A Business Unit Framework for the Development of an Infrastructure to Support Breakthrough Quality Improvement

by

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Executive Summary

In order to achieve breakthrough quality improvement and make substantive movement toward Six Sigma, it will be necessary to identify, select, and train a cadre of broadly-experienced individuals in the Six Sigma tools and methods. This must be accomplished if true cultural change is to occur and the prerequisite knowledge and skills to support such a change have an adequate vehicle from which to be transferred to the business unit community. This paper describes a framework and process for the selection and training of Six Sigma champions. There is a distinct, yet highly functional classification of champions. The classification hierarchy is characterized by Black Belts at the top, followed by Green-Belts and Yellow-Belts. This paper will focus on the Black Belts.

The Black Belts are a cadre of highly motivated individuals from various disciplines who, when adequately trained and technically supported, can serve as change agents, internal consultants, tool mentors, and Six Sigma champions. They are the paradigm shifters within an organization. They stimulate management thinking by posing new ways of doing things, challenge conventional wisdom by demonstrating successful application of new methodologies, seek out and pilot new tools, create innovative strategies, and develop others to follow in their footsteps. The Black Belts can speak the language of management (e.g., money, time, organizational dynamics, etc.) and the language of individual contributors (e.g., implementation details, quality tools, statistical techniques, problem solving methods, etc.). The Black Belts carry a very high level of peer respect and are clearly seen as leaders -- They manage risk, set direction, and lead the way to breakthrough improvement.

A new program, the Six Sigma Technical Institute (SSTI) is recommended as a vehicle for instituting a business unit and corporate level infrastructure focused on Six Sigma excellence. The SSTI program closely parallels the successful Motorola Management Institute (MMI) format, but will select technically oriented personnel from a wide array of disciplines. Graduates of the program would then be certified as Six Sigma Black Belts.

To initiate the paradigm, the business unit management selects the Black Belt candidates. Next, the candidate is assigned a management sponsor and mentor. This step ensures the candidate will receive the necessary support during and after the development cycle. Following this, the candidate attends the SSTI program. If the candidate is not well-versed in statistics and the related breakthrough strategy, then SSTI-1 would be the first step; otherwise, SSTI-2 would be the point of departure. It should be recognized that SSTI-1 is specifically designed to provide the candidate an in-depth overview of the Six Sigma breakthrough strategy and the necessary tools and methods to be used. SSTI-2 provides the candidate with the "soft" skills associated with the design and implementation of successful cultural change, as well as those skills necessary for effective consulting.

Section 1.0: Introduction and Overview

In today's world market, the ever-increasing demand for exceptionally high-quality products and services, at lower cost, has forced many corporations to view product and service quality as a major business issue. It certainly appears that this trend will continue well into the future.

In order to meet this expanding challenge, many business units have established Total Customer Satisfaction as their fundamental objective. To achieve this objective, they are embodying a wide array of operational initiatives. Some of those initiatives are cycle-time management, total quality management, statistical process control, flexible manufacturing, design of experiments, and design for manufacturability, just to mention a few. A relatively new and accepted performance target for such initiatives is Six Sigma -- 3.4 parts-per-million defective.

This paper describes a framework and process for the selection and training of Six Sigma champions. The framework is a distinct, but yet highly functional classification of champions. The classification hierarchy is characterized by Black Belts at the top, followed by Green-Belts and Yellow-Belts. This paper will focus on the Black Belts. Recognize that the framework is highly flexible and can be molded to the unique needs and constraints of virtually any business unit without compromising the overall integrity and intent of the system[1].

Section 2.0: The Three Vital Questions

One of the lessons learned by Motorola and other corporations pursuing Six Sigma is related to effective implementation. After carefully studying those business units which have discovered the secrets to successful implementation, a universal reality emerged. That reality can be best understood by considering the answers to three distinct, but interrelated questions[2]:

Question 1: How can a business unit, regardless of size, product, service, production volume, or product mix, leapfrog its way to the Six Sigma goal in a relatively short period of time?

Answer 1: Experience has shown that successful implementation depends on an interaction between the following principles:

- *Highly visible top-down management commitment to the initiatives. People must perceive active leadership versus management-ship during the course of implementation.*
- *A measurement system (metrics) to track the progress. This weaves accountability into the initiatives and provides a tangible picture of the organization's efforts.*
- *Internal and external benchmarking of the organization's products, services, and processes. This information inevitably leads to a "significant emotional event" in that the organization can see and communicate its relative position. When this happens, the organization begins to gravitate toward a breakthrough philosophy.*
- *Reach-out goal setting (10x, 100x, etc.). Such goals focuses people on changing the process by which the work gets done rather than "tweaking" the existing process. This leads to "leap-frog" rates of improvement.*

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[1] It should be emphasized that a Black-Belt candidate need not be already expert in the use of statistics. It is only necessary that the applicant have the technical potential and leadership traits required to become a Black-Belt. There will be ample opportunity for some of the more advanced skills to be developed during the certification process and beyond.

[2] This framework is a general structure for the educational development and application support of Six Sigma Black-Belts within business units. Recognize that this framework can be readily modified to best fit the specific needs and requirements of any business unit.

- *Provision of education to all levels of the organization. Without the necessary mind-tools, people can not make break-through improvement happen.*
- *Success stories which demonstrate how the tools of improvement can be applied and the results which can be achieved.*
- *Champions to promote the initiatives and provide the necessary planning, teaching, coaching, and consulting at all levels of the organization.*

Question 2: What is needed to institutionalize these principles?

