Continuous Improvement Initiatives: The Sigma Science[1] Methodology

William Ross[2]

Abstract

Most companies recognize the importance of continuous improvement on the sustainability of the organization. Continuous improvement of all facets of the organization: product performance, customer satisfaction, profits, the individuals employed therein, etc. Continuous improvement implies change! There exists a plethora of methods and models for driving continuous improvement. The model or strategies used to deploy the initiatives vary from organization to organization. In reality, there are as many strategies as there are companies implementing these initiatives. The concepts and tools also vary across organizations. It would be unreasonable to think a single deployment strategy would be effective across all organizations just as it is to argue only one set of tools is needed regardless of the situation. **There is no one strategy that can possibly be optimal across all companies or even across all divisions or plants within a company.** Each type of deployment strategy has its own set of potential burdens and contributions to the organization. Regardless of the initiative, sustainable change requires many things. Below is a short list of elements required for successful deployment of any initiative:

- An organization willing to accept the change
- Enlightened and motivated leadership
- Alignment of metrics and goals across the organization
- Excellent communication of the intent of each initiative
- Critical mass of technically competent individuals
- Successful application of the methodology (credible success stories)

In this paper, I describe deployment of the Sigma Science methodology. A methodology I have developed and refined over the last 35 years.

Failure Modes

I have selected a subset of Dr. Deming's[3] 14 Points to highlight common failure modes associated with improvement initiatives:

- Lack of understanding, planning and support from the entire management team (point 7)
- Multiplicity of initiatives and goals that result in competition for resources. Not clearly defining the intent of the initiative and what roles each functional area will play (point 1)
- Poor measures and measurement systems (points 10 & 11)
- Risk aversion which results in a reluctance to iterate (point 2)
- Lack of proper and adequate education (points 6 & 13)

Sigma Science Methodology

The power of Sigma Science is not due to the statistical toolbox, nor in the dousing of process and product issues with engineering resources. Sigma Science efforts are powerful means to achieve sustainable results merging statistical thinking with engineering and process knowledge via scientific method. "…Use of data requires

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[1] Sigma Science is a registered trademark

[2] William Ross is the Founder and CEO of Sigma Science Inc. 303.5175579, statman@comcast.net

[3] Deming, W. Edwards (1986) "*Out of the Crisis*", MIT CAES, Cambridge, MA (ISBN 0911379010)

knowledge about different sources of variation."[4] In their most potent form, Sigma Science initiatives focus on increasing the competency and critical thinking of the technical (engineering/scientific/business) organization via the creative merging of process & product knowledge, laws & principles of the physical sciences and individual contributor experience **with** statistical methods.

The way this methodology helps a company's business is to add reliable **effective** and **efficient** data acquisition and analysis skills (deductive reasoning) to the technical staff (e.g., engineers, scientists, MBA's). This will enable those individuals to better use their skills, process & product knowledge and understanding of the business needs to facilitate continuous process and product improvement. My deployment approach is to educate the management team, infuse core competencies into the technical part of the organization, mentor successful applications of the methodology, and provide guidance for iteration throughout the deployment process. My strategy includes the use of scientific method as a framework for the application of statistical thinking and analytical statistics supported by a *situation specific*[5] tool set. It relies on the company's commitment to involving influential and technically astute individuals in the process.

Deployment

Sigma Science Methodology is typically deployed in two phases though these phases may be replicated multiple times to achieve critical mass. This model can and will be adapted to the specific needs of the client.

Phase I: Edification of the management team. The primary purpose of the management training is to identify projects, develop project definitions, and identify candidates prior to Phase II. In doing so, participants will acquire a basic understanding of Sigma Science Methodology, Scientific Method, strategies for managing candidates, the manager's role in the process, and a working overview of selected tools and techniques. Questions regarding deployment pitfalls and expectations are addressed.

