Development of a Framework for Comparing Performance Improvement Programs

by

Khusrow M. Uzair

B.E., Mechanical Engineering
NED University of Engineering and Technology-Pakistan, 1991

M.S., Manufacturing Systems Engineering
University of Wisconsin-Madison, 1996

Submitted to the System Design and Management Program
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Signature of Author _____

Khusrow M. Uzair
System Design and Management Program

Certified by _____

Deborah J. Nightingale
Thesis Supervisor
Professor of Aeronautics/Astronautics and Engineering Systems Division

Accepted by _____

Steven D. Eppinger
Co-Director, LFM/SDM
GM LFM Professor of Management Science and Engineering Systems

Accepted by _____

Paul A. Lagace
Co-Director, LFM/SDM
Professor of Aeronautics & Astronautics and Engineering Systems

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Submitted to the System Design and Management Program on August 16, 2001,
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Abstract

Total Quality Management, Six Sigma, Reengineering, Quick Response Manufacturing, Agility, Variance Reduction, and Lean are seven of the most popular initiatives employed by the manufacturing industry as improvement programs. Similarities, differences, and interrelationships among these seven programs in terms of objectives, concepts, methodologies, and scope have remained confusing to the industry for quite some time. Likewise, selection of one of these, or integration of several of these preexisting in a corporation, has also remained a problematic issue in the industry.

This report attempts to reduce this confusion and resolve the pertinent issues. Besides presenting a thorough discussion on the subject, it brings forth two useful things: a comparison chart showing similarities, differences, and interrelationships among the seven improvement programs, and a decision model suggesting a step by step process for adopting a new improvement initiative. The latter suggests a toolbox approach in which an integrated set of performance metrics based on a combination of three of these programs is recommended. Implementation tools for improving the same metrics are also selected based on the speed of change desired. A decision tree facilitating such a selection between a slow/incremental and a fast/radical change has also been presented. The importance of leadership commitment and clarity of vision in the success of an improvement program have also been emphasized.

This work is based on a literature search and an industrial survey carried out with the assistance of LAI member companies. LAI, or Lean Aerospace Initiative, is a consortium of aerospace companies, government organizations, and the Massachusetts Institute of Technology.

Thesis Supervisor: Deborah J. Nightingale
Title: Professor of Aeronautics/Astronautics and Engineering Systems Division

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CHAPTER 1

INTRODUCTION

Starting in the late '80s, a wave of improving the manufacturing competitiveness arose in the corporate America. This wave soon spread to other parts of the world and it began to include transformation of other areas of the enterprise as well. The implicit objective of this transformation effort has always been to improve the market share or growth of market share and profits of a corporation. But the same objective has taken on different explicit forms since then. It even has changed names several times and it is not obvious whether these names (or buzzwords, as they are often called) depict the same objectives, whether they are complimentary movements, or whether they have any objectives in common.

Probably the foremost of these efforts had their roots in the old "Quality of Work Life" and "Efficiency Improvement" initiatives. But the earliest of the corporate transformation efforts that we are focusing on was perhaps the "total quality management" efforts of late '80s. Then came the "six sigma" program pioneered by Motorola. Along the way ISO 9000 somehow got inextricably mixed with TQM and later on diminished to some extent. A little later the concepts of "Toyota Production System", "Lean Manufacturing", and "Lean Enterprises" was brought forward by the International Motor Vehicle Program of MIT and continued further on by the Lean Aerospace Initiative Program of the same institute. TQM and Six Sigma, however, continued to be championed by some other groups at the same time. But the story does not end here. Several other improvement programs (or improvement strategies) have been pioneered by yet other groups, and they have also continued to exist to date. Notable among these are the Time Based Competition (TBC), Quick Response Manufacturing (QRM), Agile Manufacturing, Flexible Manufacturing Systems, Business Process Reengineering, and so on. Business Process Reengineering somehow got relegated down to office operations only but it is not yet understood fully if it is a part of TQM or something different from it.

What we intend to accomplish in this thesis is to perform a thorough comparative analysis of the most prevalent of all these improvement strategies and try determining the following:

- The objectives of each of these improvement strategies
- If some of these have been superseded by others
- If the remaining ones are complimentary to each other or applicable to different situations
- Which strategy works best in which situation
- What performance metrics and implementation tools do they employ
- Whether they have the same or different scopes of application

- **If a new paradigm shift is needed every time just for the sake of a change initiative, and whether the name and objectives of such a movement make a difference**

To be specific, this thesis attempts to build a framework for comparing and contrasting the most popular of these improvement programs, and to develop a structured decision process on the basis of which an appropriate improvement program could be selected or a corporation's existing programs could be integrated or reconciled. Some of the parameters the decision process is based on includes: a corporation's SWOT (strengths, weaknesses, opportunities, threats) analysis, its internal environment and culture, the degree of change required, and the performance metrics its competitive market supports. The research is largely dependent upon literature search, but an industrial survey has also been employed in supporting the framework.

The thesis starts in Chapter 2 with a detailed comparative description of the seven most popular improvement programs: Total Quality Management, Six Sigma, Reengineering, Quick Response Manufacturing, Agility, Variance Reduction, and Lean. Then Chapter 3 discusses results of an industrial survey proving the necessity of carrying out this research and helping in the formation of a strategy for building up a program selection and integration framework. Chapters 4 and 5 develop a few decision models suggesting a unique approach for adoption of a new change initiative and for integration of preexisting multiple improvement programs. Finally, Chapter 6 highlights the importance of leadership commitment and effective change-program management in contrast with the relevance of selection or adoption of a particular program. Chapter 7 concludes this thesis by summarizing key results and providing a direction for practical application and further research based on this work.

Two important outcomes of this research are: a detailed comparison chart highlighting similarities, differences, and interrelationships among the seven improvement programs; and a structured decision model for selecting a particular program or for integrating several of the existing programs in an organization. These are included with Chapters 2 and 4/5 respectively.

CHAPTER 2

A TREATISE ON VARIOUS IMPROVEMENT PROGRAMS EMPLOYED BY MANUFACTURING ENTERPRISES

As mentioned in the introduction, a large number of manufacturing improvement programs are currently being employed by US industry. Some of them have been so popular that they have become academic disciplines in themselves. Others never gained much popularity and are limited to textbooks' reference purpose only. Yet another type of improvement programs are those that have been invented by a few companies to meet their own special requirements. Being proprietary in nature, little is known about them outside the companies that invented them. Since the objective of this research was to reduce confusion regarding the popular use of these programs, the decision was made to limit its scope to the first type of programs only. Seven such programs have been found to be the most widely known. These are: Total Quality Management, Reengineering, Six Sigma, Quick Response Manufacturing, Agility, Variance Reduction, and Lean. Partly to prove the popularity of these seven programs, we also carried out an industrial survey. Results of this survey, to be discussed in the next chapter, proved that these are the seven programs most commonly employed by US aerospace and other companies.

Following is a description of these seven improvement programs, as described in several books and research papers. A summarized comparison of these programs is presented at the end of this chapter.

Total Quality Management

In simplest words, Total Quality Management has been defined as[1]: "Data-based, employee-driven, customer focused, continuous improvement."

This improvement program has its roots in the Statistical Process Control technique, invented by Walter Shewhart of Bell Laboratories. The same concept was later vehemently advocated and implemented by W. Edwards Deming in the Japanese industry. Deming, one of Shewhart's students, and a consultant and Statistician by profession, can rightfully be called the father of Total Quality Management. The idea behind his using SPC in managing quality of manufactured parts was that instead of inspecting parts after manufacture, a cheaper and more effective option for ensuring quality is to let each operator inspect his or her own work before passing it on to the next stage. A very scientific technique for inspecting one's own work is to plot control charts (SPC) and see when the process has started producing out of spec parts. Once such a behavior is detected, the operator is supposed to try finding the root cause of the deviation and then try eliminating the root cause for bringing the quality back to the desired level.

As soon as the implementation of these concepts became commonplace, the theory of total quality had to adopt further logical and innovative measures. With the passage of time, total quality management has finally become a discipline in itself. Some of the fundamental ideas this discipline is now based on are[2]:

(i)- In a manufacturing or service industry, quality must be everybody's job, and not just a separate functional area (the word 'total' in TQM has come from the same idea). Thus there is no place for quality inspected in "after" any process.

(ii)- All efforts in an enterprise should be geared towards the satisfaction of the external customers. Besides external customer, the next stage of each process step in a company is to be considered an internal customer. Generally speaking, an internal or an external customer could be better satisfied by having a lower and lower cost of production, a lower and lower lead time for delivery, a lower and lower variability, a higher and higher quality, a higher and higher flexibility, a better and better customer service.

(iii)- Each stage of any process in an enterprise must continuously improve to achieve a better satisfaction of both internal and external customers. This improvement has to be achieved through scientific methods and must be based on data, facts, and findings.

(iv)- Every stage must be empowered to take decisions for implementing this concept of continuous improvement. All employees must be treated as assets and continuously trained so as to enable them in achieving continuous improvement of the processes they work on.

(v)- Team work helps in problem solving by letting input of a diversified set of ideas. It also helps in effectively meeting the objective of customer satisfaction for the benefit of all. In a team environment, managers and executives must act as leaders and coaches rather than as bosses and supervisors.

Since total quality management is all about continuous improvement through data based problem solving, it proposes the use of a number of problem solving tools. The most famous of these are the following seven[3]: flow charts and diagrams, Pareto charts, cause-and-effect diagrams, histograms/graphs, control charts, check sheets, and scatter diagrams. The basic approach it suggests for bringing about improvements through problem solving is the famous PDCA or Shewhart / Deming Cycle. According to this approach[1], first, we (P)lan for bringing about an improvement by studying the process, defining any problem, thoroughly analyzing it, and determining its root causes and a possible solution for dealing with the root causes. This must then be followed by pilot

implementation or (D)o step in which we apply the solution determined in the previous step. A (C)heck step is then followed to see if expected results are being obtained. Finally, in the case of success we take the improved process as a new work standard and start (A)cting according to it. This leads back to a re-analysis of the process and (P)lanning for further improvements. In case expected results are not obtained in the Check step, the A(ct) step may involve re-analysis of the initial problem, which again leads to P(lanning). This cycle is graphically represented below.