Answer 2: Once these principles are adopted by management, the task of implementation most often falls squarely on the shoulders of champions. They are the ones on the forward edge of the battlefield. Their technical and human relations skills can inspire and give people the motivation they need to "take the next step." The champions are the ones who acquire and transfer the requisite knowledge. These individuals are referred to as Six Sigma Black Belts[3]. A Black Belt has many different skills. A Black Belt has the ability to work with senior management during the planning phase of breakthrough improvement, teach others how to apply Six Sigma methods and tools within their respective discipline, and then effectively support the organization back on the job. The Black Belt continually works toward institutionalizing the effective use of new tools and methods within their *line-of-sight* in order to accelerate the business unit toward attainment of its performance metric goal(s). In short, it may be said that:

- *The driving need is to create Total Customer Satisfaction*
- *The goal is Six Sigma Performance in all aspects of the business*
- *The road to this goal is characterized by performance breakthroughs*
- *Breakthroughs are initiated and lead by Six Sigma Black Belts*
- *The task is to create a process for creating Six Sigma Black Belts*

Question 3: What is the process for creating a Black Belt infrastructure within a business unit?

Answer 3: The process for creating and sustaining Black Belts is as follows:

Step 1: The business unit management makes a commitment to breakthrough quality improvement, establishes performance metrics, and sets reach-out goals; e.g., 10x, 100x, Six Sigma, 10x every two years.

Step 2: The goals are clearly communicated and supported throughout the business unit by a common metrics reporting structure.

Step 3: The business unit management identifies key individuals who are capable of technically supporting the organization in terms of the reach-out goals. These individuals are referred to as Black Belts.

Step 4: The Black Belt candidates are assigned a management sponsor and a mentor. The sponsor is responsible for guiding the Black Belt within the organization and the mentor is responsible for ensuring that the candidate's knowledge, skill, and experience is sufficient to effectivaly lead an organization.

Step 5: The management sponsor, mentor, and Black Belt candidate jointly establish line-of-sight responsibilities and select a target process or application project; e.g., a process or project which must experience breakthrough improvement. The selected process or project will be used as a basis of discussion and learning during the Six Sigma Technical Institute (SSTI) program of study.

Step 6: The business unit management makes a commitment to send the Black Belt candidates to the Six Sigma Technical Institute (SSTI).

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[3] A Black Belt is an individual who has developed a synergistic proficiency between his respective technical discipline and the Six Sigma strategies, tactics, and tools. This individual will continually work towards institutionalizing the effective use of these tools throughout the corporation, its customers, and its suppliers.

Step 7: The Black Belt candidate enrolls in the SSTI programs. It is the responsibility of the candidate and mentor to establish which programs should be attended. This will vary depending upon the candidates initial knowledge and skill level.

Step 8: The Black Belt candidate completes the SSTI-1 and/or SSTI-2 programs. After successful completion, the candidate receives certification.

Step 9: The Black Belt establishes a meeting with their management sponsor, mentor, and the business unit management so as to present their strategy for implementation[4].

Step 10: The Black Belt implements the strategy and documents the results in the form of a case study[5]. The sponsor and mentor provides support and guidance during execution of the endeavor.

Section 3.0: The Black Belt Concept

3.1 The Driving Need for Black Belts

The driving need for Black Belts is related to the three "Ts" of successful implementation -- Inspiration, Information, and Institutionalization. If these things are not accomplished, breakthrough improvement will not be realized. The Black Belt infrastructure provides a business unit with the ability to:

- Institutionalize the effective use of Six Sigma strategies and tools throughout the corporation
- Establish and develop Six Sigma Black Belts and local Six Sigma resources within all business and development units of the corporation
- Establish lines of communication between all Black Belts within the corporation
- Transfer new ideas and techniques in a timely and efficient manner through the Black Belts
- Raise both the statistical and nonstatistical levels of expertise of all Black Belts through training, workshops, and skills benchmarking.
- Promote the sharing of ideas, problems, successes, and failures among all Black Belts
- Provide more uniformity across the corporation in the use of the strategies and tools

3.2 The Skills of a Black Belt

A wide array of skills are often exhibited by effective change agents. Since the intent of a Black Belt is focused on organizational and process change (i.e., the creation and management of breakthrough improvement), it is highly desirable that a Black Belt possess the same basic skill set. Those skills are inclusive of, but not limited to:

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[4] It is highly recommended that the Black-Belt be assigned a mentor; e.g., another Black-Belt who has had extensive experience. Experience has shown that the effectivity of a Black-Belt can be greatly enhanced if that person has a mentor. Recognize that the mentor and management sponsor perform different roles. This is not to say that the two roles can not be performed by the same person.

[5] The case study is prepared in a standardized format as prescribed by the Six Sigma Research Institute. The standardized format ensures consistency between the given case study and those published in the Encyclopedia of Six Sigma Applications (Addison -Wesley Publishers). As may be apparent, this is required since the given case study may be accepted for publication in that the Encyclopedia of Six Sigma Applications is a living document; i.e., it can be added to over time. The standardized format is given in the Author's Kit and is available through the Six Sigma Research Institute, Technical Publications Section.