Phase II: Training of the technical staff and application of the methodology are meant to teach the technical staff to develop their own processes[6] to:

- perform situational analyses and link the situation to the appropriate tool set,
- predict all possible outcomes to anticipate and improve on data collection strategies,
- appropriately acquire data (sampling and experimentation),
- analyze data and interpret the outputs,
- induce learning in an iterative, scientific method framework, and
- to draw conclusions from the data and be able to use the analyst's insight to influence the changes that need to be implemented.

What we are NOT doing is trying to make engineers or managers into statisticians, but to augment their knowledge and skills with improved deductive reasoning.

[4] Deming, W. Edwards (1995) "*The New Economics*", MIT Press (ISBN 9780262541169)
[5] Delivering a set of tools without context or without regard to the situation will lead to misunderstanding and misapplication of the tool set.
[6] This is accomplished via the creation of their User Guide.

Phase II is typically delivered in six sessions over six months although the specific deployment model can be customized. This model allows for application of the methodology to project work with critical oversight. In addition, the model allows for enhanced *comprehension* of technical papers and texts pertinent to the discussions. It is an expectation/requirement there will be application of the methodology between sessions. The six sessions introduce tools to diagnose, investigate, understand and solve problems – how to think about data and how to make decisions most likely to make progress in an efficient and effective way. Getting things done in practice takes much more than just being "right" or being expert. There will be a need to interact with others not understanding the methodology. They care (mostly in a positive way) about what is happening around them. Some (probably much) of that thinking will have an influence on what you can get done. There may be a perception existing procedures and initiatives are in conflict with Sigma Science Methodology. How the organization operates in this context will determine what can be achieved. I often call this pejoratively "the politics". The specific approaches used will be dependent on the nature of the situation. Every issue or opportunity is dynamic. Realize there may be failure in initial attempts. Learn from these failures. Implementation requires patience, flexibility and a willingness to ITERATE.

"Failure is success in progress."[7]

The six formal training sessions are outlined as follows:

1. Overview, Critical Thinking, Mapping (Process and Product), Sampling and Measurement Systems (MSE)
2. Fundamental Experimental Design (DOE), Factorial and Fractional Factorial, Repeats and Replicates, Ordinal Data Sets, Critical Project Reviews
3. Components of Variation (CoV) Review and Expansion, Experimenting in a Noisy Environment, Blocking Strategies, Critical Project Reviews
4. DOE Review and Expansion, Split-plot Designs, Robust Design, Project Reviews
5. Quantitative Methods, Regression, Data Mining, ANOVA, Diagnostics, á Typical Data, Critical Project Reviews
6. Non-linear Models, Center Points, Covariates, and Optional Modules (e.g., Tolerancing, Mixture Designs), Review and User Guide Presentations

The core set of tools will provide a foundational basis for continuous improvement. Additional topic specific modules will be developed and delivered to cover weaknesses identified during deployment. The modules will be enhanced with case studies from company applications. All of the modules will be application specific and tailored to the audience. Continuous modification and customization of the modules is an ongoing effort championed by Sigma Science Inc.

Activities to prepare for deployment of the initiative

1. Project Selection[8]:

Start with the *motivation* for the project/effort. What are the drivers (e.g., efficiency, cost, resource allocation, customer satisfaction, management goals)? What is the nature of

[7] Albert Einstein

[8] Ross, William (2017) "Considerations Regarding Project Selection for Technical Training"

the motivation? Are there metrics driving the project selection? To what extent is lack of knowledge driving the effort? Is it essential to the business? What is the scope of the project? What is the sense of urgency? Will it provide an opportunity for the individual to learn? How has the motivation been translated into a *definition*? What are the questions regarding the situation? How was the situation identified? Typically, the definitions may tell you what is urgent and what is important, they may not lead to how the situation should be tackled or the scope of the effort. You should expect to have to iterate and redefine the situation. This step is inevitable. It's a red flag if you do not iterate the definition. Statements from the customer, managers, other departments will require interpretation (they all have their own biases). The experiences of the operators and the maintenance people require interpretation. The expectations from various functional areas and management will require interpretation – they may suggest what is needed in general but may be misleading in the specifics. They will lack the detail eventually needed to analyze, understand and resolve the issue. Problem definition can and will drive behaviors in the organization. Do you want a quick fix or to understand the problem and subsequently implement a solution? If a solution is offered, ask what data would be needed to support this. Make lists of potential future projects (a seedbed of projects). Consider priorities and what resources will be required. Be cautious of spreading resources too thin.