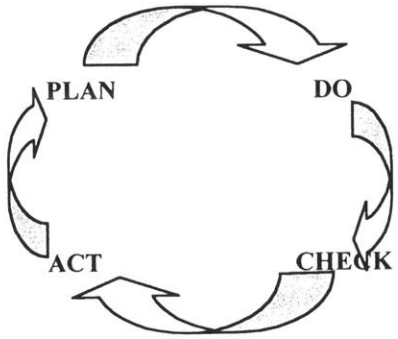


Fig. 2.1:
The PDCA Cycle

It should be noted that total quality management, by the very nature of it, brings about a slow, incremental, and continuous improvement in systems and operations. Its primary performance metric is customer satisfaction, and its scope of application is enterprise-wide. TQM advocators say that if we pursue the delight and satisfaction of the internal and external customers in everything that we do in business, profitability and market share improvements will follow automatically.

The Six Sigma Movement

First initiated at Motorola in the early '80s, and later on pioneered by Mikel Harry and Richard Schroeder[4], the Six Sigma movement is distinct from other improvement efforts in that it emphasizes setting up of quantifiable improvement targets and employs statistics for getting closer and closer to that target. This quantifiable target is defined in terms of number of defects present in a given product or process. The number of defects is in turn linked to the annual profit margins of the business.

The basic premise that Six Sigma is based on is that product or process defects are an undesirable expense and therefore eat away profits. By eliminating these defects, all the cost spent in detection, analysis, and fixing of defects is saved and thus show up in the form of improved annual profit margins. Besides this direct cost saving, improved quality because of elimination of defects results in improved customer satisfaction, which leads to increased market share. The

strategy Six Sigma proposes for elimination of defects is the same as the one prescribed by TQM and similar technologies, though the terminology defined is a bit different. Six Sigma segregates this process into the *define*, *measure*, *analyze*, *improve*, and *control* steps. The '*define*' step consists of definition of the problem and determining a roadmap for its solution. The '*measure*' step involves data collection and an assessment of the present state of defectiveness. *Analyze* means determining the root causes of the problem and then brainstorming and finding out possible ways of elimination of these root causes. *Improve* means to implement the determined solution, and *control* means continuous monitoring and taking up of corrective actions to make sure that the defect or the problem does not relapse. Six Sigma proponents advocate the use of all seven TQM tools for detection of defects. The overall strategy of Six Sigma is also similar to that of TQM, namely, to proactively discover the existence of problems and their root causes and to eliminate the root causes rather than implementing a "solution" of the problems. TQM, however, proposes an incremental continuous improvement in individual operations, whereas Six Sigma sets out transforming a whole process with a focus on profitability and quantifiable elimination of defects. This transformation could be incremental as well as radical.

It must also be noted that the term 'defect' in Six Sigma has a broader meaning. It is not only anything that fails to meet the customer's expectations or requirements, but also anything that blocks or inhibits customer satisfaction. Based on the concept of normal distribution of defects in statistics, Six Sigma says that mathematically, such defects cannot be eliminated in entirety from a process. A "six" sigma boundary of defects elimination, however, means that now the probability of existence of defects is only 3.4 defects per million opportunities of finding them. This is set as the ultimate goal of a Six Sigma improvement strategy. Against that, a five sigma quality would mean a probable existence of 233 defects per million opportunities (DPMO), 4 sigma, 6210 DPMO, 3 sigma 66,807 DPMO, and 2 sigma 308,537 DPMO. This could be illustrated graphically as shown below[5].

This graph is only shown to the extent of 3 Sigma. Total area under the entire curve approaches 100%

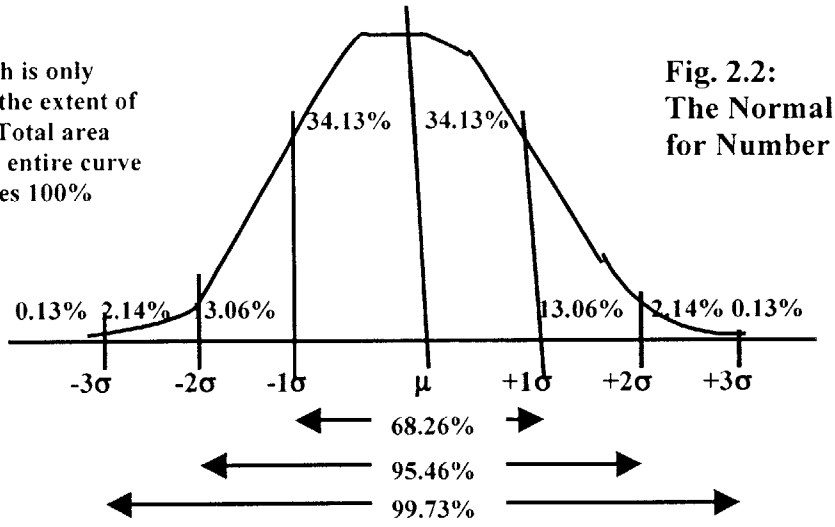


Fig. 2.2: The Normal Distribution for Number of Defects

It has been empirically determined[4] that for a typical industrial concern, a 3 sigma quality would mean that the overall process defects eat away 25 to 40% of its sales revenue. Likewise, a 4 sigma quality means that 15 to 25% of the sales revenue is being lost away in process defects, a 5 sigma means 5 to 15%, while a six sigma has its lost cost as less than one percent of the total sales. Companies having their quality or defects at 2 sigma or below are not competitive, and therefore hardly considered. Normally, 3.5 or 4 sigma is the level most American manufacturing and service companies stand at.

Six Sigma is applicable to all enterprise processes and the products produced therein. All resulting improvements thus culminate in an improvement of the whole business. As enumerated earlier, each sigma creates an exponential reduction in defects, and the profit margins generally grow 20% year after year for each sigma shift. Earlier sigma improvements are somewhat easier because of the presence of more than evident defects and problems. But the improvement process itself could be slow because of the TQM type of incremental improvement. Thus during this phase, slow improvements might result. But the closer a company comes to achieving six sigma, the ultimate target, the more demanding the improvements become. In this phase, improvements might only be possible by a reengineering-type fundamental redesign of the whole process. Such improvements therefore could be fast and dramatic. In any case, the cost/ benefits of achieving Six Sigma across all processes and products needs to be evaluated and the decisions for implementation based upon that.

Reengineering

Reengineering, as defined by Hammer and Champy[6], is the fundamental rethinking and radical redesign of business processes to achieve dramatic

improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed.

Unlike total quality management, reengineering does not seek to make businesses better through incremental improvements in an existing process. The aim of reengineering is a quantum leap in performance --- the 100% or even tenfold improvements that can follow only from an entire revamp of the existing work processes and structures. Thus reengineering is approached only when a dramatic improvement in performance is required. Such a need could be felt in the face of customer requirements, global competition, or unrelenting change in the market conditions. And such a dramatic improvement could only be achieved by challenging the very basic assumptions at the root of current business processes, and by restarting all over from scratch.

Although the performance metrics a business wants to dramatically improve using reengineering may vary, the basic objective remains the enhancement of value provided to the customers. Some of the themes revolving around a reengineering effort are innovation, focus on results, and reinvention of processes.

The Japanese word *Kaizen,* meaning incremental improvement, is a general term, but with a quality or customer satisfaction in focus it becomes synonymous to TQM. Likewise, the Japanese term often used for reengineering-type radical or breakthrough improvements is *Kaikaku* or *Kaizen Blitz*[7]. There is, however, a fine line of distinction between Kaikaku and Reengineering. Kaikaku, as originally defined, is applicable to any small "area" of the enterprise, mostly shop floor, and despite bringing about a step-function-like leap in performance, it does not necessarily have to be a redesign from scratch. Reengineering, on the other hand, is only applicable to an entire enterprise "process," and it is always a reinvention or starting over from a clean sheet of paper.

Elaborating this point further, whereas the concepts of TQM, Kaizen, and Kaikaku could be applied to any operation, a set of operations, or an entire process, reengineering is only applicable to a process. A process is defined as a self-sufficient collection of activities that takes one or more kind of inputs and creates an output that has some value to the final customer. An example of an operation would be bringing in a set of documents from one office to the other, while that of a process would be 'order processing at company X.' Traditionally, reengineering has been applied successfully to white collar enterprise processes only. In principle, however, the concept is equally applicable to a blue-collar process. In either case, information technology, because of its power of bringing about dramatic improvements, is considered an important enabler in reengineering.

Over the past many years, reengineering, because of the dramatic improvements it brings about in performance, has been accused of leading to enterprise layoffs due to mass elimination of non-value-added operations from its various processes. This accusation has vehemently been fought over by Michael Hammer, the founder of reengineering movement[8]. According to him, it is the enterprise leadership's responsibility to utilize in value-added tasks the human resources saved by reengineering. It is even prestigious and satisfying for human resources themselves to contribute towards value-added tasks rather than being wasted away in redundant and non-value-added tasks. According to Hammer, the same is the objective of Reengineering.

Despite these criticisms, there are success stories of reengineering galore in the corporate world. The most popular ones are those of Hallmark Cards, Taco Bell, and Bell Atlantic. Some of the common characteristics running through these stories are combining several jobs into one, decentralization of decision-making authority, start performing process steps in a natural order, start performing work where it makes most sense, and reduction in checks and controls.

Quick Response Manufacturing (QRM)

The objective of a QRM program, just like most of the other programs in this list, is to improve the market share and profitability of an enterprise. This is also an enterprise-wide program focused on operations and processes.

Quick Response Manufacturing could be traced back to the Toyota Production System pioneered by Taiichi Ohno and Shigeo Shingo. The Toyota Production System was invented at Toyota Company, Japan, in a direct confrontation with the mass production system flourishing at Ford Motor Company and General Motors Corporation in USA[9]. In an effort to boost up the Japanese auto and engineering industry immediately after the Second World War, Eiji Toyoda and Taiichi Ohno of Toyota Company visited Ford Motor Company a number of times to "learn" the secret of their success. They soon realized that the challenges faced by their company and the Japanese economy are completely different from those of the US auto industry. Whereas the US manufacturers had virtually no space constraints for expanding their factories, Japan being a small territory, could only afford a limited space for its factories. Being a world-war survivor, Japan at the same time had very scarce capital and other resources to invest in production. This meant that they had to achieve a lot using as little a capital input as was logically possible. This situation demanded the birth of an entirely new way of manufacturing things, and Taiichi Ohno and Eiji Toyoda did it.