- Technical
- Statistical
- Leadership
- Coaching
- Communications
- Instructional
- Team Work
- Business Literacy
- Mentoring
- Empathy
- Interpersonal
- Problem Solving
- Facilitation
- Process Mapping
- Presentation
- Managing Diversity
- Report Writing
- Consulting
- Active Listening
- Software
- Computer Literacy
- Negotiation
- Communication
- Sales
- Project Management
- Organizational Skills
- Motivation

3.3 The Roles of a Black Belt

As previously stated, a Six Sigma Black Belt is an individual within the business unit who displays a synergistic proficiency between their respective discipline and the Six Sigma strategies, tactics, and tools. Perhaps the roles and responsibilities of a Black Belt can be best understood by the following characterization:

- *The Black Belts are a cadre of individual contributors from various discipline areas which, when adequately trained and technically supported, can serve as change agents, internal consultants, tool mentors, and Six Sigma champions.*
- *The Black Belts are the paradigm shifters within an organization. They stimulate management thinking by posing new ways of doing things, challenge conventional wisdom by demonstrating successful application of new methodologies, seek out and pilot new tools, create innovative strategies, and develop others to follow in their footsteps.*
- *The Black Belts can speak the language of management (e.g., money, time, organizational dynamics, etc.) and the language of individual contributors (e.g., implementation details, quality tools, statistical techniques, problem solving methods, etc.)*
- *The Black Belts carry a very high level of peer respect and are clearly seen as leaders -- They manage risk, set direction, and lead the way to breakthrough improvement.*

In addition, the Black Belt must perform several critical functions within a business unit:

- *Mentoring to Green Belts so as to cultivate a network of local Six Sigma champions.*
- *Teaching Green Belts and local personnel in new strategies and tools.*
- *Coaching Green Belts one-on-one support to local personnel.*
- *Transferring new strategies and tools through training, workshops, case studies, local symposia, etc.*
- *Discovering new application opportunities for Six Sigma strategies and tools, both internal and external (e.g., suppliers and customers).*
- *Identifying new business opportunities through partnerships with other organizations.*
- *Influencing management (internal, customer, and supplier) on the use of Six Sigma strategies and tools.*

Thus, Black Belts serve in two major capacities:

- *Lead and direct the implementation of Six Sigma tools and applications at the business unit level to solve immediate problems, as well as devise and execute plans for breakthrough quality improvement.*
- *Facilitate or participate directly in the design and development of customized, site-specific training courses for use at the business unit level and provide for the training of others in the use of Six Sigma tools and methods. Available to the Black Belt are the SSRI's tools, products, and professional staff in addition to the products and services offered by Motorola University.*

With this approach, the business unit can rapidly develop and propagate highly-focused, site-specific knowledge in a low cost manner. Ultimately, this will accelerate the achievement of breakthrough improvement and lead the way to Six Sigma Quality within the business unit.

3.4 The Black Belt Development Process

As previously discussed in section 1.0, there is a distinct process for developing Black Belts. The process is graphically displayed in figure 1. It should be recognized that the process is highly flexible, but retains the capability to ensure consistency with respect to certification. Because the process will be utilized by several different corporations (with global operations), flexibility is a key requirement. It is key in the sense that various logistical and administrative constraints prohibits the use of a precise benchmarking and tracking system, relative to any given Black Belt's skills and knowledge[6]. Therefore, Black Belt certification must occur after the SSTI-2 experience.

Figure 1. Synopsis of the Black Belt Development Process

For these reasons, it is imperative that each Black Belt candidate be assigned a management sponsor and mentor. Along with the Black Belt, the business unit sponsor and mentor must ensure that the highest knowledge and skill standards are present throughout the Black Belt's growth and development. Remember that the power of a Black Belt depends heavily on peer recognition, just like any other leadership position. Consequently, it may be said that if some attempt is made to "short-circuit" the system, the business unit suffers, as well as the Black Belt. Therefore, it is in the interest of all to maintain process integrity.

Section 4.0: The Scope of Belt Development

In many instances, a business unit sets out to implement a particular initiative or program and quickly discovers that the overall progress toward institutionalization is much slower than originally anticipated. Often, this is a function of the infrastructure which supports the initiative. Too often, the business unit discovers that the supporting infrastructure is insufficient. In such cases, the general strategy is to hope that champions will "bubble-up" and drive the effort forward. Obviously, a business unit should not undertake such a strategy, regardless of its intuitive or cost appeal. Doing the right things the first time directly translates to creating a highly effective infrastructure. The general scope of such an infrastructure can be best summarized in the following manner:

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6 This point is emphasized owing to the fact that the Black-Belt candidates enter the certification cycle with varying knowledge and skill. Hence, the need for certification flexibility. In turn, this leads to the need for a self-monitoring follow-on system. The Black-Belt development process is a framework, not an all encompassing set of requirements. It is a catalyst for initiating an infrastructure within a business unit. If the business unit prioritizes and supports the spirit of the process, the outcome will be favorable.

4.1 Black Belt Training

- *The aim is to create technical leaders, advanced users, and teachers of the Six Sigma tools and methods. These individuals have the potential to produce highly credible break-through success stories and then subsequently transfer those methods, techniques, procedures, and tools to Green-Belts.*

- *The focus is on developing an in-depth understanding of the Six Sigma philosophy, theory, and application tactics, as well as advanced applications in the areas of descriptive statistics, inferential statistics, nonparametric statistics, quantitative benchmarking, process control techniques, process diagnostic methods, experiment design, as well as organizational/group dynamics and the change process.*

- *The intent is to implant people within the organization who can; a) effectively develop and lead Green-Belts, b) work with and advise management on the formulation and subsequent implementation of improvement plans, and c) utilize the Six Sigma tools and methods.*

- *The target population for Black Belt training is characterized by those individuals who are highly regarded within their respective discipline area or line of work and are also actively involved in the process of organizational change and development.*

4.2 Green-Belt Training

- *The aim is to create users of statistics and fundamental Six Sigma methods. These individuals have leadership ability and are able to management small team dynamics (e.g., process improvement teams).*

- *The focus is on developing a mechanistic skill level with respect to intermediate statistics, process control, experiment design, diagnostic methods, as well as an in-depth understanding of Six Sigma concepts and application tactics.*

- *The intent is to implant people within the organization who can demonstrate credible application of the tools and also effectively lead small problem solving teams, as well as provide for the direction, development, and support of Yellow-Belts.*

