SIX SIGMA IMPLEMENTATION AT GENERAL DYNAMICS

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Abstract

The General Dynamics, Missiles and Electronics Group (GDM&E Group) adopted the Six Sigma Black Belt approach to continual quality improvement in the late 1980's. Modeled after the Motorola Six Sigma Quality Black Belts before anyone knew what a "Black Belt" was, the General Dynamics Lean Operations Task Force was a team of 32 highly trained and motivated "Black Belts" and "Master Black Belts" selected from throughout the Group. Their objective was the implementation of Six Sigma philosophy, tools and techniques, working with all levels of the organization in a structured implementation, leading to measurable and significant reductions in the cost of poor quality and process cycle times. The Lean Operations Task Force was a highly successful, leading edge implementation of the Six Sigma Black Belt approach currently in use and gaining recognition today by numerous companies, GE, Allied Signal and Raytheon chief amongst them.

This paper will discuss the situation leading to the implementation of Six Sigma Management Quality Method within the General Dynamics Missiles and Electronics Group, including the establishment and training of the Lean Operations Six Sigma Black Belt Task Force, it's successes and lessons learned.

Conditions Leading to Adopting the Six Sigma Quality Management Method

Continual Improvement plans generally call for slow, gradual infusion of skills and knowledge into an organization in a top-down fashion. It is hoped that, at some point, management will "run with the ball" and begin to aggressively promote the transformation on a daily basis. It is also hoped that they will begin to encourage employees to explore Statistical Process Control (SPC) applications and apply a structured problem solving and process analysis methodology to daily work problems. The general assumption was that management would begin to evaluate the fit of existing practices and procedure applications within the organizations' Mission, Values and Guiding Principles (MVGP) and then recommend related changes to bring policies and procedures in line with the MVGP.

The objective of this sort of effort is to create a work environment in which the MVGP and all of the Continual Improvement tools and techniques are incorporated into the day-to-day work of intact employee groups (areas, sections, and so on), as well as cross-functional teams.

In most cases during the late 80's, this was barely happening, if at all, within the Missiles and Electronics Group of the General Dynamics Corporation.

Indications of Insufficient Progress

There were a number of signs that were indicative of a lack of sufficient progress. The key indicators of insufficient progress were:

1. Lack of visible control charts. The visible use of SPC tools and techniques would have been the most simple and basic evidence that employees having received SPC training were exploring and applying what they had learned. In many cases, these visible, user level charts were non-existent even after the training was provided on an "as needed" basis. Generally, charts were used for presentation to management of project status and not for process analysis and improvement efforts.

2. Improperly prepared control charts. At that time, cross-functional teams had been getting a great deal of attention. Yet, on a regular, predictable basis, the few teams that presented control charts for process analysis and improvement displayed charts that violated basic SPC principles. This often occurred in spite of management's review and participation. This indicated that there were not sufficient "experts" available to teach and coach the proper use of control charts. This also meant that bad practices were being reinforced throughout the organization, leading to faulty analysis and decisions.

3. Inadequate problem solving efforts. There were few intact work groups that utilized a structured problem solving methodology to explore the group's own processes and where supervisors were aggressively forming a participatory relationship with their people (other than those that had always operated that way). If we were to truly empower people to own their processes and improve them, they needed to be taught to work as a team, use SPC, and apply a structured problem solving method on their own jobs. This generally did not happen because management was not sufficiently skilled or confident (or sufficiently interested or willing) to inaugurate such efforts.

4. Lack of organized focus on key processes. The bulk of continual process improvement effort (as contrasted to ongoing process work within the traditional management approach) were being pursued by cross-functional teams that were formed in a more or less random manner as issues come to employees' and/or management attention. This strategy made it highly unlikely that any large macro-process would be extensively attacked in a systematic fashion. When one considers that any large macro-process would probably require at least thirty to forty coordinated team efforts to deal with its entire 'length', it became clear that the random approach to team formation would not do the trick if we wanted any sizable results on critical macro-processes.