Both Taiichi Ohno and Eiji Toyoda analyzed that in order for them to minimize the use of factory space, they had to produce a large number of different models

and types of autos on the same shop floor. At the same time they did not want to stock huge inventories of each model and type because: (a)- they did not want to invest in building warehouses, and (b)- they knew that holding inventories for prolonged periods is in itself an expensive overhead. Further, they prophesied that they would have a great competitive advantage from the customer-satisfaction point of view, if they could change their production in synergy with changing customer demands. All this demanded that they devise a method for reducing the setup times to the least possible so that changeover to different models and types of product does not entail long delays and inordinate man-hours. Once this target for "Single Minute Changeover" was set, it was not impossible to be achieved by Shigeo Shingo, the most capable of Taiichi Ohno's engineers.

Negligible setup/changeover times, with concomitant low work-in-process, raw material, and finished good inventories form one-half of the premise of Quick Response Manufacturing[10]. The other half is the notion that a manufacturing company should also try continuously decreasing its lead time for manufacturing and product development and for all enterprise processes by a radical redesign or an incremental problem-solving approach. The idea is that on one hand customer satisfaction is being achieved by minimizing the changeover/setup times, and on the other hand, a lead in achieving the same objective is being achieved by bringing one's products to the market faster than all the competitors. As mentioned before, the required continuous reduction in all these time parameters could be radical as well as incremental, depending upon the need and situation. Means for achieving such a change includes, but is definitely not limited to, such methodologies as worker empowerment, Integrated Product & Process Teams (IPPT), Total Productive Maintenance (TPM), and cellular layouts.

The primary performance metric considered by QRM for bringing about improvement is "time." This is so much so that according to QRM proponents, everything an enterprise does should be geared towards reducing the time spent in all pertinent organizational and industrial processes. According to them, just like cost reduction was the competitive weapon in the '70s and quality in the '80s, lead time reduction is that weapon in the '90s and in the new century. The thing to note, however, is that QRM proponents also claim that as a result of lead-time reduction, quality, cost, and other improvements take place automatically. The argument by them runs as follows [11]. If all the work-in-process inventories are minimized in a manufacturing system, problems become easier to be identified, and therefore process and product quality improvement opportunities increase. The analogy often presented in this regard is that of water tides in a pond. If inventories are analogous to water and stones/rocks in the bottom of the pond are like quality problems, reducing the volume of water

always highlights the presence of stones and hence become more prone to get removed. Likewise, since lead-time reduction involves elimination of non-value-added chunks of time, it automatically eliminates all kinds of waste and thus improves cost reduction.

Agility

In view of the rapidly changing global economy, technological advances, and increasing complexity of products and systems, management of change has gained unprecedented importance. This was particularly true for weapon systems, which takes 15 years to develop but key technologies in them change sometimes every three years[12]. In the early '90s, for the benefit of military industrial establishment in particular, the Department of Defense and the National Science Foundation set aside 120 million dollars to develop tools to manage this problem of responding to unexpected change. Using these funds, ARPA (Advanced Research Projects Agency), Pentagon's premier research center for high-risk, high payoff projects, established an Agility Forum at Lehigh University (PA), under the auspices of the Iacocca Institute. Three NSF-funded, university research centers were soon established and thirty new research contracts were issued. Most of these programs digressed to other similar theories like quick response, supply chain management, or electronic commerce, but a few core projects under the management of USAF were able to remain focused on the original idea. Their work was later on further developed by the Agility Forum and some consultants and academicians.

Today, Agility is defined as the ability of an organization to respond well to unexpected change, and even to leverage that ability as a competitive strategy. This change could be external as well as internal. It could be a market change because of unexpected mergers or acquisitions or changing customer preferences because of some completely unforeseen external factors. It could also be technological changes so critical to the viability of the products an enterprise is manufacturing. The objective of an agility initiative is to keep an enterprise continually competitive in the face of all these changes.

Whereas other improvement programs are built on the assumption of a static environment, Agility is closer to reality in that it realizes the environment to be very dynamic. For example, the lean program assumes that better, faster, cheaper is always the guarantee of success. This is not entirely correct because sometimes it benefits an organization to have some waste in its structure to cope with sudden changes in its internal or external environment. A good example of this situation is that of Wang Laboratories and IBM. When Wang Laboratories invented the word processor ---- an innovation that quickly created a billion-dollar company ---- shock waves hit the world's largest typewriter producer,

IBM. IBM had dominated that market with the most-preferred (better, cheaper, customer-focused) products, but they were initially unable to respond to Wang's innovation. Wang successfully redefined and dominated this market precisely because they took advantage of change. However, Wang's market started eroding with the appearance of word processing software on personal computers. When IBM faced and responded to the new realities by creating the word-processing capable personal computer, Wang was unable to change, and they were soon bankrupt. What put Wang out of business this time was IBM roaring back by entering (or creating) the PC business. IBM was able to respond successfully because of the previously underutilized skills of their many-layered, redundant, and expensive technical management pool.

To be a paragon of best management practices and to have a customer-focused, waste-free environment is important. But what is even more important in this new hi-tech age is the ability to maintain this position, as well as to respond to any unexpected changes in an appropriate way (for example to start making something else better, faster, and cheaper; or to become better, faster, cheaper in a different way). This is what agility is all about. It is important to note that flexibility of systems and processes to quickly respond to changing customer requirements is a part of agility, but this is not the whole concept of agility. Agility also includes taking an appropriate (not necessarily quick) action to unexpected changes at strategic levels. The aim is to keep the enterprise ahead of competitors all the time. This very much ties in with the profitability goal, the main target of all the improvement programs.

Another concept commonly defined a part of the agility movement is that of the 'Virtual Enterprises.' The basic premise of this concept is that keeping business partnerships (for example with suppliers) fixed or long-term can sometimes go against agility. An enterprise should also be able to form quick partnerships to cope with unanticipated changes in the market situation or whatsoever. These makeshift extended enterprises, known as 'Virtual Enterprises,' have the added virtue of being very agile, besides being lean because of minimum overheads.

Variance Reduction

Spurred by significant reductions in defense budgets, a joint initiative was taken by DoD and the aerospace industry in late '90s to find out ways of reducing the cost of production from the aerospace industry. Spearheaded by Stephen Ruffa from DoD and Michael Perozziello from the industry, an extensive research was soon carried out to determine the best methodology for carrying out significant and effective reductions in costs of production. Their findings were brought out in the form of a report and a book[13] (published in the year 2000), and the essence of their findings has since been called the principle of variance reduction.

Whereas other improvement programs have profitability improvement as an implied target, Variance Reduction takes it as an explicit objective. Further, it proposes to achieve this target both for the enterprise in question and for the customers, by a continuous reduction in cost of production. The basic concept of the principle of Variance Reduction is that inventory reduction and cycle-time reduction are the two primary metrics for reducing cost of production. In order for them to take place effectively, variance in all operations in the enterprise must be managed first. Thus variance reduction must be taken as the fundamental of the three primary performance metrics (cycle time reduction, inventory reduction, and variance reduction) in all enterprise operations. The success of all improvement efforts is dependent upon whether variance in processes, operations, and systems has been managed well or not.

The analogy presented by the proponents of Variance Reduction program is the following. In a traffic stream some disruptive behavior of a rash driver often causes a ripple effect and chokes down the whole traffic. Putting in a few police cars on the highway to check such rash driving will remove all disruptions from the stream and hence will improve the overall efficiency of all people driving on the road. This will also enable further improvements like improving the speed limit or improving the fuel efficiency of cars. If there is any roadblock or construction site on the highway, that needs to be fixed even before putting in police cars. This is because if the roadblock is not removed, the police cars will themselves get choked in the narrow passages instead of keeping rash drivers in check. Thus variance reduction is the primary metric to be controlled before any other improvement program could be put to action.

The Variance Reduction Program does not end at reducing variances. Instead, it sees that as a primary metric for improvement. The two other primary metrics it proposes are inventory and cycle time reduction. Strong improvement in both inventories and cycle time is seen only when variation in all processes and operations has been greatly mitigated. Variance Reduction program also has a set of six enablers for improving these three primary metrics, and hence for achieving the target of cost-of-production reductions. These are: control of inventory, control of manufacturing operations, quality improvements, supplier improvements, flow improvements, and emphasis of manufacturing in design. Each of these enablers, in turn, is supposed to be implemented by a set of initiatives. The overall configuration is as shown below.

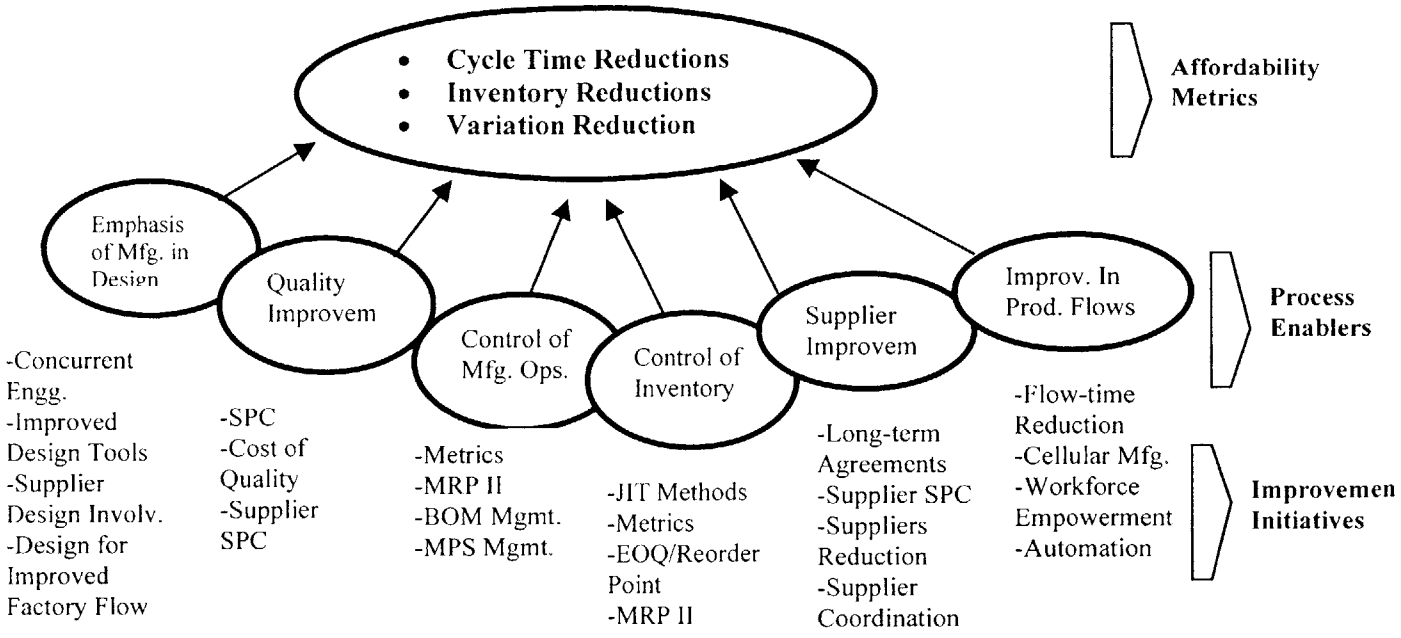


Fig. 2.3: The Improvement Framework for Variance Reduction

The Variance Reduction program also suggests the implementation of these six enablers in a particular order. This is shown below. Lower level enablers, if implemented first, will have a better impact on making higher level enablers effective.