The description of the project starts by learning some details:

- "Internally" within the situation. What are the quantitative data? What does the data look like? Are there any patterns? What are the qualitative data? (e.g., What do the operators think? What does marketing think? What do the customers think and why? etc.) How can you better define the measures ("big" Y's) and "little" y's that may be leading indicators?
- "Externally" looking at the context. (Examples: How does this fit to the wider business strategy or affect product reputation? How does this integrate with leadership's priorities?) The customer information will be very important, but it is frequently "coded" (that is, in terms that are tough to understand, communicate and use) or "distant" (that is, the data comes from people who are hard to involve or may be peripheral to the issues). We will need to find ways to challenge the paradigms. In situations where the measurement system is an unknown and there are quite a few higher level thoughts (regarding different departments, disciplines, locations, etc.), it is recommended sampling be done. Directed sampling is an efficient way to compare some higher order hypotheses to get some direction (vs. emotional decision making and blaming).

We will discuss in this course the concept of sampling (components of variation) and sampling with manipulation (design of experiments) approach. How to get clues from an existing data set if there is any (data mining). Consider the parallel paths that can address the issue in a timely way. Generally there will be merit in a set of paths rather than one linear progression into understanding the causal structure. Some of these paths will lead to added understanding and some try to leap to a valuable answer. The blend will be a function of many details. Where's the balance between improving stability and finding the leverage? There is merit in both. Either approach requires you establish a regimented methodology that itself frequently leads to progress through

iteration. Doing this impacts the culture of your business. Some will welcome this and others will resist. There will be a need to improve skills at being persuasive in making such changes. Anticipate and predict **ALL** possible outcomes (not just what is wanted). This will augment learning and stimulate iteration**. It IS OK to be wrong**...learn from these events. For situations that require expediency, it will be appropriate to get on with the experimentation work quickly. That is NOT a recommendation to run trial-and-error or one-factor-at-a-time experiments that tell you little and are a waste of resources. Rather it is a recommendation to work in a thoughtful, designed way to add to your experience and to learn (**KISS**: **K**eep **I**t **S**imple and **S**equential). Right from the get-go you will need to communicate the expectations. New metrics may be used for short periods of time. Data collection methods will change. Experimenting requires you increase variation in order to learn and progress – so experimenting can create short-term issues.

Each project builds confidence or loses confidence in each candidate personally or in the approach they have used or in even in the business unit in which they work. But confidence is directly related to expectations and priorities. Achieving a quick success can bring all kinds of benefits in the future. It may lead to freedom to do more or to access more resources. Best of all it may give freedom to fail and therefore to try something which may pay off big in the long run. One strategy is to go after the easy wins promptly. They are there for the taking and will enhance credibility to the initiative. Keep in mind there needs to be parallel approaches. Ones that look at the bigger issues, are tougher to work, which require more complex lines of attack, but will pay off for the business long-term.

2. Candidate Selection

The training does teach your people very advanced tools and techniques; however, 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 selection and application of the tools. In deployment, it is recommended candidates be selected based on their in-depth knowledge about the projects selected for the training. At a minimum, they need to be able to elucidate rational hypotheses regarding the situation.

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 sessions (e.g., one session of training and project reviews followed by three weeks of project application). Project reviews and site visits (mentoring) are an integral part of the development of 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 or any initiative.

3. Communication:

Communication of the intent of the initiative is imperative. Unless the objectives of the initiative are clearly communicated throughout the organization, there will be confusion as to what this will mean to them. There are a number of items to watch out for. The

biggest are those situations where there is a misfit between what is needed from others and what motivates them. Within the team of individuals identified to participate in the training – especially those who are juggling multiple projects and priorities. Outside the identified team – especially those who control key resources that will be needed – including customer requirements that are imposed or budgetary limits that are penal to exceed. Create a plan to deal with these situations or to minimize how they impact what we are trying to do. Resist the urge to publicize the benefits of the initiative before results have been achieved.