As a result of the conditions detailed above, the Missiles and Electronics Group senior management recognized the need to provide proper emphasis, structure and resources if the Group were to ever achieve improvements that went beyond the easy to achieve "low hanging

fruit." Determined to be a critical success factor in achieving these desired long term gains, was the hiring of a Director of Lean Strategies. To be successful, the new Director had to be schooled at the right hand of the "gurus," and they had to be able to lead the unification, focus and control of all continual improvement initiatives currently underway within the group. Additionally critical would be the Director's ability to coach, teach and mentor all levels of the organization in the Six Sigma methodology, including its social / cultural aspects as well as the obvious technical aspects. The newly hired Director of Lean Strategies, Dr. E William Lareau, reported to the Executive Vice President of the 23,000 employee GDM&E Group and was ultimately responsible for all Six Sigma / TQM / continual improvement activities. Once on board, Dr. Lareau developed and implemented the following proposal to establish a Six Sigma Quality Management Task Force of highly trained people, who, by today's standards, were Six Sigma Black Belts and Master Black Belts.

A Proposal to Implement a Six Sigma Quality Management Task Force

Forming a Six Sigma Quality Management Task Force

1. The Task Force should be drawn from existing employee roles. The vacated positions would not be filled, thus driving the thinning of existing management ranks.

2. The Task Force should be in operation for at least two years, unless it should evolve into a different form during that time: Plan, Do, Study, Act (PDSA).

3. The effort would be concluded as the Task Force duties are assumed by intact work groups.

4. Task Force members could then be "re-absorbed" into the organization and given full consideration for placement within middle and upper management ranks (they would be too valuable to lose!!).

5. Specific skill considerations for the Task Force are:
   a. Individuals with Manufacturing Supervision experience.
   b. Individuals with Manufacturing Engineer experience.
   c. Individuals with Quality Engineer experience.
   d. Individuals with teamwork, group dynamics and process skills and knowledge (specific training and experience in these areas).

6. The rest of the individuals should have varied backgrounds, filling out the cross functionality of the Task Force.

Objectives and Responsibilities of the Task Force

The Task Force should perform the following duties and work towards the following objectives:

1. Coach cross-functional teams. As required, Task Force members will meet with teams and provide the following support:
   a. Assist in maintaining correct problem solving practices.
   b. Identification of metrics and development of SPC tools.
   c. Coaching in proper teamwork and effective group decision making.
   d. Determine whether the issues at hand are process or policy related and then make appropriate recommendations/changes as necessary.
   e. Identification and formation of additional teams that may be required to supplement a specific cross-functional team.

2. Provide Six Sigma related training. The Task Force will provide and/or coordinate all Six Sigma related training, such as:
   a. Six Sigma philosophy/awareness
   b. Process flow charting and reengineering
   c. SPC / advanced SPC
   d. Structured problem solving
   e. Concurrent Engineering
   f. Interpersonal skills
   g. Taguchi Quality Methods and Design of Experiments
   h. Quality Function Deployment
   i. Any other relevant training as required.

This is essential so that there is consistency among training efforts across the organization. As the Task Force efforts wind down after a few years, a new training organization would then be formed (using some of the Task Force members) to provide on-going training and a minimum of special professional support. This action would result in a training function which would be powerfully focused on, and skilled in, Six Sigma process improvement efforts.

3. Coordinate macro-process improvement focus. Working with management, the Task Force will:
   a. Identify key macro-processes for improvement.
   b. Work with area management and personnel to determine the scope of the macro-process.
   c. Develop an action plan for attacking an entire macro-process in a sequential, well-coordinated manner, working with one or two work groups/areas at a time.
   d. Working in teams of two to four, Task Force personnel will 'move into' a specific work area to work with, coach and train supervision and employees in process improvement skill and techniques on-the-job.
   e. Work with involved departments and management to identify appropriate benchmarks for macro-processes.

4. Coach/train intact work groups on-the-job. The Task Force should perform the following specific functions within each work group.
   a. Explain their role and function clearly and specifically to all employees in the work area.

b. Assist local supervision in establishing a team oriented, participatory work environment.
c. Study the process to gain an understanding of the operations.
d. Assist personnel in identifying key outputs and metrics.
e. Assist personnel in establishing control points and formulating SPC tools to monitor key parameters.
f. Coordinate/coach problem solving and process improvement efforts that are initiated as a result of the process investigation (both cross-functional and intact work group teams).
g. Assist in collecting data and doing 'leg work' when existing personnel in the work area are overburdened.
h. Coordinate support services, when required, from outside groups such as Engineering and Material Acquisition.