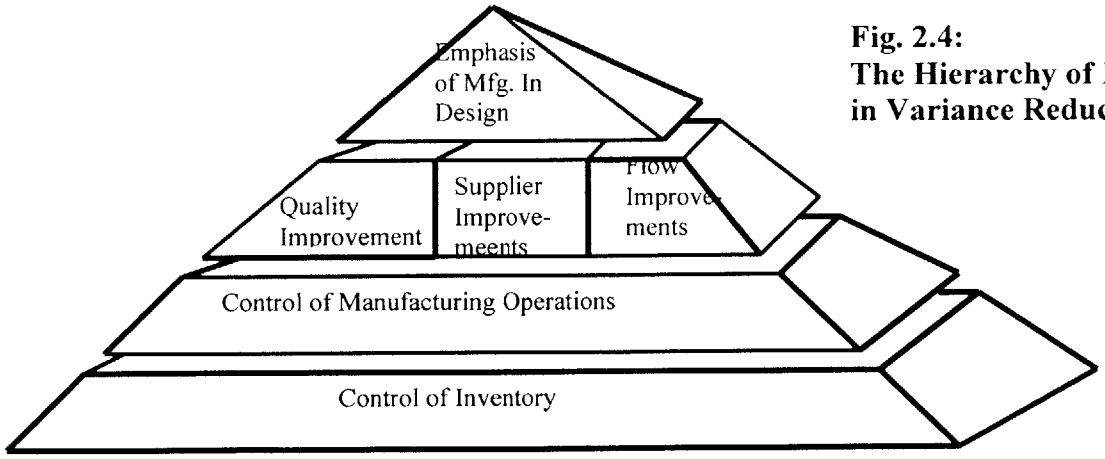


Fig. 2.4: The Hierarchy of Enablers in Variance Reduction

The improvement initiatives each of the enabler supports could also be taken as tools or techniques for implementation. It is thus obvious that tools and methodologies for improvement of this program are not much different from those of the other programs. Also, the scope of application of this program includes all enterprise functional processes, just like in other programs. The

degree of change brought about by this program could be dramatic or incremental depending upon the approach taken for implementing each of the initiatives. The program itself has no specific guidelines regarding this.

The Lean Initiative

The history of lean, as also mentioned under Quick Response Manufacturing above, goes back to the Toyota Production System invented by the Toyota Motor Company in Japan. The concepts were, however, for the first time theorized by Daniel Roos, Jim Womack, and Daniel Jones of International Motor Vehicle Program, MIT, in their classic book, *The Machine that Changed the World.* Based on this work, a whole philosophy of lean thinking and lean initiative was later on developed by two of these researchers in mid '90s, and the same was presented in their book *Lean Thinking.*[14]

The lean initiative, as it has been matured into now, is somewhat different from other improvement strategies in that it is kind of independent of either the speed or the mechanism of bringing about the improvement. It also does not advocate the use of a single performance metric for bringing about improvements. We therefore say that Lean is the basic framework within which the other improvement strategies work. Whereas TQM advocates customer satisfaction by working on what the enterprise already has, and Six Sigma, Reengineering, QRM, and Variance Reduction talk the same thing by giving this goal different orientations, lean goes an extra mile in going beyond what the enterprise already has. It talks about customer satisfaction by doing more for the customer than normally expected (creating value) and by using very carefully and effectively whatever it has (waste elimination). In other words, lean is about doing only what the customer wants and also doing whatever the customer wants. The notion of continuous improvement seems to be shared by all these programs, including lean.

In general, putting lean thinking into practice encompasses the following five steps[14]:

Step 1: Specify value to be provided to the customer, where value is anything customer needs at any time and at any place

Step 2: Identify the value stream (linked action steps or processes for providing value) for each product or service provided to the customer.

Step 3: Line up these value-creating actions in such a way that value flows to the customer without interruptions.

Step 4: Let the customers pull value from the enterprise, through the value stream, whenever they want.

Step 5: Continuously review these steps and perform them more and more effectively in the pursuance of perfection.

Value stream mapping (i.e. its identification), pertinent to step number two above, is an important tool for implementing a lean initiative. It provides a basis for performing an in-depth analysis of each of the action steps leading to provision of value to a customer. As a result of this analysis, those steps creating no value to the customer may be singled out and eliminated. These form what lean thinkers call "wastes" or *Muda,* in Japanese. Once these wastes are eliminated, the remaining value-creating steps must "flow," the concept presented in step three above. This involves discarding the traditional batch-and-queue mentality, and implementing batch sizes to the order of single units. Setup time reduction, cellular manufacturing, and Integrated Product and Process Teams (IPPT) are all tools and techniques supporting this step. The next step (step number four above) says that customers pulling products and services through the enterprise, rather than the enterprise pushing them on to the customers, is another key to sustained competence of an enterprise. This "pulling" action cascades upstream, all the way to the supplier network. Kanban, Just in Time (JIT), and Production Smoothing are all techniques supporting this principle. Finally, the step five above is the same continuous improvement philosophy common to all of our seven improvement programs. Here it says that there should be no end to the process of reducing waste and specification/ creation of value for the customer, by continuously improving the products and services and the way they are provided to the customers.

These five principle steps lead to doing more and more with less and less and at the same time coming closer and closer to providing customers with exactly what they want. Although not explicitly stated in there, lean implementation is obviously customer focused and it has to be knowledge driven. This is because continuous waste elimination and letting customers pull value through the enterprise is not possible unless it is supported by empowered teams of employees that are continuously trained and enabled to make knowledge and data-based decisions. To many lean thinkers, therefore, lean thinking is a knowledge-driven and customer-focused process through which all people in a defined enterprise continuously eliminate waste and add value, creating sustainable competitive advantage.

Unlike the other improvement programs, because of the all encompassing nature of the lean principles, there has been a great deal of effort in implementing lean across various extended enterprises, especially those outside auto and general manufacturing. The Lean Aerospace Initiative Program of MIT has been at the forefront of this movement, and it has successfully developed a number of tools and models in this regard. Notable among them are the Lean Enterprise Model[15] (LEM), a Transition-to-Lean Roadmap[16] (TTL), and Lean Enterprise Self-Assessment Tool[17] (LESAT).

Comparison of All the Improvement Programs

A comparison chart summarizing the above program descriptions is given in Table 2.1 on the next few pages. An abridged version of the same chart is also presented right after that (Table 2.2). From these charts and descriptions a few points can decidedly be made.

- TQM and Reengineering are two different approaches for improving customer satisfaction. At the same time, both of them are aimed at betterment of the competitive position of a company by way of improving the value provided to the customers. Thus they both could be described as leading the company on the path to leanness. Lean still remains a superset of both because of the additional concepts of value creation /specification and its "pull" by the customers.

- Six Sigma, QRM, and Variance Reduction could be implemented either using the TQM approach or the Reengineering approach. What makes these programs specialties of TQM or Reengineering is their definition of a target metric for performance improvement. Six Sigma is TQM in its entirety, except that it has a statistical quantitative focus on reducing the number of "defects." Likewise, QRM has a focus on "time parameter", and Variance Reduction on "variability in processes." They are all siblings in a sense that they all define a primary metric and yet claim that focusing on that metric will automatically lead to improvement in all other performance metrics, thus leading to improved profitability and market share, by way of improved customer satisfaction. Being specialties of TQM or Reengineering, they still fall under the framework of Lean.

- Six Sigma, QRM, and Variance Reduction; all three talk about waste reduction from enterprise processes in one way or another. To Six Sigma, non-value-added operations indirectly lead to customer dissatisfaction, and therefore are defects. QRM proposes elimination of no-value-added chunks of time and inventory. Variance Reduction also talks about elimination of no-value-added chunks of time and inventory. None of them, however, talks about value creation or its pull (though QRM does have the pull concept). Hence all three of them still fall under the Lean framework.

- Agility, on the other hand, seems to be the other side of the picture painted by lean. Whereas Lean tells the recipe of remaining ahead of competitors under the prevailing global and highly competitive environment, Agility tells how to remain competitive if this environment starts changing. Lean cannot be called a part of Agility because Agility has no guiding principles for any particular static environment. Similarly, Agility is not a part of Lean because Lean does

not have a solution for a situation where everything (including the competitive environment) starts changing unexpectedly. Just like both the head and the tail of a coin together make a coin, both agility and leanness are essential for survival and for remaining ahead of competitors. Just like both the head and the tail side of a coin share the same structure and material of the coin, both agility and lean share the basic objective; yet they are different and complimentary in their concepts.

