A Strategic Vision for Accelerating the Implementation of Motorola's Six Sigma Initiative

by

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As we are all aware, the Six Sigma initiative has offered a distinct advantage in the quest for Total Customer Satisfaction. In fact, the corporate initiative has proved to be a solid foundation for unifying many of the seemingly discrete functions within an autonomous organization, as well as across the corporation.

For this reason, in addition to many others, the trek toward Six Sigma will continue to bear fruit. However, there is still one outstanding question; "Is the Six Sigma tree growing fast enough so as to provide the quantity of fruit needed by 1992 and beyond?" In order to answer this question, we must consider the Six Sigma perspective.

The Six Sigma Perspective

In concrete terms, the primary thrust of Six Sigma is one of minimizing product variation. From this perspective, we may also say that there are three primary determinants of product variation -- design, process, and materiel.

Since virtually all hardware, software, administrative, and service related products embody these three sources of variation, we may conclude that the Six Sigma initiative has the ability to cut across all facets and functions of the corporation. The Six Sigma initiative has few, if any, barriers with respect to conceptual applicability.

The Cultural Change Process

So as to facilitate institutionalization of the Six Sigma initiative, Motorola University (MU) created and sponsored several educational courses. These courses provided the cross-product and cross-functional concepts necessary to adequately stimulate the general Motorola population in the desired direction. Obviously, the courses have played a strategic role in the cultural change process, as evidenced by the unified corporate focus, or as some would say, the "superordinate goal" related to Total Customer Satisfaction.

As an example of such focus, let us consider the development and subsequent manufacture of product hardware. In this arena, it is common knowledge that, as a corporation, we must design for producibility, apply statistical process control techniques, and develop certified "best-in-class" suppliers so as to achieve Six Sigma performance by 1992. It is well recognized that such performance will ultimately lead us closer toward the fundamental goal.

Such strategic objectives have been exceptionally well communicated across the many facets of our corporation. Although the objectives are being actively pursued, their consequential attainment is being realized at a somewhat slower rate. This is even more pronounced in the areas of administration and service related products and activities.

The Process of Acceleration

In order to accelerate Motorola's Six Sigma program to the next level of implementation, we must focus on the development and enhancement of discipline and function specific tools, methods, and tactics. Of course, many of the tools already exist; however, they are not operationally leveraged in the context of Six Sigma theory. In these cases, leveraged application will require the creation of "extension" devices, methods, and tactics.

For those situations where there is a general dearth of tools, methods, and tactics, the process of invention must be applied. In turn, the new Six Sigma tools, methods, and tactics must be firmly stationed on viable implementation platforms.

If these things are done, we will significantly optimize the likelihood of a Six Sigma harvest across all product and organizational lines. In addition, we will be better postured for transporting the Six Sigma initiative well beyond 1992.

Leveraging the Six Sigma Tools

As previously mentioned, the primary thrust of Six Sigma is one of minimizing variation and its resultant impact on a product, regardless of what the product may be. Hence, we may say that Six Sigma advocates the important concept of design/process robustness; e.g., making the product and process hermetic/tolerant to natural and unavoidable sources of underlying variation.

When taken together, the goal of variation reduction and design/process robustness synergistically merge to leverage product performance, quality, cost, and cycle time. Ultimately, such a merger improves the likelihood of satisfying the customer and concurrently increasing profitability.

In current form, many of the existing tools can not be fully exploited in the context of Six Sigma theory. The vast majority of tools are not adequately configured for the task of creating robust designs. Their inherent *modus operandi* most often disallows the type of direct manipulation necessary to concurrently optimize producibility, quality, and cost. To do so requires the use of highly specialized methods and tactics working in unison with specific types of data. For the most part, such an interface has yet to be thoroughly defined, let alone institutionalized as a way of "doing daily business."

To illustrate the latter point, let us consider a simple example. Let us hypothesize that a certain engineer has been tasked to optimize a particular aspect of a certain product design. In this case, the engineer's job is one of creating a high-performance, high-quality, low-cost design which is suitable for efficient manufacture. Naturally, this implies that the design must be configured in such a manner so as to consistently be hermetic or "robust" to perturbing sources of underlying variation.

To ensure that such criteria are met, the engineer must be able to factor known and/or hypothesized sources of process and materiel variation into the design process and supporting tools. Doing so will allow the engineer to isolate those settings which: a) maximize performance, b) maximize each of the tolerances, and c) minimize part count.