- *The target population for Green-Belt training is best characterized by those individuals who have an aptitude for statistics and a strong interest in making breakthrough improvement happen. Green-Belt training should be made available to a fairly limited number of individuals. A portion of the Green-Belts should display the potential for eventual progression to Black Belt status.*

4.3 Yellow-Belt Training

- *The aim is to create statistical literacy; i.e., providing the participants with the language of statistics.*

- *The focus is on basic statistics, fundamental six sigma concepts, process control techniques, introductory experiment design, and lots of success stories.*

- *The intent is to inspire the participants on the need for and means to achieve breakthrough improvement.*

- *The target population for Yellow-Belt training is best characterized by those individuals who participate on a breakthrough team or operationally interact with such a team on regular basis. Yellow-Belt training should be made available to a wide array of technical, operations, and management personnel.*

4.4 General Training

- *The aim is to create an understanding of Six Sigma and basic statistics, as well as a conceptual knowledge of process control.*

- *The focus is on elementary statistics, basic six sigma concepts, fundamental process control techniques, and lots of success stories.*

- *The intent is to inspire the participants on the need for and means to achieve breakthrough improvement.*

- *General training should be made available to all those individuals related to the selected process who are not selected for the belt development program.*

Section 5.0: The Belt Development Curriculum

5.1 Extent of Training

Table 1 provides a generic training model of the course titles and classroom time commitments[7] for each of the various belts (yellow, green, and black), as well as those individuals not directly involved in the belt development program (general), but participating in the breakthrough improvement process. As may be apparent, the training model is designed to create a hierarchical consulting/application infrastructure within a business unit. This particular training model will provide the organization with the necessary mind tools to technically support a breakthrough initiative.

Appendix A contains a detailed modular breakdown of the listed courses and programs. Appendix B contains a general description of the courses. Recognize that Table 1, in addition to Appendices A and B, constitute an educational framework. The intent is to define the knowledge and skills which a Black Belt must ultimately posses in order to be effective on-the-job.

The information presented in this section should serve as a general guide from which to assess one's current knowledge and skills in relation to that of a model or "typical" Black Belt[8]. Also recognize that the given information was not an arbitrary selection — it was compiled after extensive research and exhaustive interviews with highly qualified practitioners[9]. In short, it is a proven model that will produce individuals who are qualified to effectively and efficiently lead a business unit in the context of a breakthrough improvement initiative.

5.2 The Six Sigma Technical Institute

The Six Sigma Technical Institute (SSTI) is a leading edge program which closely parallels the successful Motorola Management Institute (MMI) format, except that the program targets technical ladder personnel and management. SSTI is a means to surface, crystallize, and subsequently focus the analytical talent within a business unit in terms of implementing and sustaining a quality breakthrough initiative. More specifically, SSTI is intended to:

- *Support the development of a corporate wide, hierarchical consulting infrastructure related to the application of Six Sigma tools, methods, practices, and procedures.*
- *Prepare Black Belts candidates as cultural change agents by providing them the skills necessary to understand organizational norms and behavior, as well as how to manage change in a productive and efficient manner.*

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[7] The annual classroom time commitment per year varies across individuals and organizations. For example, if a Black-Belt candidate has not received any previous instruction in statistics or the application thereof, the time commitment will be more extensive. Yet another example would be an organization which can not allow a Black-Belt candidate extensive periods of time off the job for purposes of training. In this case, the annual classroom time will be less, but the overall amount of time to prepare a Black-Belt will be greatly extended.

[8] Another device for determining one's current knowledge and skill level is a proven questionnaire. The questionnaire quantitatively benchmarks a person's current application skill level (with regard to statistics, SPC, design of experiments, etc.) in relation to others. The tool is effective for "sorting out who should go to what training." For more information on this tool, contact the author.

[9] The practitioners are from Motorola, Texas Instruments (DSEG), Kodak, Digital Equipment, Asea Brown Boveri, International Business Machines, and the Six Sigma Research Institute, as well as its adjunct faculty. Also recognize that members from these organizations comprise the Black-Belt development and certification committee, lead by Dr. Skip Weed (Motorola). This committee was largely responsible for the constructs presented in this paper as well as the SSTI curriculum. A deep sense of gratitude is owed to this committee for their extensive commitment of time, effort, and resources.

- *Provide Black- and Green-Belt candidates an in-depth overview of the strategies, tactics, tools, and methods they must become familiar with in order to support on-the-job application and consulting efforts.*

- *Motivate the participant and encourage other individuals to join the* Six Sigma Black Belt *certification program.*

- *Provide a cross-functional forum for the presentation and subsequent discussion of current/future analytical and organizational issues pertaining to such topics as:*

  - cultural change
  - effective consulting
  - concurrent engineering
  - robust design
  - real-time process control
  - machine characterization
  - process optimization
  - systems analysis
  - software optimization
  - metrology
  - service analysis
  - design simulation

- *Provide a platform from which world-class speakers can present their vision of the future in terms of analytical paradigms and the organizational structures required to support such change.*

- *Provide a real-time laboratory experience which models the product design and manufacturing environment via the* Black-Box Simulator System[10].