Table 2.1: A Detailed Comparison Of All Seven Programs

Change Program	Brief History	Basic Objectives	Fundamental Concepts/ Principles	Performance Metrics Supported	Degree of Change Brought About	Tools/Methodologies	Scope of Application in an Enterprise
Total Quality Management	Dates back to Edward Deming, and his quality philosophy, which in turn was built on the work ofShewhart and others	Bring about and sustain a company's winning position by continuously improving customer satisfaction	Data-based, employee-driven, continuous incremental improvement in all enterprise operations with a focus on customer satisfaction	Customer satisfaction is the primary performance metric.	Slow, incremental.	The seven famous TQM tools are: histograms, flow charts, scatter diagrams, cause-and-effect diagrams, Pareto charts, control charts, and check sheets. Basic methodology is plan, do, check, act.	The whole enterprise including all core, support, and strategic planning processes.
Six Sigma	Theorized by Mikel Harry and Rich Shroeder. 6Sigma concepts were first implemented and perfected by Motorola, and later on by GE & AlliedSignal.	To improve market share and profitability of an enterprise by continuously reducing the number of defects in its products and processes.	A defect is anything going against customer satisfaction. The basic concept of Six Sigma is that number of these defects should keep on decreasing in all products and processes going on in the enterprise. The ultimate target for such reductions should be the six sigma level of a normal distribution, which is 3.4 defects per million.	Number of "defects" is the primary metric in Six Sigma. The term "defect," in turn could be defined differently in different contexts. Cpk is an important gauge for tracking the primary metric.	Could be dramatic as well as incremental, depending upon the tools and methodologies adopted for reducing the number of defects.	Statistical analysis is the primary tool. All seven TQM tools mentioned above are however considered basic in all data analysis. The general methodology for bringing about improvements is:define, measure, analyze, improve, and control.	The whole enterprise including all core, support, and strategic planning processes.

Table 2.1 Cont...

Reengineering	Pioneered by Michael Hammer in early '90s; he built upon his ideas based on Peter Drucker's work and on the general need of corporate Ameca to reinvent itself in the face of Japanese competition.	To achieve dramatic leaps in performance by redesigning an enterprise process.	Quantum leaps in performance and dramatic improvements in competitive position can never be achieved by fixing problems in a system; it can only be achieved by starting over, by rethinking the fundamental design of processes, by reinventing the way things are done. The most notable of the changes required are from Adam Smith's theory of speicalization of labour to generalization&empowermnt	Varies from case to case, and cannot be generalized. Most commonly, cost of production, lead time to deliver, and quick changeover are the performance metrics required to be improved.	Very fast and radical	No fixed tool or methodology applies. It's all about designing something afresh. Information technology is, however, a useful enabler in most of the cases.	The whole enterprise including all core, support, and strategic planning processes.
Quick Response Manufacturing	Built upon the Toyota Production System by giving the same philosophy a new dimension. Initiated by Boston Consulting Group in late '80s and later on pioneered by Rajan Suri, Suzanne deTrivelle, and other academicians.	To capture market share and improve profitabity by taking lead time as the primary performance metric for improving all enterprise operations.	Lead time is the primary waste in all industrial operations. Reducing lead time for manufacture & product development results in bringing products to the market faster than the competitors and in improving customer satisfaction. Also, reducing changeover/setup times reduce inventories thus reducing costs.	Lead time is the primary metric of performance in this philosophy.	Could be dramatic as well as incremental, depending upon the tools and methodologies adopted.	PDCA (plan, do, check, act) is the primary tool. However, any possible tool helpful in achieving the objective is recommended. Examples are kanban, JIT, SMED, SPC, etc. etc.	The whole enterprise including all core, support, and strategic planning processes.

Table 2.1 Cont...

Agility	Started in the early '90s by DoD and NSF. An Agility Forum was established by them in response to a conference's recommendations. Lehigh University in Pennsylvania has been at the forefront of this movement.	Objective here is to improve and sustain an enterprise's competitive position by making it flexible enough to meet any and all changing customer demands and to cope with any sudden changes in external or internal environment.	The basic concept of the agile movement is that instead of having any fixed objectives & a set methodology for continuously improving one's competitiveness, the best strategy is to develop an ability to cope with changing customer expectations and other externalities	Flexiblity of systems and processes as well as the enterprise policies is the primary metric here.	Could be fast or slow depeding upon the situation. It is actually not a change process, but the abiltiy to cope with change	Any possible tool helping to achieve the objectives is applicable. The best tool, however, is the right strategy at the planning level. At a micro manufacturing level, SMED, empowerment, etc. are useful.	The whole enterprise including all core, support, and strategic planning processes.
Variance Reduction	This new approach was discovered and advocated by Stephen Ruffa and Michael Perozzielo of the aerospace industry in late '90s; was discovered by them while researching on reducing cost of production in the aero industry	To reduce cost of production, so as to improve the overall competitiveness of the organization.	The basic concept is that it is hard to reduce inventory or to slash lead time unless variability is reduced from the processes. Once variance is reduced from the processes, it becomes a lot easier to device ways of improving lead time or inventory. Cost of production goes down as soon as variance, lead/cycle times, and inventories are reduced.	Variance reduction is the primary metric for performance here. The two secondary metrics are cycle time reduction and inventory reduction.	Could be dramatic as well as incremental, depending upon the need and the method used.	A whole set of techniques or initiatives like Concurrent Engg, SPC, MRP II, Cellular Mfg., etc. lead to six different process enablers. The enablers help in improving the three metrics. The six enablers are: Design for Mfg, Quality Imp., Control of Mfg. Ops., Cont. of Inventory, Supplier Improvmnts, & Improvement in Production Flows.	The whole enterprise including all core, support, and strategic planning processes.

Table2.1 Cont...

Lean	The philosphy of Lean came into being as a result of the quest for Japanese auto mfg. success by the IMVP researchers of MIT. The concepts were first presented in the IMVP book "The Machine that Changed the World."	The objective is to increase the overall competitiveness of an enterprise by reducing waste and increasing the overall value created for the customer.	The five basic principles of lean thinking are: specify value for the customer by specific product, identify the value stream for each product, make value flow without interruptions, let the customer pull value through the stream, and pursue perfection in all this.	Value created for a customer is the primary metric.	Could be dramatic as well as incremental, depending upon the tools and methodologies adopted.	Value Stream Mapping and all popular tools/ techniques, especially from Toyota Production system, as and when applicable.	The whole enterprise including all core, support, and strategic planning processes.

TABLE 2.2: AN ABRIDGED COMPARISON CHART

Change Program	Basic Objective	Fundamental Concepts / Principles	Performance Metric	Change Introduced	Tools and Methodologies	Scope of Application
TQM	A progressively competitive position of the enterprise	Data-based, employee-driven, continuous improvement	Customer satisfaction	Slow, incremental	Detailed analysis of operations using Plan-Do-Check-Act cycle.	Enterprise-wide
Six Sigma	Sustain and contin-uously improve the market share & profitability of an enterprise	No. of product & process defects in an enterprise should keep on approaching the Six Sigma target (3.4 defects/million)	No. of defects, where a defect is anything causing customer dissatisfaction	Could be dramatic as well as incremental	General methodology is the define-measure-an-alyze-improve-control cycle; Statistical ana-lysis is a primary tool	Enterprise-wide
Reengin-eering	To achieve dramatic leaps in performance of an enterprise	Quantum leaps in performance are only possible by reinventing & redesigning processes	Cannot be generalized	Very fast and radical	No general tool or me-thodology; it's all about creativity, starting over from scratch	Enterprise-wide
QRM	To capture market share /continuously improve profitability	Reducing lead/ setup time for enterprise processes improves response to customers	The time parameter, wherever it is applicable	Could be dramatic as well as incremental	A mix of tools including JIT, Kanban, SMED, TPM, & Empowered Teams	Enterprise-wide
Agility	Improve /sustain an enterprise's compe-titive position under unexpected internal or external changes	Instead of having a set methodology & objectives, an enterprise must develop an ability to cope with unexpected changes	Flexibility of systems, pro-cesses, & enter-prise's strategies / policies	Rather being a change, it's deployment of ability to cope with change	Deployment of correct strategies + all tools improving flexibility (SMED, Kanban, Empowerment, etc.)	Enterprise-wide
Variance Reduc-tion	To continuously reduce cost of pro-duction & improve profitability	Reduction in inventory and cycle time is the key to cost reduction; this is only possible by an effective variance management	Variance reduction in products and processes	Could be dramatic as well as incremental	A mix of tools including JIT, Empowerment, Concurrent Engg., etc. supporting a set of six process enablers	Enterprise-wide
Lean	Continuously improve an enterprise's competitive position	Key to success is continuously improving the value created for the customers by letting them pull value through a streamlined value stream	Value created for the customer	Could be dramatic as well as incremental	Value stream analysis, supported by a mix of tools from Toyota Production System (like JIT, Kanban, Poka-yoke, etc.)	Enterprise-wide

CHAPTER 3

INDUSTRIAL SURVEY AND ANALYSIS OF SURVEY RESULTS

An industrial survey was performed in support of this research in March-April 2001. Although it was limited to the LAI (Lean Aerospace Initiative) consortium member companies, it still covered a range of small and large manufacturing enterprises having various different product lines, histories, and corporate cultures. Besides establishing the popularity of the seven improvement programs we decided to focus this research on, the purpose of carrying out this survey was two fold:

(a)- To ascertain the level of confusion and uncertainty prevailing in the industry regarding the selection of a particular improvement program or integration of several preexisting programs.

(b)- To gain some insights into the objectives/circumstances causing the selection of these programs, determine reasons behind the success or failure of these programs, and ascertain how the industry relates these programs together.

The questions asked in the survey pertained to scope of application of their ongoing improvement programs, circumstances leading to the selection of these programs, whether any objectives were defined before their adoption, and the roles played by the companies' top leadership in making the change programs a success. The survey respondents were also asked to identify the performance metrics and implementation tools in use by their companies in relation to their current improvement programs. A few additional questions at the end were about their perception of these programs' success or failure, and whether their companies were facing any problems in integrating any simultaneously existing multiple improvement programs.

A copy of the questionnaire used in this survey is given in Appendix I at the end of this report. Altogether fifteen persons from eight different aerospace companies were interviewed in this survey. The situation of each company regarding the selection and implementation of improvement programs is presented below. A detailed analysis of these survey results and a brief conclusion are presented at the end of this chapter. To protect the confidentiality of participating companies, their real names have been replaced here with A, B, C, D, etc.

Company A ---- Number of respondents = 3

Company A is a large manufacturer of aerospace components. From its responses to our survey it was clear that Company A is quite unclear regarding any differences and connection between TQM, Reengineering, Lean, and several

of its generic programs. It tried several of them from time to time in same and different parts of the company, and at least five of them are still being run simultaneously with a mediocre rate of change evident in the enterprise performance. Penetration of these programs is also limited just to the enterprise' core processes.

DoD's invitation and trends in the industry triggered the start of these programs, and the objectives were therefore never fully defined before starting them. In the absence of any guiding vision at the top, the improvement programs running together are not integrated. A random mix of performance metrics are being employed for monitoring the overall progress of the company, and nothing ties them altogether in driving the company on the path of performance excellence. Likewise, a random-mix of implementation tools is being used for these programs.