5. Create "expert" and "expert work groups" ("Black Belts"). The objective of the Task Force efforts is not only to generate process improvement. Perhaps the most critical and long-lasting impact will be the creation of experts and expert teams that will be able to independently carry on process improvement efforts in their own work groups once they have been trained.

Proposed Training and Preparation of the Six Sigma Task Force

Each member of the Task Force should be exhaustively trained so that they can not only supply expert [Black Belt / Master Black Belt] support, but so that they will be prepared to fill many roles. Each member should receive at least the following training (training will be continuous and will evolve as time passes).

1. Statistical Process Control. Each member should take a basic and an advanced course at least twice and should participate in an exhaustive series of practicum seminars. They should be transformed into SPC experts by going over dozens of "bad" control charts and requiring them to calculate and interpret and charts in the correct manner. They should, of course, be trained to teach SPC to any group.

2. Six Sigma Quality Philosophy/Awareness. Each member should be required to study Deming's philosophy in detail and teach it when they are sufficiently polished.

3. Problem Solving. Each member should attend the structured problem solving class at least twice. This should then be followed by exhaustive coaching as problem solving methodologies are further developed and applied.

4. Just-In-time (JIT). Each member should be required to attend a 40 hour Just-In-Time workshop (conducted in house) so that they will be able to quickly identify key process points and issues when they are "in the field".

5. Team-oriented training. Each member should be exhaustively trained in interpersonal and coaching/guiding skills, such as Battelle leadership and/or Teleometrics training.

6. Taguchi Quality Methods and Design-of-Experiments (DOE). Each member should attend the basic Taguchi DOE class taught by the American Supplier Institute.

7. Concurrent Engineering. Each member should be required to attend a Concurrent Engineering seminar and should be able to teach it.

Other training should be provided as required and as it is developed. This training should be completed within the first six months of their assignment to the Task Force and should continue, as required.

Task Force Administration and Resources

It is essential that the Task Force be co-located. If they are not all in one area, it will be hard to exchange information and forge the strong team bonds essential for the success of the Task Force. This effort is very much like a Concurrent Engineering team endeavor and requires much of the same type of treatment.

Other administration considerations include:

1. Resource allocation (budget, furniture, phones, computer/software, etc.). An easy way to provide for this is to have each department of origin provide for the respective Task Force members' needs.

2. Pay, status, titles, etc.. This obviously an area of some concern for the Task Force members. It is suggested that the Task Force members stay in whatever pay and labor grades they already possess without any formal paperwork changes. This saves all sorts of administrative time and money.

   There are a lot of details that have to be worked out dependent upon the policies, procedures and structure of your particular organization. There is no other way (with minor variants expected) to achieve the type of results we must have. In most organizations, the existing culture change initiatives and process improvement efforts are not sufficient to help us reach the objectives/results that are outlined above. This effort requires a lot of investment and hard work. It is absolutely essential that we make the investment and do the work.

This proposal was accepted by the Missiles and Electronics Group senior management and was implemented across the organization.

The Task Force Hiring Process and Forming the Team

The Interviewing Process

Applications for the Six Sigma Task Force were made open to all employees within the Missiles and Electronics Group. A team of four people, personally selected by Dr. Lareau to be the Task Force Leads, developed and implemented a three phased interview and selection process. Each of the 364 applicants for the Task Force were given an initial interview by an interview panel of two Task Force Leads. During the initial Phase, the applicants were screened for their skills and background relevant to the Task Force, including prior team projects and activities, SPC and process flow experience.

Applicants who successfully passed the initial screening process, were subsequently interviewed by the four Task Force Leads in Phase Two. In Phase Two, the Task Force applicants were screened for their ability to work in teams and their ability to coach, teach and mentor people at all levels of a very diverse employee base. Applicants who progressed into Phase Three of the process, were all considered to be basically qualified to be on the Task Force. However, the issue of team cross-functionality of the Task Force and the to successfully negotiate and "sell" senior management was deemed critical to the success of the Task Force. Thus, the third phase of the interviewing process incorporated a role-play exercise in which the applicants were tasked with persuading a "reluctant VP" into endorsing a Six Sigma project within the VP's area of responsibility ("This Six Sigma stuff is just a fad and this, too, shall pass . . ."). Upon completion of the interviewing process, thirty-two candidates were selected and were made offers to join the Task Force. All offers were accepted.