- *Provide the candidate an opportunity to develop a network of individuals pursuing similar goals and objectives.*

Some of the benefits of the SSTI program for the business unit and candidate are inclusive of, but not limited to:

- Enlightenment on current and future technical issues
- A renewal experience which promotes internal resolve
- Career enhancement by developing hard and soft skills
- An opportunity to develop and solidify a Black Belt network
- Provide a window into common crossfunctional activities
- Serve as a conduit for introducing leading edge tools and methods
- Enhance problem solving leadership skills and techniques
- Increased the likelihood of Six Sigma implementation
- Provide a formalized means to tap and focus the resident skill base
- Understand how to implement an initiative crossfunctionally
- Gain insight into knowledge reuse across business units
- Provide a platform for communicating and supporting corporate goals
- Serve as a means for upgrading the skills of suppliers and key customers

To achieve these intents and benefits, the SSTI experience is broken-down into two key components, tables 2 and 3, respectively. The agenda for the first component, SSTI-1 is displayed in table 2. This particular component targets the Green-Belt candidates and those Black Belt candidates requiring an instructional grounding in intermediate through advanced statistics[11]. The program focuses on an in-depth technical overview of Six Sigma principals and practices, a proven quality breakthrough strategy, and the supporting analytical tools necessary to realize the reach-out quality goal(s). Each of these aims is set in the context of

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[10] The Black-Box Simulator System is a software program which can be readily configured to emulate a manufacturing process. The software displays a "control panel" which consists of n number of knobs, dials, and switches, as well as a data display window (for histograms, control charts, etc.). The user would employ the simulator to discover how the various six-sigma tools are applied under different manufacturing scenarios. The simulator would also be used to study the effect of different analytical tools relative to the same set of manufacturing conditions. As may be apparent, the system is primarily intended to serve as an instructional device during the course of classroom training, although it may be used for other purposes such as a real-time machine control device or as a modeling/problem-solving tool.

[11] The exact entry level can be readily determined using a proven questionnaire coupled with an on-site interview. The questionnaire quantitatively benchmarks a candidates' current application skill level (with regard to statistics, SPC, design of experiments, etc.) in relation to other black-belt candidates, as well as other organizations.

concurrent engineering and cross-functional teaming to achieve Six Sigma designs, processes, software, and services. Individuals eligible for the SSTI-1 program will include engineers, scientists, technical professionals of all disciplines, and any member of management who must exercise technical leadership.

Table 1. Generic Training Model for the Six Sigma Belt Development Initiative

Course	Title	General	Yellow	Green	Black
1	The Vision of Six Sigma: Level 1	4	4	•	•
2	The Vision of Six Sigma: Level 2	•	4	•	•
3	Six Sigma Technical Institute: Level 1	•	•	40	40
4	Six Sigma Technical Institute: Level 2	•	•	•	40
5	Basic Statistics: Level 1	8	8	8	8
6	Basic Statistics: Level 2	•	•	16	16
7	Applied Diagnostic Methods: Level 1	•	8	8	8
8	Applied Diagnostic Methods: Level 2	•	•	•	8
9	Statistical Process Control: Level 1	8	8	8	8
10	Statistical Process Control: Level 2	•	•	16	16
11	Design of Experiments: Level 1	•	8	8	8
12	Design of Experiments: Level 2	•	•	16	16
13	Understanding Group Dynamics	•	•	•	16
14	Effective Consulting Practices	•	•	•	16
	Total Classroom Hours	20	40	120	200

Table 2. SSTI-1 Program Agenda

Time	Consecutive Days 1	2	3	4	5
Morning 8:00 - 12:00	*Session 1:* Core Six Sigma Concepts	*Session 3:* The Breakthrough Strategy	*Session 5:* Performance Metrics (continued)	*Session 7:* Diagnosing Process Performance	*Session 9:* Controlling Process Performance
Afternoon 1:00 - 5:00	*Session 2:* Advanced Six Sigma Concepts	*Session 4:* Developing Performance Metrics	*Session 6:* The Science of Benchmarking	*Session 8:* Optimizing Process Performance	*Session 10:* Action Plan Presentation
Evening 6:00 - 8:30	Action Planning Session	Action Planning Session	Action Planning Session	Action Planning Session	Key Note & Evening Dinner

The second component, SSTI-2, is displayed in table 3. This component targets the Black Belt candidate and does not require any prerequisite training. The program focuses on developing an awareness and sensitivity toward the impact of change on the organization and at the individual level. In addition, the participant will discover how to best plan for change, analyze change, establish vision and direction for the team, and overcome management barriers. The participant will also gain tremendous insight into the elements of dynamic leadership.

Table 3. SSTI-2 Program Agenda

Time	Consecutive Days 1	2	3	4	5
Morning 8:00 - 12:00	*Session 1:* Company of the Future	*Session 3:* Concurrent Engineering Principles	*Session 5:* Managing Organizational Change (A)	*Session 7:* Science of Knowledge Transfer	*Session 9:* Action Plan Presentation
Afternoon 1:00 - 5:00	*Session 2:* New Six Sigma Tools/Methods	*Session 4:* Future Trends in Statistics	*Session 6:* Managing Organizational Change (B)	*Session 8:* Effective Consulting Practices	*Session 10:* Optional Time Period
Evening 6:00 - 8:30	Action Planning Session	Action Planning Session	Action Planning Session	Action Planning Session	Key Note & Evening Dinner

5.2 The Six Sigma Research Institute

In late 1986, Motorola announced the achievement of Total Customer Satisfaction as the corporation's fundamental objective. To support this goal, five interrelated, key initiatives were defined. Of these initiatives, achievement of Six Sigma Quality by 1992 was considered paramount. To achieve this level of virtual perfection, it was determined that the three predominant sources of product variation — inadequate design margin, insufficient process control, and unstable or varying materials and components — must be attacked simultaneously. It was also reasoned that the same level of perfection must also be achieved in services and other nonmanufactured products, since deficiencies in these areas are major sources of customer dissatisfaction.

