are the key to success in this teaching method. The financial success that comes from project breakthroughs disarm skeptics as it demystifies analysis. Not infrequently, this learning experience leads to 30-day DMAIC breakthrough project applications that can and often do yield 50-100K results. The Roman Catapult is a teaching model that has withstood the test of time in the field of statistical evidence. The catapult used in this hands-on, interactive presentation is an analogy. Analogies are comparisons. They promote more thoughtful approaches to business decisions.

The data matrix array (Figure 2) for the Roman Catapult demonstration arrays the distance outcomes for eight different combinations of three variables set at two levels. Two levels of three variables (23) form a cube known as a designed experiment. The Figure 2 array shows what the Cartesian coordinate cube looks like in a "column/row" or "field/record" layout. Trigger is the X variable. Arm is the Y variable. Ammo is the third, or Z, variable. The response measure is the Distance in inches that the ammunition flies.

Look closely at the patterns you see. What are the common variable settings for the two longest shots, 65 and 67? What are the variable settings for the two shortest shots, 23 and 22? Which variable doesn't seem to have much effect on the system?

	Trigger	Arm	Ammo	Distance
1	Low	Low	Yellow	36
2	High	Low	Yellow	23
3	Low	High	Yellow	65
4	High	High	Yellow	38
5	Low	Low	White	35
6	High	Low	White	22
7	Low	High	White	67
8	High	High	White	37

Figure 2: This fundamental essential 2^3 data matrix helps people understand the power of the evidence-based decisions for which Six Sigma has achieved acceptance.

Our live catapult and data matrix analysis demonstration confirms your intuitive inferences. Coincidentally those inferences are also statistically significant at the clear and convincing 95-percent level of confidence! This model yields clear and convincing evidence that the trigger and arm settings are system drivers. The two-factor interaction between the trigger and arm settings shows a preponderance of statistical evidence. No math, no calculations, Black Belt and no advanced statistical degrees are required to complete this vector analysis. Business executives like these model features.

As the live demonstration also shows, these eight data points also make astonishingly accurate predictions for future outcomes of this complex catapult system possible.

3 HOW VECTOR ANALYSIS PRODUCES STATISTICAL EVIDENCE

In a correct analysis, the RAW DATA in the response measure column—in this case labeled 'Distance'—are treated as a single entity. This entity is called a vector. A vector defines magnitude and direction; it is often represented as a line with an arrowhead on the end of it. The DATA AVERAGE of the distance measurements—in this case the average is 40.38—becomes the second vector in a correct analysis. The differences between each raw data measurement and the overall average create the third vector, the third element, in a correct data analysis. We have named this the VARIATIONS vector for easy recall. This vector is also called a sample standard deviation, sometimes called sigma. This vector is where Six Sigma gets it name (Figure 3).

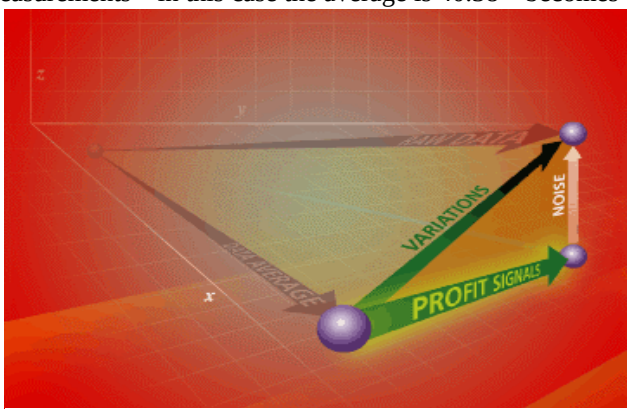

Figure 3: A correct data analysis creates a three dimensional geometric figure composed of right triangles called a tetrahedron.

Each variable—the trigger, arm, and ammo—has its own "PROFIT SIGNALS" vector. The hypercube model makes this possible. The final vector in the analysis quantifies the chance statistical fluctuations or NOISE that attend every measurement. All of these vectors are detailed on the Excel template (*Sloan-vector-analysis.xls*) associated with this paper on your CD ROM version of the proceedings.

Sir Ronald Fisher, the genius who invented the analysis technique called the Analysis of Variance, or ANOVA, described it as a "simple method of arranging arithmetical facts so as to isolate and display essential features of a body of data with utmost simplicity." And so it is. When the ratio of the mean squared length of PROFIT SIGNAL compared to the mean squared length of the NOISE vector is "relatively large," that F ratio tells us we have evidence that is statistically significant. When that ratio is "relatively small," we have no evidence of statistical significance.