Company A has a real problem in integrating its various improvement programs together. Two of the problems they are most concerned about are duplication of effort and handling of program interfaces. Part of the reason behind these problems is a mediocre leadership commitment for bringing about a performance turnaround.

Company B ---- Number of respondents = 2

Company B is a major player in the commercial aircraft business. It all started when as a result of multiple acquisitions, huge debts had to be paid off, and that forced the new enterprise leadership to consider adopting some kind of an all-encompassing waste reduction program. At the same time, there was a need to transform all the different cultures prevalent in the parent companies into one unique culture of operational excellence. The new CEO of the newborn company had some experience with Six-Sigma before, and he was therefore inclined to select that as an overarching improvement program. However, with the involvement of the company in Lean Aerospace Initiative (LAI), some of the lean principles were combined with Six Sigma, for introducing an effective waste-reduction and operational excellence program throughout the enterprise. The original organizations of Company B also had vestiges of their own improvement programs still present in pockets throughout the enterprise. This made the enterprise leadership decide upon choosing a toolbox approach. They came up with their own generic program encompassing elements of almost all of our seven improvement programs and created a shared vision for it across the enterprise. Company B has been religiously pursuing this initiative for three years now with huge success.

Part of the reason for Company B's success could be attributed to their leadership's commitment, having a clear objective, and the urgency of need to improve the situation prevalent in the company. The other part could be attributed to their toolbox or umbrella approach. Further, some of the Company B's survey responses show that various improvement programs preexisting in various pockets within the enterprise have had some difficulty in transitioning to the new umbrella program. This very much proves that the integration of various preexisting improvement programs does affect the success of any new change initiative in any company.

Company C ---- Number of respondents = 2

Company C, a leader in technological innovation in the aerospace industry, has adopted Lean as its umbrella improvement program. Just like Company B, they have taken a toolbox approach and have included elements of TQM, Variance Reduction, Reengineering, and others in their Lean program.

Company C had tried almost all of the individual improvement programs in the past. They all died out one after another due to lack of leadership commitment and other reasons, leaving legacies of their critical elements behind. A few years ago, under the new competitive environment created by large-scale mergers and acquisitions in the industry, the corporate board started contemplating about starting a new performance improvement program one more time. This coincided with an invitation by DoD to help form the Lean Aerospace Initiative Program at MIT. This provided the corporate leadership an opportunity to tie all the old programs' legacies together under the new name of "Lean." They also appointed a new VP to pursue this all-encompassing single improvement program throughout the enterprise.

According to survey respondents from Company C, their lean implementation has been a success story. Full support from the CEO and a dedicated VP are, however, major factors behind their success. The other reason, again, could be their all-encompassing, toolbox approach towards improvement.

Company D ---- Number of respondents = 2

Since late '80s, Company D has been experimenting with every possible improvement program in various parts of the enterprise. These include TQM, Six Sigma, Reengineering, Quick Response Manufacturing, Agility, Variance Reduction, Lean, and a generic program which was abandoned just after one year of its inception. Except for the last one, all of them still exist in pockets in several areas of the enterprise.

With its involvement in LAI in 1999, and in an effort to copy industry trends, the enterprise leadership soon started to emphasize "Lean" more than any other program. To date, however, they are themselves not clear about differences and similarities among various improvement programs. Often times, they mention their initiative as a hybrid of Six Sigma and Lean. However, in general, people in Company D are slow in adopting this and are really waiting to see if it will also go away. In essence, the company leadership is using the same tools as used in other programs, and yet calls it Lean/Six Sigma Program. Integration of pre-existing improvement programs is definitely an issue company D needs to cope with. Further, they need to adopt a toolbox / strategic vision approach used by Company B and C. So far Company D has just been trying to incorporate their hybrid program at a strategic/planning level. Recently, the company has also started publishing integrated training materials under the umbrella of Lean/Six Sigma, but people still find these overlapping goals and terminology confusing and frustrating.

As clear from the above description, Company D has not been very successful in its change initiatives. One obvious reason behind this is that they have not been successful in integrating their preexisting programs together. The other reason is that their change initiative has not yet achieved an enterprise-wide strategic flavor. A third reason, however, is that their top leadership has probably not been as proactive in bringing about a change as some of the other companies' leadership has been. This point was observed from some of the responses from Company D's survey forms. Their objectives for program adoption were also not crystal clear, probably due to lack of an urgency or a pressing need for change.

Company E ---- Number of respondents = 3

Company E is a medium-sized aerospace company and has been acquiring several small companies in the past. As such, all known improvement initiatives like TQM, Six Sigma, Variance Reduction, Lean, and even some generic ones have been in existence in various areas of the company. For the last three or four years, however, the enterprise leadership has been supporting Lean as an all-encompassing program. Other programs have therefore been eclipsed or are just seen now as means for achieving the "Lean" end. Today, Lean has penetrated all of the enterprise' core and support processes and has even started to influence the high level strategic planning processes.

Increased awareness on waste reduction in fact triggered Company E's leadership to consider adopting 'Lean' for improving its competitive position. Objectives were set, but not as clearly as those in companies B and C. Leadership commitment was also strong, but not very proactive. Probably because of this reason, Lean could not be adopted at the highest level, which resulted in still not-

so-good integration of all preexisting improvement programs. Thus a toolbox approach has been adopted in principle, but almost all the process and system improvement tools are being used somewhat independently in Company E's journey to Lean. Many areas of the company have their own preferences for selecting lean implementation tools. From this description it is not difficult to infer that Company E's success must not have been remarkably good. Responses to our survey questions for this company do in fact confirm that.

Company F ---- Number of respondents = 1

Company F happens to be the most focused of all the survey respondents. They have a well-defined system and process improvement program by the name of 'Continuous Improvement.' This program has been going on there for the last ten years with marvelous results and an all-out success. Recently they have also tried to incorporate a few elements of 'Lean' and 'Six Sigma' in this program, but the basic structure of the program still remains the same.

The 'Continuous Improvement Program' of Company F is only focused on the manufacturing area. The goal of this program has been clearly defined as "to make the company the lowest-cost producer within its market niche." Top leadership of the company has been behind the introduction of this program and they have been actively supporting it since then. The primary performance metrics chosen for this program are cost, return on assets, shareholder value, and customer satisfaction. Other popular performance metrics are also used sometimes, but they are always considered as secondary. All possible tools that could help in improving these metrics are employed for implementing this program at Company F. The result is that a high or medium-to-high improvement in all these metrics has consistently been obtained. Today the company is regarded as the leanest and the most profitable one in the industry.

Clearly, the reasons behind the success of Company F's change program are well-defined objectives, committed leadership, a guiding vision, and a well-integrated program in terms of metrics and tools.

Company G ---- Number of respondents = 1

Like most other companies, Company G is also not clear about the difference between all the system or process improvement programs. They have been running both TQM and Lean programs for quite some time, but utilize lean as their primary focus. Reconciliation or integration of the two programs is still a problematic issue for them. The CEO of the company, who became intrigued with the idea after attending a seminar on Lean, is responsible for introducing Lean on top of TQM. The rate of change being brought about in the company by

either of the two programs is very slow. Neither of the two programs has penetrated far beyond the core and a few support processes of the enterprise.

Lead time, work-in-process inventories, productivity, and floor space are the primary metrics of improvement considered by Company G, but they often times also include many other popular performance metrics in their lists. Nonetheless, improvement in any of these metrics has to date been really slow. The tools they use for implementing their program/s have also been chosen at random. They think they can improve their performance if they put more financial resources behind their programs.

Lack of sufficient leadership commitment, lack of a clear objective or vision, and lack of integration among the two improvement programs they have been running simultaneously are responsible for Company G's little success with its change initiatives.

Company H ---- Number of respondents = 1

Company H has apparently chosen a toolbox approach and it says that its change program consists of Six Sigma, Supply Chain Management incorporating Lean, and High Performance Workplace incorporating Employee Empowerment. However, it also admits that it is facing problems in integrating so many things together and that it is facing a lack of focus, confusion, and an 'inconsistent application of anything.' This is despite their umbrella program having an all-encompassing focus.

Company H's current umbrella/hybrid program was initiated by the top enterprise leadership with an objective of reducing production cycle times, improving product reliability, and reducing cost of poor quality. However, several other metrics are also considered by them when it comes to performance improvement. This means that the various metrics they are using simultaneously are not complementary or are not integrated together because of lack of an overarching vision. The same could be said about their implementation tools.

Company H presents a good example of poor integration of programs, despite having a superficial umbrella program. But some of the other reasons behind its not-so-good change performance could be lack of urgency, mediocre leadership commitment, or lack of a clear roadmap /corporate vision.

Analysis of Survey Results

Selection and Success of Programs:

A summary chart showing selection of programs by the surveyed companies, their implementation background, and their overall impact, is presented as Table 3.1 on the next page. Based on these summarized results and from the companies' above-described current situations regarding selection and implementation of various improvement programs, the following key points can be made.

- The seven improvement programs we initially decided to focus our research on, are indeed the most popular ones, at least in the aerospace industry. Lean is currently the most popular among these seven. Eleven out of the fifteen respondents cited it as one of the programs currently in use in their organizations. Eight of them (out of fifteen) defined Lean as their primary or umbrella program.

- Agility and QRM are the least-employed improvement programs in the aerospace industry. None of the eight companies surveyed mentioned Agility as its current improvement program. Only one of them mentioned QRM as one of its active programs. Only two out of the eight companies are using Variance Reduction as one of their explicitly defined improvement programs.

- Nearly half of the improvement programs currently employed by the industry are being implemented enterprise-wide. Seven out of the fifteen survey respondents said their program is enterprise-wide, three said their primary program is limited to manufacturing, and the remaining five said it encompasses all the core and support processes. The success of a program does not seem to depend as such on its scope of implementation.

- Four out of the eight companies surveyed (A, D, G, and H) declared the existence of more than one disintegrated, independent improvement program in their enterprises. The same four companies happen to be the ones in which their respondents expressed dissatisfaction (i.e. low or medium satisfaction) with the progress of improvement program/s in their enterprises. This shows that existence of multiple programs in a disintegrated fashion could be an important cause of poor performance of change initiatives.

- A strong correlation is also found between the existence of multiple disintegrated programs and a poor clarity of objectives. This leads us to believe that clarity of objectives and existence of a guiding vision help towards integration of multiple improvement programs.