To date, Motorola has made tremendous strides in upgrading the quality of its products – 5.4 sigma as a corporation[12]. Particularly noteworthy is the standardization and control of many of the corporation's manufacturing processes. To accelerate the achievement of Six Sigma Quality, Motorola founded the Six Sigma Research Institute (SSRI) in the second quarter of 1990 in conjunction with several partners. The contributing partners are Asea Brown Boveri, Digital Equipment Corporation, International Business Machines, Texas Instruments (DSEG), and Kodak. The fundamental mission of SSRI is:

> *"...To research and develop the theoretical framework and supporting tools necessary to accelerate the achievement of Six Sigma Quality, and to facilitate the subsequent transfer of such knowledge and skills to Motorola's technical and managerial communities."*

Notice that the mission statement emphasizes the facilitation of knowledge transfer. This tends to imply a high level of interaction between tools and people. The basic model for achieving the mission is shown in

[12] This may be verified by contacting the corporate quality office of Motorola.

Figure 1. In particular, it is important to recognize that the model positions the Black Belt at the core. Without this person, successful implementation of quality breakthrough initiatives is greatly diminished -- advanced Six Sigma tools and methods can not be leveraged without a powerful infrastructure to support on-the-job application. This implies the need for instructional support systems, tactical tools, classroom training, technical leadership, and perhaps most important, management support and guidance.

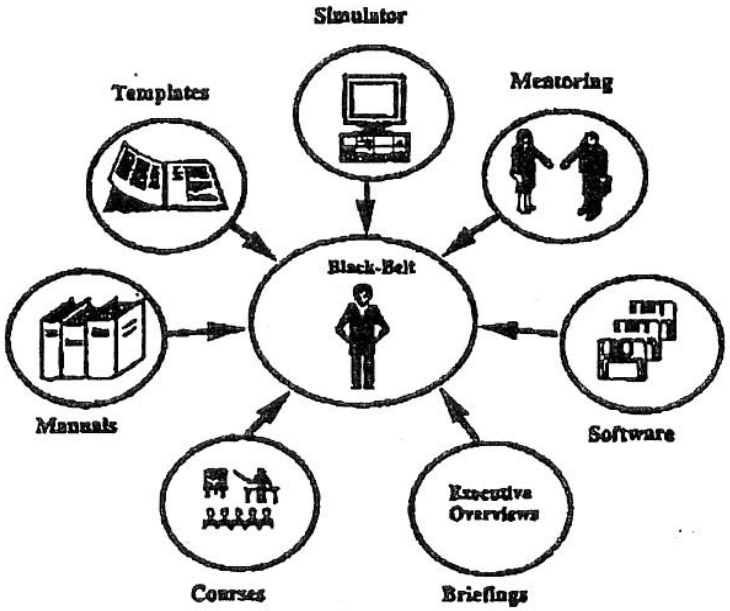


Figure 2. Basic Tool Kit for a Six Sigma Black Belt

To fulfill the tool component of the aforementioned mission statement, the SSRI has concentrated its efforts on the creation of a set of analytical tools and supporting products that can be used to characterize and optimize the quality, performance, cycle-time, and cost of product designs, manufacturing processes, software, and services. Specifically, the targeted areas are inclusive of:

- Process Characterization and Optimization
- Process Design Methodology
- Producibility Analysis
- Mechanical Design Tolerancing
- Thermal Analysis and Optimization
- Stress-Strain Analysis and Optimization
- RF Analysis and Optimization
- Digital Analysis and Optimization
- Analog Analysis and Optimization
- Software Analysis and Optimization
- Service Analysis and Optimization
- Supplier Selection, Certification, and Control

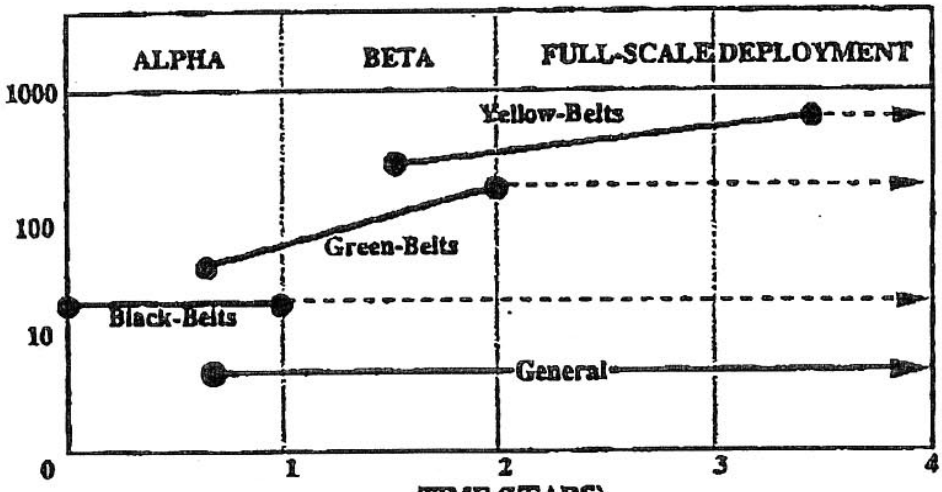
The application tools and methods to be used within these technical areas are being documented in a set of encyclopedias, to be published by Addison-Wesley. Naturally, many of the "mind tools" are supported by various custom software products. In conjunction with the encyclopedias, a generic instructional design shell is being configured so as to support the development and short-cycle, low-cost transfer of the knowledge and tools. Of course, the target of such a transfer process is the various business units of an

organization. The instructional design shell (IDS) will greatly facilitate the rapid prototyping of highly-focused, customized training materials.