The three dimensional shape of a correct analysis, which is called a tetrahedron, can be built to scale using a Strange Attractor or other modeling set. Again, fast demonstrations and physical models help people grasp abstract ideas. With those

ideas in hand, business leaders tend to make statistical analysis a central part of every-day-of-the-week, more profitable business decisions.

4 HOW TO USE EVIDENCE AND SIX SIGMA TO CREATE MILLION DOLLAR BREAKTHROUGHS

Money talks. The Latin Hypercube, the Cartesian Coordinate's model system, three-dimensional and *n*-dimensional vector analysis are becoming mainstream business decision tools because they help companies make more money using fewer resources (Figure 4). One health care and one manufacturing case study are provided as examples.

A debate has raged in the world of medicine regarding the merits of "on-pump" versus "off-pump beating heart" surgeries since 1982. Tradition favors the heart stopping "on-pump" technique. Overwhelming statistical evidence favoring the "off-pump" technique clinical outcomes surfaced with an article published by the Society of Thoracic Surgeons in 1992. Up until the economic forces of market pressure emerged in the late 20th Century, "on-pump" remained in favor.

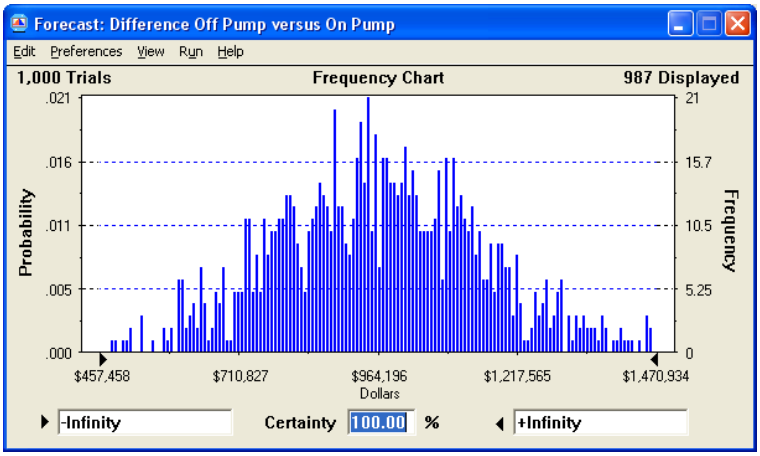

Figure 4: When surgeons and hospital executives viewed the predicted results for off-pump beating heart CABG surgeries that came from a Crystal Ball Latin Hypercube model, practice patterns began to change. The prediction model was accurate.

As an increasing number of patients demanded "off-pump" techniques be used, surgeons who has resisted acquiesced. The vector analysis model for statistical evidence combined with financial simulations created a persuasive case for breakthrough improvement. For this one procedure, the breakthrough improvement of "off-pump beating heart surgery" typically yields shorter hospital stays, reduced neurological damage, and an additional $1 MM in revenue per doctor per year for the hospital.

We find similar parallels in virtually every industry. Tradition remains favored over statistical evidence until economic models change opinions. As another example, I offer the following. For 25 years an extrusion manufacturer "knew" that the "best way" to produce distortion free product was to increase the quantity of resin used and to slow the line speed down. As the data matrix vector analysis I present live illustrates, the correct solution is counter intuitive and precisely the opposite. With clear and convincing evidence, the superior way to produce distortion free product with the tools under study was to decrease the amount of material and to virtually double line speed. Though the breakthrough project took less than 30 days to complete, the breakthrough was valued at more than $1MM less than a year later.

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BIOGRAPHY

Daniel Sloan is an internationally recognized Six Sigma Master Black Belt. His 14 years of experience have been distinguished by Six Sigma seminars in Mexico, Uruguay, Brazil, Australia, and 40 of the United States. McGraw Hill and Quality Press published five of his 6 books on breakthrough improvement. As the Senior Vice President of Applied Business Science for a $500 million company he was responsible for training all Black Belts and Green Belts at eight facilities across the country. With "factory floor" Six Sigma successes in regional medical centers, non-woven fabrics, extruded products, medical

equipment, aerospace engineering, automotive parts, to Internet router products, and health care companies, Daniel has a proven track record in helping organizations produce bottom line results. His newest book written with Russell A. Boyles, PHD, *Profit Signals – How Evidence Based Decisions Power Six Sigma Breakthroughs*, was published in 2003.