Logically, the aforementioned scenario assumes that three things are present -- the correct analytical tools/methods are at hand, there is free access to the necessary process/materiel data, and there exists the technical knowledge necessary for properly interfacing the data, engineering tools, and Six Sigma optimization methods.

Thus, it is abundantly clear that in any engineering situation, the tools must be compatable with the resident data, both of which must be compatable with the Six Sigma optimization methods and tactics. In turn, this implies that the tools, data, methods, tactics, and prerequisite training must be defined and subsequently created in an integrated or "holistic" manner if "true" Six Sigma performance is to be realized.

The Analytical System

As should be apparent, the aforementioned scenario underscores the need for viewing Six Sigma Design (SSD) as a "systems" problem. In other words, all elements of the *design-manufacturing-supplier* interface must harmonize, in an analytical and statistical sense so to speak.

If any portion of the corresponding *data-tool-method* link is not "in-phase" within or across the interactive elements (e.g., design, process, and materiel), various difficulties and roadblocks are introduced into the total system. In turn, this makes the entire product development and production cycle much more difficult to orchestrate and optimize. Evidence of such difficulties is quite often visible in those situations where only a few aspects of a given design or process can be made "Six Sigma."

As the analytical system displays increased noise due to such technical difficulties (arising from ineffective *data-tool-method* linkage), the entire system becomes "tactics dependent." Recognize that a tactic is a maneuver which exploits the full power of a tool.

Hence, whenever optimization of the product development and production cycle becomes overly dependent upon clever tactics and "jump wiring," it must be elevated to, and subsequently driven by, problem solving experts (e.g., tool tacticians). This is to say that lower levels of the technical ladder can not be fully empowered during the design or production phase. In turn, this means that the leveraging of people, knowledge, and skills is difficult -- at best.

In many respects, we have all seen evidence of the latter situation. For example, let us consider a case in which management fully commits (in both spirit and budget) to the creation of a Six Sigma product. After doing so, the workforce is sent to a training program so as to absorb the prerequisite knowledge and skills.

Following the training program, many of the participants return and say; "I don't quite see how this [method, technique, or procedure] applies to what I am doing!" Such a statement is rendered because the participant intuitively sees some form of disfunctionality in the existing data-tool-method linkage within their respective "design, process, and materiel line-of-sight."

Because most training classes focus on the mechanics of discrete tools and methods rather than their interconnectivity, structure and related tactics, the participant is not quite sure what needs to be done to overcome the perceived application limitation(s). From an organizational perspective, this forces cultural change to plateau. As a consequence, strategic momentum diminishes and the fundamental objective begins to fade.

Macro-Perspective of the Proposed Solution

In order to avoid the latter dilemma, Motorola Inc. must move forward with the unified development/enhancement of advanced Six Sigma tools, extension devices/methods, and standardized application tactics. To do this, we must first define and map the total system of "design for producibility (DFP)" from an analytical and statistical perspective.

Such a perspective must be taken because mathematical statistics serve as a foundation for the Six Sigma initiative. All of this must be done using a common core of statistical theory and reasoning. Doing so will make the entire system simpler, more valid, less confusing, and more communicable in terms of the education process.

Concurrent to the latter plan, supporting software must be developed and/or revised. Naturally, this would facilitate application consistency and create commonalty among the MU courses. In addition, it would make the resultant Six Sigma tools, methods, and tactics (as related to the data-tool-method linkages) easier to utilize because all such links would be based on the same core of statistical and application knowledge. As a consequence, more people could be empowered, therein allowing "people leverage" to be maximized.

In addition, the prerequisite data and related collection methodologies must be defined and rigorously documented. Finally, the total system must be made measurable so as to track and assess the relative efficacy of implementation. Of course, a formalized consulting support system would also be created to support the total system. The reasons for this should be fairly intuitive.

The end result would be an effective cross-discipline, -product, and -functional system which is optimally aimed at the attainment of Six Sigma products, services, and administration.

Micro-Perspective of the Proposed Solution

So as to better organize the micro-perspective of the solution, we shall consider six areas. Namely, those areas are; a) the Six Sigma tool development process, b) the role of Motorola University, c) the infrastructure necessary to facilitate the solution, d) the timeline for solution implementation, e) the costs associated with solution attainment, and f) the expected return-on-investment. We shall now consider each of these interrelated areas.