To facilitate a hands-on approach to training, the SSRI has also developed a "black-box" simulator (BBS). The simulator will allow a student to: a) manipulate the "control panel knobs" of a simulated machine or "parameters" of a simulated design; b) capture the resultant output data and then; c) subsequently analyze the data using the method or tool being taught. In this manner, the student can "experience" how the tool or method would behave when applied in the real world. This can not be accomplished with "paper and pencil" exercises at the back of a book. Virtually any manufacturing or product design scenario can be configured on the BBS; i.e., production volume, sampling rate, background noise, sampling interval, etc., can all be established so as to conform to the student's work environment. Naturally, the ultimate successful application of the aforementioned products is highly dependent upon the business unit sponsoring and developing a cadre of Black Belts.

Section 6.0: General Deployment Strategy

A general deployment and implementation strategy is presented in figure 3. It must be recognized that this particular strategy is for illustrative purposes only. The BUSINESS UNIT organization must formulate a unique strategy which best meets their strategic goals, business objectives, and operating requirements. Also recognize that the formulation of such a strategy is interactively linked to various elements of the contract framework presented in this document. In particular, these elements must be considered during project planning and development of the overall project timeline.



Alpha: Preparation and Deployment of Initial Black Belts

Beta: Preparation and Deployment of Green-Belts

Full Scale: Deployment of Yellow-Belts and Breakthrough Improvement Teams

Figure 3. General Deployment Strategy

Section 7.0: Acknowledgements

We wish to thank the members of the Black Belt Advisory Committee for their contributions to the successful development of the Black Belt initiative. Without their time and dedication, such a world-class program would not have been possible. We have especially appreciated the efforts of Dr. Skip Weed for the leadership he provided in guiding the Committee.

Members of the Black Belt Advisory Committee

Skip Weed, Chairman	Motorola
Thomas Babin	Motorola
David Hill	Motorola
George Koons	Motorola
J. Ronald Lawson	Motorola
Brian Rigg	Motorola
Reigle Stewart	Motorola
Robert Stuart	Motorola
Stephen Urban	Asea, Brown, Boveri
Richard Leonhardt	Digital Equipment Corp.
Virginia Moszkowicz	Eastman Kodak
Phil Ryan	International Business Machines
Tom Cheek	Texas Instruments
Richard Karn	Texas Instruments
Ron Randall	Texas Instruments

APPENDIX A

Vision of Six Sigma: Level 1

Module	Title	Time
1	Understanding Customer Satisfaction	10
2	Linking Probability to Satisfaction	15
3	Understanding the Normal Distribution	40
4	Understanding the Standard Deviation	20
6	Understanding Six Sigma Quality	20
8	Computing the Standard Deviation	15
13	Rolled-Throughput Yield	30
14	Defects-per-Unit Metric	20
16	Performance Benchmarking Results	40
22	Keys for Implementing Six Sigma	30
	Minutes =	240
	Hours =	4.0

Vision of Six Sigma: Level 2

Module	Title	Time
1	Understanding Customer Satisfaction	10
2	Linking Probability to Satisfaction	10
3	Understanding the Normal Distribution	40
4	Understanding the Standard Deviation	20
5	Understanding Mean Variation	20
6	Understanding Six Sigma Quality	15
7	Understanding Sources of Variation	10
8	Computing the Standard Deviation	10
9	Visualizing the Standard Deviation	10
10	Estimating Defect Probability	20
11	Types of Defect Models	20
12	Indices of Capability	20
13	Rolled Throughput Yield	30
14	Defects-per-Unit Metric	20
15	Science of Benchmarking	75
16	Performance Benchmarking Results	20
17	Correlating Quality to Cycle Time	20
18	Correlating Cycle Time to Inventory	20
19	Correlating Quality to Product Reliability	20
20	Correlating Quality to R.O.I.	20
21	Six Sigma Blueprint	20
22	Keys for Implementing Six Sigma	30
	Minutes =	480
	Hours =	8.0

Basic Statistics: Level 1

Module	Title	Time
29	Nature of Data	30
30	Grouped Data	30
31	Graphic Representation	90
32	Measures of Central Tendency	60
33	Measures of Variability	60
34	Normal Distribution	60
35	Z Transform	60
36	Table of Normal Area	90
	Minutes =	**480**
	Hours =	**8.0**

Basic Statistics: Level 2

Module	Title	Time
37	Nature of Data	30
38	Grouped Data	30
39	Graphic Representation	90
40	Measures of Central Tendency	60
41	Measures of Variability	60
42	Normal Distribution	60
43	Z Transform	60
44	Data Transformations	30
45	Hypothesis Testing	120
46	T-Test of Difference	90
47	F-Test of Difference	90
48	Analysis-of-Variance	120
49	Linear Regression	120
	Minutes =	**960**
	Hours =	**16.0**

Applied Diagnostic Methods: Level 1

Module	Title	Time
50	Response Variable Definition	30
51	Process Mapping	75
52	Leverage Principle	15
53	Data Collection Practices	60
54	Fishbone Diagram	30
55	Brainstorming	75
56	Cause and Effect Matrices	60
57	Multivari Analysis	75
58	Pre-Control Plan	60
	Minutes =	480
	Hours =	8.0

Applied Diagnostic Methods: Level 2

Module	Title	Time
59	Graphical Correlation	60
60	Realistic Tolerancing	60
61	B vs C Test of Difference	90
62	Runs Test of Randomness	60
63	Cross-Tabulation	60
64	Chi-Square Test of Difference	75
65	Median Test of Difference	75
	Minutes =	480
	Hours =	8.0

Statistical Process Control: Level 1

Module	Title	Time
66	Understanding Statistical Process Control	60
67	Basic Indices of Capability	90
68	Understanding Process Capability Studies	90
69	Control Charts for Variables Data	90
70	Control Charts for Attribute Data	90
71	Implementing Control Charts	60
	Minutes =	480
	Hours =	8.0