Forming the Team

Once hired, the Task Force members were co-located, bringing with them their desks and office supplies, including computers and necessary peripherals. Their training began immediately both as a group at large and in smaller subgroups, as appropriate. And always, the concepts and theories that were learned in the classroom, would be immediately applied within the work environment on projects that would have significant return on investment (ROI) opportunities. The very nature of requiring a significant ROI from the projects meant that, in addition to the standard Six Sigma offerings of SPC, DOE and FMEA (Failure Modes and Effects Analysis), the Task Force had to be well educated in Strategic Planning and benchmarking, SWOT (Strength, Weakness, Opportunity, Threat) Analysis, Quality Function Deployment, project management, organizational needs analysis.

The education of the Task Force was conducted in accordance with the proposal, including a significant investment in a personal library for each team member, made up of the following books:

1. American Samurai, E. William Lareau
2. Benchmarking, Robert C. Camp
3. Deming's Route to Quality and Productivity, W. W. Scherkenbach
4. Deployment Flow Charting, Dr. Myron Tribus
5. How to Lead Work teams: Facilitation Skills, Fran Rees
6. Kaizen: The key to Japan's Competitive Success, Masaaki Imai
7. KANBAN: Just-In-Time at Toyota

8. Mining Group Gold, Thomas A. Kayser
9. On Becoming a Leader, Dr. Warren Bennis
10. Out of the Crisis, Dr. W. Edwards Deming
11. Peopleware: Productive Projects and Teams, Demarco and Lister
12. Poka-Yoke, Shigeo Shingo
13. Quality Function Deployment, Yoji Akao
14. Quality is Free, Philip Crosby
15. Self-directed Work Teams, Orsburn, Moran, Musselwhite, Zenger
16. Seven Habits of Highly Effective People, Covey
17. Study of the Toyota Production System, Shigeo Shingo
18. Taguchi Methods and Quality Function Deployment, Ryan (editor)
19. The Deming Management Method, Mary Walton
20. The Machine That Changed the World, Womack, Roos, Jones
21. The Memory Jogger Plus+, Richard Brassard
22. The Team Handbook, Peter Scholtes
23. World Class Manufacturing, Schonberger
24. Zero Quality Control, Shigeo Shingo

Task Force members were required to read and conduct theoretical research as necessary during normal business hours in order to support their learning, including attending the Deming Seminar and other internal / external education as needs dictated and opportunities allowed. Though the library and training were necessary to the education and development of the Task Force, it must be remembered that all knowledge and skills training were delivered in a just-in-time manner. The application of the new knowledge and skills would immediately be transferred into the Six Sigma projects and disseminated to the work teams, thus completing the process of theory, application, monitor/control, and measurable results within the PDSA context of continual improvement.

Six Sigma Project Selection And Pilot Project

Project Selection

All of the Task Force initial efforts were directed at the Convair Division Aircraft Manufacturing Product Line, a $1.5 billion program responsible for manufacturing the MD-11 tri-jet fuselage assembly for the McDonnell Douglas Aircraft Company. This determination was made by the Missiles and Electronics Group senior management based upon critical business needs and the tremendous schedule and cost pressures associated with the MD-11 Program.

Within the MD-11program, specific improvement projects were selected based upon the needs of the organization as determined by the external customer requirements, internal management indicators, and Pareto analysis (80/20 Rule). Final project selection was made by the MD-11 Six Sigma Project Steering Committee based upon analysis of cost, risk, schedule and opportunity considerations. The Steering Committee was made up of equal representation by program management and hourly bargaining unit represented employees. The Steering Committee made the decision to pursue a project for improvement at the "front-

end" of the product line. Not only would benefit accrue to the area of focus, but subsequent benefit would flow to downstream processes as well.

The Pilot Project

The focal area for the pilot project was an area called "Item 580," which was the very forward portion of the fuselage assembly, just aft of the cockpit, containing passenger and cargo doors whose proper assembly was critical to all subsequent assembly processes. The following article from the corporate publication, The General Dynamics World, April 1990, best describes the project. This was the first of a regular series in the GD World detailing Six Sigma successes from throughout the General Dynamics Corporation.

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TQM CASE STUDIES by Julie Andrews

Work Team Takes Over, Trims Time, Lifts Quality

IT'S SIX O'CLOCK in the morning and Convair Division's MD-11 fuselage first shift has just clocked in. The daily "stand-up" meeting is underway for the team of Item 580, a complex panel assembly containing the cargo door that sits just forward of the wing of the McDonnell Douglas jetliner.