TABLE 3.1: INDUSTRIAL SURVEY AT A GLANCE:

PROGRAMS USED, THEIR SCOPE, CLARITY OF OBJECTIVES, LEADERSHIP COMMITMENT, AND SATISFACTION WITH PROGRESS

Companies Surveyed		Improvement Programs Currently in Use								Umbrella Program	Scope	Clarity of Objective	L/ship Commit.	Satisfaction w/Progress
		TQM	6 Sigma	Reengg.	QRM	Agility	Var.Red.	Lean	Generic					
A	Rsp1	X		X				X	X	All	Core Prc+ Finance	Low	Medium	Medium
	Rsp2	X						X	X (two)	TQM	Mnfg + Des./Dev.	Low	Medium	Medium
	Rsp3								X	Generic One	Mnfg only	Medium	High	Medium
B	Rsp1		X							6Sigma + Lean+V.R.	Enterprise-wide	High	High	Medium
	Rsp2								X	6Sigma + Lean+V.R.	Enterprise-wide	High	High	High
C	Rsp1							X		Lean = All Seven	Enterprise-wide	Medium	High	High
	Rsp2							X		Lean	Enterprise-wide	Medium	High	High
D	Rsp1	X	X	X	X		X	X	X	Lean + 6Sigma	Enterprise-wide	Low	Medium	Medium
	Rsp2							X		Lean, incl. 6S,Rng,VR	Core&Supp. Procs	Medium	Medium to High	Medium to High
E	Rsp1							X		Lean	Enterprise-wide	Medium	High	High
	Rsp2							X		Lean, enc-ompss. all	Core&Supp. Procs	Medium	Medium	Medium
	Rsp3		X	X			X	X		Lean	Core&Supp. Procs	Medium	High	High
F	Rsp1								Contin. Improv.	C.Imp.,incl Lean&6S	Mnfg. only	High	High	High
G	Rsp1	X						X		Lean	Core&Supp. Procs	Low	Low to Medium	Low
H	Rsp1	X	X	X				X	X	A Mixture	Enterprise-wide	Low	Medium to High	Low to Medium

- **Unless countered by a highly committed and proactive leadership, poor clarity of change objectives always results in poor or mediocre change performance. In other words, having a clear objective for a major change initiative is one of the keys to success. A company must have a clear vision on what it wants to achieve out of a program before it starts. Once the objective has been determined, performance metrics should be very clearly defined in line with that objective. Implementation tools could then be selected accordingly, and a continuous monitoring of performance metrics could then act as a control knob operation for regulating the program. This leads to integration of different improvement efforts or initiatives simultaneously existing in an enterprise.**

- **A state of urgency for bringing about a performance turnaround helps, but is not an absolute precondition for the success of a change program.**

- **A medium or low leadership commitment always results in a medium or low level of satisfaction of employees with the change program/s. In other words, a high leadership commitment for bringing about a change is critical for success.**

Performance Metrics:

Detailed statistics on selection of performance metrics by our surveyed companies are presented in Table 3.2 on the next two pages. A histogram corresponding to this table is shown in Appendix II, at the end of this report. The following points could be inferred based on these statistics.

- **A total lack of consensus was found in each of the surveyed companies regarding what performance metrics are being used for improvement. In not even a single company, did more than one respondent mention the same set of performance metrics for their organization.**

- **Also, for the present at least, no relationship between choice of a performance metric and choice of an improvement program exists in the industry. Different performance metrics were cited by different companies, despite them using the same improvement program.**

- **Profitability, defect or defect rates, and inventory reduction were mentioned as performance metrics by 100% of the respondents. Customer satisfaction was mentioned as a performance metric by more than 90% of the respondents (fourteen out of fifteen).**

TABLE 3.2: SELECTION OF PERFORMANCE METRICS BY VARIOUS COMPANIES FOR THEIR IMPROVEMENT PROGRAMS

In the header, the first row tells the company's name, the second row, the number of respondent answering the survey questions on behalf of that company, and the third row tells the kind of program that particular respondent thinks is currently predominantly prevalent in their company.

In the chart, shaded boxes represent the performance metrics a particular respondent thinks are in use at their company. Different shades or textures have been used to denote the degree of importance of a particular performance metric in the eyes of the respondents. A shade like means that the perform. metric is a primary one according to that respondent. A shade like means that the performance metric is one of secondary importance, and a shade like denotes a performance metric of tertiary importance. A plain black box like means that the respondent feels that all performance metrics used in that company are of equal importance.

Performance Metrics	Company A			Company B		Company C		Company D		Company E			Co. F	Co. G	Co. H
	Rsp1	Rsp2	Rsp3	Rsp1	Rsp2	Rsp1	Rsp2	Rsp1	Rsp2	Rsp1	Rsp2	Rsp3	Rsp1	Rsp1	Rsp1
	Mixt.	TQM	Gnrc	Gnrc	Gnrc	Lean	Lean	L/6S	L/6S	Lean	Lean	Lean	C. Impr	Lean	Gnrc
Mfg. Lead Time															
Product Dev. Cycle Time															
Setup/Ch. Ov. Time															
Flow Efficiency															
Info Release Retr. Time															
Throughput Time															
Percent On-Time Deliver.															
Cost or Profit Improv.															
Return on Assets															
Defects and Defect Rates															

(Performance Metrics Cont..., Table 3.2)

Performance Metrics	Company A			Company B		Company C		Company D		Company E			Co. F	Co. G	Co. H
	Rsp1	Rsp2	Rsp3	Rsp1	Rsp2	Rsp1	Rsp2	Rsp1	Rsp2	Rsp1	Rsp2	Rsp3	Rsp1	Rsp1	Rsp1
	Mixt.	TQM	Gnrc	Gnrc	Gnrc	Lean	Lean	L/6S	L/6S	Lean	Lean	Lean	C. Impr	Lean	Gnrc
No. of Design or Engg. Chng															
Customer Satisfaction															
Employee Satisfaction															
Employee Turnover															
Inventory Reduction															
Cost of Quality															
Output per Employee															
Warranty Costs															
Shareholder Value															
Number of Accidents															
Percent Scrap Prod.															
Overheads															
Working Cap. Reduction															
Economic Profit															

Note: The last five of these metrics were added by the companies' respondents themselves.

- Warranty Costs and Information Retrieval /Release Time have been found to be the least popular performance metric. Next to them are employee satisfaction and output per employee.

Implementation Tools:

Detailed statistics on selection of implementation tools by our surveyed companies are presented in Table 3.3 on the next three pages. A histogram corresponding to this table is shown in Appendix II, at the end of this report. The following points could be inferred based on these statistics.

- Cpk (which in reality is a metric) and Empowered Teams are the most popular (fifteen out of fifteen) implementation tools used in the companies surveyed. Next to these (fourteen out of fifteen) are Cellular Manufacturing, Root-Cause Analysis, and Kaizen.

- The least popular implementation tools are Quality Circles (one out of fifteen), Design Structure Matrices (three out of fifteen), and Life Cycle Analysis (four out of fifteen).

- Just like performance metrics, there is a great deal of confusion prevalent in the industry regarding the selection of tools. In not even a single company, did more than one respondent cite the same set of implementation tools for their organization.

- Also, for the present at least, there is no definite relationship existing between choice of an implementation tool and choice of an improvement program. Different implementation tools were cited by different companies, despite them using the same improvement program.

- For the same program, implementation across an enterprise was found to entail more implementation tools than implementation just across core and support processes. Enterprise-wide programs encompassing more than one improvement program have been found to be using the largest number of implementation tools.

Survey Conclusion

As perceived in the beginning, a great deal of confusion does exist in the industry regarding the similarities and differences between the various different improvement programs. Selective elimination or integration of existing programs is always an issue while embarking on a major change initiative.

TABLE 3.3: SELECTION OF IMPLEMENTATION TOOLS BY VARIOUS COMPANIES FOR THEIR IMPROVEMENT PROGRAMS

In the header, the first row tells the company's name, the second row, the number of respondent answering the survey questions on behalf of that company, and the third row tells the kind of program that particular respondent thinks is currently predominantly prevalent in their company.

In the chart, shaded boxes represent the implementation tools a particular respondent thinks are in use at their company. Different shades or textures have been used to denote the degree of importance of a particular implementation tool in the eyes of the respondents. A shade like  means that the implement. tool is a primary one according to that respondent. A shade like  means that the implementation tool is one of secondary importance, and a shade like  denotes a implementation tool of tertiary importance. A plain black box like  means that the respondent feels that all implementation tools used in that company are of equal importance.

Implementation Tools	Company A			Company B		Company C		Company D		Company E			Co. F	Co. G	Co. H
	Rsp1	Rsp2	Rsp3	Rsp1	Rsp2	Rsp1	Rsp2	Rsp1	Rsp2	Rsp1	Rsp2	Rsp3	Rsp1	Rsp1	Rsp1
	Mixt.	TQM	Gnrc	Gnrc	Gnrc	Lean	Lean	L/6S	L/6S	Lean	Lean	Lean	C. Impr	Lean	Gnrc
Activity-Bsd Costing															
Andon Board															
Cpk															
Single Piece Flow															
Jidoka															
Design of Experiments															
Design Struc Matrices															
Empowered Teams															
Cont. Educ./ Trng. Prog.															
ERP															
SWS for Quick Setup															
Quality Circles															

(Implementation Tools Cont..., Table 3.3)

Implementation Tools	Company A			Company B		Company C		Company D		Company E			Co. F	Co. G	Co. H
	Rsp1	Rsp2	Rsp3	Rsp1	Rsp2	Rsp1	Rsp2	Rsp1	Rsp2	Rsp1	Rsp2	Rsp3	Rsp1	Rsp1	Rsp1
	Mixt.	TQM	Gnrc	Gnrc	Gnrc	Lean	Lean	L/6S	L/6S	Lean	Lean	Lean	C. Impr	Lean	Gnrc
Root Cause Analysis															
SMED															
Process Flow Mapping															
Value Strm. Mapping															
Cellular Manufacturng															
Critical Path Analysis															
Strategic All./Partnsh.															
Heijunka															
Hoshin Kanri															
IPPT															
DFMA															
JIT															
Kaizen															
Kanban															
Life Cycle Analysis															
Poka-Yoke															
FMEA															
QFD															

(Implementation Tools Cont..., Table 3.3)

Implementation Tools	Company A			Company B		Company C		Company D		Company E			Co. F	Co. G	Co. H
	Rsp1	Rsp2	Rsp3	Rsp1	Rsp2	Rsp1	Rsp2	Rsp1	Rsp2	Rsp1	Rsp2	Rsp3	Rsp1	Rsp1	Rsp1
	Mixt.	TQM	Gnrc	Gnrc	Gnrc	Lean	Lean	L/6S	L/6S	Lean	Lean	Lean	C. Impr	Lean	Gnrc
Five S															
SPC															
TPM															
Suggestion& Reward Prgm															
Profit/Gain Sharing															

A high leadership commitment, adoption of a clear objective and vision, and a toolbox approach towards multiplicity of programs seem to be the best methodology. By toolbox approach is meant selection of performance metrics in line with the objective, irrespective of to which improvement program the metrics belong. And this followed by selection of implementation tools and techniques helping towards improvement of those metrics, irrespective of to which improvement program the tools belong.