Statistical Process Control: Level 2

Module	Title	Time
72	Foundations of SPC	30
73	Short-Term Indices of Capability	60
74	Long-Term Indices of Capability	120
75	Process Capability Studies	120
76	Control Chart for Individuals	90
77	Xbar Chart (average)	180
78	R Chart (range)	90
79	S Chart (standard deviation)	90
80	NP Chart (number nonconforming)	40
81	P Chart (proportion nonconforming)	40
82	U Chart (defects-per-unit chart)	40
83	Planning Process Control	60
	Minutes =	960
	Hours =	16.0

Design of Experiments: Level 1

Module	Title	Time
84	Experiment Design Principles	30
85	Experimentation Systems	30
86	Single Factor Experiments	60
87	2^2 Full Factorial Experiments	90
88	2^k Full Factorial Experiments	120
89	Multi Factor Multi Level Designs	90
90	Planning Experiments	60
	Minutes =	480
	Hours =	8.0

Design of Experiments: Level 2

Module	Title	Time
91	Analysis of 2^2 Full Factorials	60
92	Yate's Algorithm	60
93	Analysis of 2^3 Full Factorials	45
94	Principles of Fractional Factorials	120
95	2^4-1 Fractional Design	60
96	2^5-1 Fractional Design	60
97	2^6-2 Fractional Design	60
98	2^k-p Fractional Designs	60
99	Screening Designs	45
100	Response Surface Designs	180
101	Principles of Robust Design	210
	Minutes =	960
	Hours =	16.0

Leveraging Organizational Dynamics

Module	Title	Time
102	Technology and Human Behavior	30
103	Components of Management	60
104	Change as a Process	90
105	Analysis of Change	30
106	Implementation and Control of Change	90
107	Perception and Attitude Formation	60
108	Motivation and Human Behavior	30
109	Dynamics of Group Behavior and Control	120
110	Effective Managerial Leadership	30
111	Synergistic Management Practices	30
112	Conflict Management	90
113	Decision Optimization	60
114	Effective Delegation	30
115	Dynamics of Effective Communication	90
116	Formulating Organizational Success	60
117	Strategic and Operations Planning	60
	Minutes =	**960**
	Hours =	**16.0**

Effective Consulting Practices

Module	Title	Time
118	Creating Management Sponsorship	60
119	Marketing Technical Expertise	90
120	Components of Consulting	120
121	Short Cycle Knowledge Transfer Process	60
122	Short Cycle Knowledge Transfer Tools	60
123	Six Sigma Implementation Process	90
	Minutes =	**480**
	Hours =	**8.0**

APPENDIX B

Vision of Six Sigma (Model Description)

The customers that form the enormous base of today's world market are sending a clear and undeniable message -- produce higher quality products at lower costs with greater responsiveness. Companies are hearing this message and rising to the Six Sigma challenge. For many, the stalking of Six Sigma Quality has led to the development of new and exciting approaches for the improvement of business, engineering, and manufacturing, service, and administration performance. This course has been specifically designed to structure an in-depth overview of the fundamental strategies, tactics, and tools necessary for achieving Six Sigma product designs, manufacturing processes, service quality, quality of administration. Up front, the workshop will cover the basic tenants of Six Sigma in a non-technical manner and then proceed to a more technically oriented discussion of the program. Specifically, participants of this workshop will discover:

Non Technical Discussion

- The Driving Need for Six Sigma Quality
- The Fundamental Objective of Six Sigma
- The Basic Tenants of Six Sigma Quality
- Key Business Conclusions Resulting From Global Benchmarking
- Six Sigma as a Target for Total Quality Management (TQM)
- The Primary Tools for Achieving Six Sigma
- The Customer's Perspective of Six Sigma
- The Financial Impact of Six Sigma on the Bottom Line
- Strategies and Tactics for Implementing Six Sigma

Technical Discussion

- Advanced Six Sigma Concepts
- The Impact of Product and Process Complexity on Quality
- The Impact of Six Sigma on Product Reliability
- The Impact of Six Sigma on Manufacturing Cycle-Time
- The Impact of Six Sigma on Inventory
- Developing Six Sigma Suppliers
- How to Create and Maintain Six Sigma Product Designs
- How to Create and Maintain Six Sigma Manufacturing Processes
- How to Create and Maintain Six Sigma Services

In addition, several "real life" case studies will be presented and thoroughly discussed. The case studies are configured to illustrate many of the "how to's" with respect to selected Six Sigma methods and practices. In particular, the cases will highlight the astounding results which can be readily achieved when Six Sigma practices are embodied and institutionalized within an organization.

Basic Statistics (Model Description)

Designed to provide the participant with basic skills in the use of descriptive statistics. Primary emphasis is placed on measurement scales, measures of central tendency and variability, statistical notation, and basic probability models. In addition, the participant learns the fundamentals related to the development of statistical graphs and charts. From here, the participant progresses to more advanced techniques and concepts such as confidence intervals, hypothesis testing, and tests of difference. Industrial examples are used to illustrate application and utility. This particular series of courses serves the participant as a vehicle for progressing through the belt development program. Reinforcement of major concepts and principles is realized through exercises, scenarios, case studies, and field studies.

Applied Diagnostic Methods (Model Description)

Designed to provide the participant with the analytical and statistical tools necessary for isolating critical sources of process and product variation. The methods and techniques for statistically analyzing, describing, and graphing resultant data is given a major emphasis. Participation in this program yields the ability to initiate a variable search at the macro-level and successfully execute statistical techniques to isolate critical variables at the micro-level. In particular, the participant will learn how to select the right variables for inclusion in a factorial experiment as well as how to establish realistic process tolerances. In addition, the participant develops the analytical language and philosophy necessary for communicating