The Six Sigma Development Process

The reader should recognize that the theory, mechanics, and application procedures related to each of the prospective Six Sigma tools, methods, and tactics will be documented in a series of "how to" booklets -- each of which will be created using the development process given in Appendix A.

The titles of the required booklets are inclusive of, but not necessarily limited to:

- The Nature of Six Sigma Quality
- Six Sigma Producibility Analysis and Process Characterization
- Six Sigma Mechanical Design Tolerancing
- Six Sigma Thermal Analysis and Optimization
- Six Sigma Stress Analysis and Optimization
- Six Sigma Digital Design Analysis and Optimization
- Six Sigma RF Design Analysis and Optimization
- Six Sigma Analog Design Analysis and Optimization
- Six Sigma Software Design Analysis and Characterization
- Six Sigma Supplier Selection, Certification, and Control
- Six Sigma Service Analysis and Optimization
- Six Sigma Metrology and Data Management

It should be pointed out that the first three booklets have already been completed and published. Also recognize that each of the aforementioned booklets undergo intensive technical review by a team of recognized university professors. This must be done so as to judge philosophical consistency, test the validity of all theoretical constructs, and ensure the mathematical integrity of the related equations and analytical guidelines.

The Role of Motorola University

Once a booklet has undergone technical review and the supporting software has been created, Motorola University (MU) would develop, pilot, promote, and deliver related instructional content to the target populations.

In addition, MU would develop "black belt" consultants via a curriculum much like MMI; however, the program would be focused specifically for technical ladder personnel. A less technical version would also be developed for the management ladder, as well as service and administration oriented personnel. The prospective candidates would be identified by each of the business units within Motorola Inc. and then sent to MU for intensive training.

In terms of the training experience, approximately one-half of the curriculum would consist of philosophy, theory, and mechanics, as presented in the previously described Six Sigma booklets. The other half of the curriculum would be dedicated to an intensive application experience. For example, such an experience could be derived for technical ladder personnel via a planned manipulation of the *Black-Box Simulator* -- an electronic device which can create a near infinite number of "real time" product design and manufacturing engineering scenarios.

In this manner, the participants can get "hands on" experience as related to the Six Sigma tools, methods, and tactics (for virtually all types of data). It should also be noted that each candidate would receive specialized training in the art of consulting, as well as several other related skills.

As a graduation requirement, each candidate would publish an applications paper which has undergone substantiative technical review. The papers would be kept on file (in a common computer format) at MU, therein serving as a source of case studies for future classes. The papers would also be evidence of Motorola's quest for Six Sigma Quality (which may be useful for the next MB award application). Annually, the best papers would be selected -- after which the respective authors would be duly recognized and rewarded.

Recognize that all necessary prerequisite training would occur at the local level prior to the MU "bootcamp" experience; e.g., training in descriptive/inferential statistics, diagnostic methods, experiment design, etc. Upon graduation from the 2 week program, the employee would be presented a diploma and consulting certificate.

After graduation, each of the "black belt" consultants would then be responsible for the professional development of at least three "brown-belts" within their respective technical discipline and organization. This must be done by each consultant so as to retain certified status. In turn, the brown-belts would develop "green-belts," and so on.

The Infrastructure Necessary to Support the Solution

As previously indicated, a key aspect of the proposed solution involves the development and/or enhancement of the Six Sigma tool kit, related methods, and application tactics. This aspect should be thought of as "the weak link." If a strong link is to be realized, it would be necessary to create a highly specialized laboratory (e.g., Advanced Quantitative Research Laboratory) in direct support of such development activities.

The primary mission of the Advanced Quantitative Research Laboratory (AQRL) would be applied research. More specifically, the AQRL would be responsible for the enhancement, development, documentation, dissemination, promotion, and support of advanced Six Sigma tools, methods, and tactics.

In order to accomplish the primary mission, the AQRL staff would operationally interface with the various Motorola business units, key universities, corporations, professional societies, technical societies, Motorola councils, and Motorola University.

From a personnel perspective, the AQRL staff should consist of 6 professionals and 1 clerk. An overview of the professional job expectations are as follows:

- **Chief Quantitative Research Scientist (1):** Job grade EO-13 or EO-14. Will be directly responsible for providing the analytical/research vision, statistical direction and technical leadership related to the research and development of advanced Six Sigma tools. In addition, the scientist will also be responsible for administration of the Advanced Quantitative Research Laboratory.