There are many ways to work on "the system". Who gains what from solving the problem? The personal gains are important as well as the business gains. Who wants what outcome? Aim work at capitalizing on these preferences. The reward systems (both the monetary and the non-monetary) are the most powerful leverages motivating change. There are some that say rewards other than money are the most powerful persuaders for action. How does what we want to do fit with the availability of resources and the competition from other issues and initiatives for those limited resources? We all operate within tight resource constraints. It seems management will squeeze the resources until the system squeals loudly enough to backtrack a little. Success will get more visibility to make the case for what is possible. It is very smart to plan work to gain credibility and then to build on that progress. The organization should plan to use its collective gray matter and not the company's green matter (don't turn off engineering or intuition!!!). Often, an imaginative approach around new metrics or new measurement systems will open new routes into valuable insights. When results have been accomplished, that is something to communicate and to celebrate.

Consider now the actions taken as robust ideas for potential execution are developed. How quickly can the organization move and apply the learning? How quickly an "early" conclusion can be implemented depends on the cost of being wrong and perhaps on the value of being right (and to some extent the degree of belief). If the penalty for failure is a disaster with the consumer then we had better ease into the new situation cautiously. But if the new experience has little downside risk – for example any off product will never reach the customer and the cost of re-working it is small, then by all means proceed at flank speed. All along we talk about making better engineers and scientists. We are not in the business of making better statisticians or better politicians. We will be providing the tools to let the organization operate more effectively and efficiently. This discussion provides a context to do that.

4. Developing the processes for…

- Identifying, selecting (changing) and evaluating metrics
- setting goals,
- explaining the intent of the initiative, the metrics and the goals,
- project selection and resourcing,
- establishing actions as a result of data analysis, and
- communicating to the organization.

Activities to do during and after the training

The management team should be interested in the engineer's work (or at least act interested). Consider managements' role:

- Asking questions and challenging hypotheses

- Allocating resources
- Removing barriers
- Encouraging individuals by creating the appropriate environment
- Modeling/mentoring the appropriate behavior
- Changing expectations as to what the technical team should be doing

The training participants will go through changes during the 6-month process. They will NOT be experts to start. They may be confused and overwhelmed at the start, but with time and **practice** things will be clearer. Allow them the opportunity to learn (for example, try less than perfect sampling plans). Encourage them to get help from others in the class, outside the class or from the instructor.

These are some of the considerations/constraints in implementing the methodology:

- Business and resource requirements
  - What is the strategic context?
  - What are the personnel issues?
  - What is practical to get done in the time allocated?
  - What are the customer expectations?
  - Do we have the people we need to accomplish this?
- You may have in-house tests meant to be predictors of what customers want. These are often the company's crown jewels and are protected vigorously.
  - Are they appropriate? Adequate? Capable?
  - What is technically possible?
  - What added technical insight do you need?
  - Are there better measures?
- What are the external constraints – safety, availability, regulatory, etc.?
- How does the initiative align with other initiatives and the mission for the business unit?
- What has been happening recently and does it affect the issue? Examples might be recent reorganizations, other business stresses, economics, etc.
- What is a crisis/conflict and how is it dealt with? Systemic issues?
  - Support system
  - Communication system
  - Reward system
  - Follow up
  - Schedule and expectations
  - Distractions and competing priorities & metrics
  - Greater system changes to address systemic problems
  - Relationship between customer & technical service
  - Communications between the customer and the production unit

Do you want to add reliable (**effective** and **efficient**) data acquisition and analysis skills (deductive reasoning) to the technical staff in your company? Do you want to elevate the understanding of your company's products and processes? Determine how your product works, how it fails, how to continuously improve it?

For further information, please don't hesitate to contact me.