Last June the team took 1,825 hours to build Item 580 with 15 quality assurance reports (QARs), 462 defects and 360 hours of rework and repair. Five ship sets later, the cycle time to build had dropped to 995 hours, with zero quality assurance reports, and zero defects, rework and repair. The projected cost savings of labor alone are $33,200 per ship set or $1.66 million per year at full production rate. [this after the team took on additional work and processes in order to better control the work and quality]

What happened in between? At the start of ship set number 458, the 10-member Item 580 team took ownership of their processes by planning their assembly sequence, team member assignments, time to build the item, and cross-training needs.

Chuck Hannabarger, Six Sigma Task Force Lead, Jay Rief, Industrial Engineer, and Operations Supervisors Dan Brooks and Bob Perkins served as the leaders and facilitators for the pilot project. The facilitators provided initial Six Sigma training and brought on the right people from tooling, inspection, and other functions as needed to solve the problems identified by the team.

It was important to the success of the initial project to implement it in an area where management, supervision and the assemblers were receptive to the philosophy of Six Sigma Quality, Hannabarger said. The Six Sigma Quality Method depends on teamwork, continuous process improvements and no barriers between management and employees.

Item 580 is still consistently one of the best performing items on the MD-11 line even though some members of the original team have been promoted or reassigned due to the needs of the organization. The team members continue to monitor their performance by tracking progress, cost and quality at their daily meetings.

Hannabarger and Rief are confident that other Six Sigma projects will be initiated throughout the MD-11 fuselage assembly line. A huge tooling and manpower buildup is under way to support production, which will more than double in 1990 and peak at 50 assemblies per year by 1992. . . . The Item 580 project proves that cost can be cut through other special action teams looking at overall tooling, parts, and training issues that affect a specific assembly team like Item 580.

Lessons Learned and Conclusion

It Takes the Social Side, Too

We also learned that, though the application of the technical tools like SPC and DOE are critical to the reduction of costs and the continual improvement of quality, paying attention to the social aspects and properly managing the social change process is even more critical. Implementation of the Six Sigma Quality Method will always be limited by the organizational structure and the corporate values and belief systems. Any incongruency between the goals of the organization and its rewards and recognition policy can be devastating, yet few organizations ever get alignment between the two. Many will talk about teams, but reward individual performance (employee of the year / month / week / day . . .). They will talk about overall optimization of the system, but will reward the management of an area that reduced their overall costs and improved their quality, but have sub-optimized the rest of the system. Make sure that the overall organizational structure, including communication links and supporting technology is what you need, when you need it. Teams cannot flourish in a traditional top-down environment, so make sure the micro-managers are set upon the path of transition.

Don't Assume the Support of Middle Management!

No matter our best intentions and our belief that managers were receptive - as the GD World article states - the middle managers perceived the activities surrounding the pilot project as tampering with their processes and within their work area, even though there was "consensus" reached and a consultative approach taken by the leadership involved. The middle managers felt that they really had no choice in the matter, due to corporate visibility and pressure to "do something!" Initially, the middle managers perceived that they were being told that they did not know how to manage their areas and that they needed "special help." Though the results of the pilot project ultimately "sold" most of middle management on the Six Sigma Quality Method, we recognized the need to do a far better job of enlisting middle management help and in getting them to champion the process throughout the organization. Always be very careful to reinforce the good work done in the past and to create a "pull" system for education in the "new way."

Through trial and error we ultimately realized the need to sell management in the language that works best for them - just as we had with the union and the hourly team members. Finance types could maybe care less about reduced cycle time on the shop floor, but tend to get very excited about the time value of money and having an extra million dollars or so to play with. Engineers could maybe care less about big dollar savings, but would love to have improved CAD/CAM capability and reduced engineering changes. We recognized the need to apply Blanchard's situational leadership approach and to get inside the head of the people we were working with in order to understand their language and their needs. Once this was accomplished, we found it much easier to get true consensus and to gain our client's trust for the perceived that we had their best interests at heart. We effectively removed the fear factor associated with our presence and became recognized as a valuable resource, ultimately helping to regain the delivery schedule and to reduce costs by over $850,000 per week ($44.2 million per year).