- **Principal Quantitative Research Scientist (2):** Job grade EO-11 or EO-12. Will be responsible for the research, development, and demonstrated application of advanced Six Sigma product design (hardware and software) engineering tools. The results of such activity will culminate in the form of substantiative booklets (co-authored by "discipline specific experts"). In addition, the scientist will also be responsible for the provision of consulting services to Motorola University and other Motorola organizations.

- **Senior Quantitative Research Scientist (2):** Job grade EO-10 or EO-11. Will be responsible for the research, development, and demonstrated application of advanced Six Sigma manufacturing and service related tools. The results of such activity will culminate in the form of substantiative booklets (co-authored by "discipline specific experts"). In addition, the scientist will also be responsible for the provision of consulting services to Motorola University and other Motorola organizations.

- **Staff Software Engineer (1):** Job grade EO-9 or EO-10. Will be responsible for the definition, design, and subsequent creation of software in support of the Six Sigma Tool development effort. The results of such efforts (as related to a given SSE tool) would culminate in fully functional software (IBM and Macintosh compatible). In addition, the engineer will be responsible for the provision of all necessary supporting technical documentation. The engineer would also be responsible for the supervision of contract programmers (used on an "as needed" basis).

In support of the AQRL staff, the following labor categories would be required on an "as needed" basis:

- **Contract Computer Programmer:** To be hired on a project-by-project basis. Will be responsible for the writing of software code and related technical documentation.

- **Contract Technical Writer/Illustrator:** To be hired on a project-by-project basis. Will be responsible for technical illustration, formatting, editing, and subsequent publication of the Six Sigma booklets and software documentation.

Note: The "disciple specific experts" will be provided, as required, by participating Motorola organizations.

The secondary mission of the AQRL is related to a supporting role. Some of the activities would be inclusive of, but not limited to:

- Internal and, in some instances, external consulting of a technical nature (in support of Motorola University). Note that this activity has the potential to make the AQRL virtually self-supporting.

- Master Instructor development and facilitation (in support of Motorola University).

- Representing Motorola, Inc. at certain key technical symposiums, workshops, etc.

- Development of corporate metrics (in support of the manufacturing and quality councils).

- Technical review of internal case studies to be used by Motorola University in conjunction with course materials.

- Periodically provide instructor services to Motorola University.

- Publication of an internal journal related to the development and application of Six Sigma tools, methods, and tactics.

Time Line for Solution Implementation

In order to achieve the overall mission and strategic objectives related to the vision presented in this paper, a time-line of activities would be carefully created and communicated. The overall timeline has been located in Appendix B.

Costs Associated with Solution Attainment

The macro-financial/labor planning exercise revealed that approximately 4,000 hours are required to fully complete a Six Sigma project (10 projects have been identified as critical). Recognize that the time required to complete a project was based on actual experience with the process defined in Appendix A.

At an overhead rate of $50.00 per labor hour, the total cost (across all projects) would be approximately $2,000,000.00. Including capital equipment (for computers, etc.), the grand total was estimated to be in the vicinity of $2,200,000.00.

Expected Return on Investment

As we all know, the quantification of expected return on investment (ROI) is often difficult. This is primarily due to many of the intangible benefits which accompany an improvement or enhancement initiative.

However, the general magnitude of savings can be better appreciated by applying known benchmarks.

For example, as stated in Motorola's *Design For Manufacturability* participant handbook, "... inventory carrying cost equals at least 25% of the value of average annual inventory." In 1985, inventory was valued at $801 million (annual report). This translates to approximately $200,000,000.00 of nonvalue added cost. Obviously, a leveraged reduction in this cost would be of great benefit to the corporation.

It is well known that design producibility and production inventory are highly correlated -- if produciblity can be enhanced, inventory costs can be significantly reduced. If a 10% improvement in the aforementioned inventory cost can be realized as a result of the enhanced Six Sigma tools, methods, and tactics (which is virtually certain), the ROI is self-evident.

As indicated, many of the hidden benefits can not be quantifiable. For example, when our customers attend various symposiums, conferences, etc. and see (first hand) how Motorola Inc. is improving performance, quality, and cost, their confidence in our abilities and products is significantly increased.

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