Another point this survey has shown is that the perceived success of a change program does not depend upon its scope of application.

These ideas will be further elaborated upon in the next chapter.

CHAPTER 4

SELECTION OR INTEGRATION OF IMPROVEMENT PROGRAMS IN TERMS OF PERFORMANCE METRICS AND IMPLEMENTATION TOOLS

As discussed in the previous chapter, our industrial survey did bring out the importance of integration of preexisting improvement programs in an enterprise. It also proved the importance of leadership commitment and clarity of objectives for the success of an improvement program. Almost none of our surveyed companies were found to select a stand-alone improvement program from our list of seven. Most of them either started a generic program, which again was a combination of at least some of our seven programs, or tried to integrate various preexisting programs under an indigenously created vision. Development of a set of criteria for selecting any particular improvement program given the specific situation of a company thus largely remained unresolved. In the following few pages we have made an effort to address this issue.

Performance Metrics and Their Role in Program Selection

A quick glance at the comparison chart we developed in Chapter 2 shows that one of the primary elements our seven programs differ in is the performance metric they focus on. It was therefore natural to suspect that choice of a performance metric would lead to choice of a program, and the criteria suggesting the choice of a performance metric should therefore be investigated.

A performance metric is a parameter desired to be improved as a result of a change program. It has to be a quantifiable and measurable parameter so that the effect of change could be assessed and control actions taken. In a free market economy like that of the US, the ultimate objective of a change program has always been to increase profitability or to increase market share. But these are long term parameters of success. Performance metrics are short-term parameters that prophecy the achievement of these long term parameters. Examples of such short-term measurable performance metrics are lead time to manufacture, employee turnover, set up times, cost of production, and customer satisfaction survey scores.

There are certain things that need to be considered in the selection of these performance metrics. A good performance metric should be:

- easy to monitor and measure,
- must be a good and accurate measure of long-term profitability, sustainability, and growth of the enterprise, and
- it must also be an indicator of the desired improvement in the right context.

For example, talking in terms of an enterprise-wide improvement, out of the five performance metrics mentioned above, all except the set up time have an enterprise focus. Set up time, as a performance metric, seems more appropriate for a job shop or a machine center. Likewise, out of these five performance metrics, customer satisfaction survey score is perhaps more difficult to measure and monitor than the others. Finally, employee turnover is easy to measure and monitor and could have the right context if considered for the whole enterprise, but it is not necessarily a measure of the long-term profitability of an enterprise to an accurate extent.

Operational and Non-Operational Performance Metrics

It is true that internal-operations' performance metrics like unit cost of production and lead time to manufacture are an appropriate measure of success, but it is also true that success is not only defined by them[18]. An enterprise's overall success is not dependent upon operational excellence alone. For example, all the capacity saved by reduction of rework or lead-time or WIP inventories, if not utilized for some other purpose or sold off for money, will have a negligible effect on the bottom line. Likewise, development of new products and bringing them to market at the right time, finding new markets and new customers after improving operational performance, and maintaining proper cash flows, etc., are as important as improving operations. This means that we ought to have performance metrics for these actions too. The point, however, is that all these other kind of performance measures are determining factors for long-term profitability, but they all pertain to results of our improvement programs and hence could only be applied after an operations or process improvement program like TQM, Six Sigma, Reengineering, or Lean. Hence performance metrics for an "improvement program" must initially focus and converge to a single set of "operations-related" metrics. This set could consist of only one performance metric or more than one. Further, as long as they all satisfy the criteria for appropriateness of a performance metric outlined earlier, performance metrics within such a set could be of equal or of varying degrees of importance.

It is also possible that one functional area or division of the enterprise has one set of operational performance metrics and another functional area or division of the enterprise has a different set of operational performance metric. This is perfectly fine as long as each set satisfies the criteria for appropriateness, and they all are compatible with each other in determining the success (i.e. long-term profitability) of the enterprise.

Cascading of Operational Performance Metrics

Besides having different degrees of importance, operational metrics could also be supportive of each other in a cascading sense. For example, 'lead time to manufacture' is a high-level performance metric, 'work-in-process inventory reduction' is a low-level performance metric supporting that, and 'setup time' could be a third tier metric supporting 'work-in-process inventory reduction.' They are all appropriate operational performance metrics according to the criteria we listed earlier, yet they look at operational performance from different levels. Another example of cascades of performance metrics could be 'employee satisfaction' supported by both 'employee turnover rate' and 'absenteeism.'

Short-listing of Performance Metrics

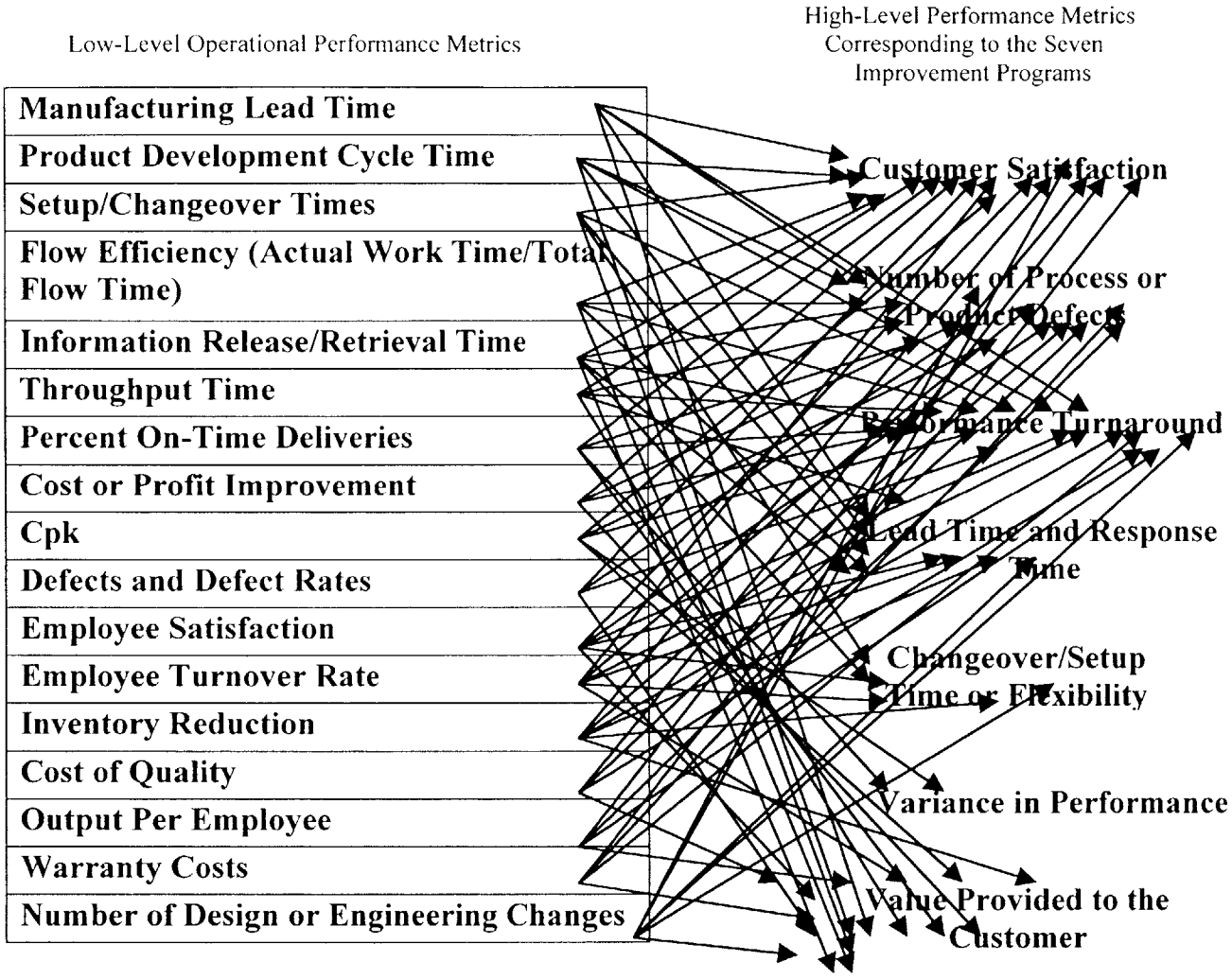
Using this cascading concept, all possible operational performance metrics could be shown leading to one of the seven primary performance metrics defined by our seven performance improvement programs. The following table (Table 4.1) shows our improvement programs' primary performance metrics again. Below that is Table 4.2 showing various low-level performance metrics leading to each of these seven primary performance metrics.

Table 4.1: Primary Performance Metrics for the Seven Improvement Programs

CHANGE PROGRAM	PERFORMANCE METRIC
Total Quality Management	Customer satisfaction
Six Sigma	Number of process or product defects
Reengineering	Performance turnaround
Quick Response Manufacturing	Lead time and response time
Agility	Changeover/Setup time or Flexibility
Variance Reduction	Variance in performance
Lean	Value provided to the customer

In the following table we have shown all performance metrics we used in our questionnaire (see Appendix I), linked to these seven high-level performance metrics. Return on Assets and Shareholder Value, however, pertained to non-operational performance metrics, and were therefore not included. Also, Customer Satisfaction, already a high-level performance metric in our questionnaire, has not been linked to itself below.

Table 4.2: All Low-Level Operational Performance Metrics Lead to the Seven High-Level Performance Metrics



It can be seen that all of these performance metrics support at least one of our high-level improvement program performance metrics. In conclusion, based on its current situation, an enterprise should select from the seven high-level performance metrics.

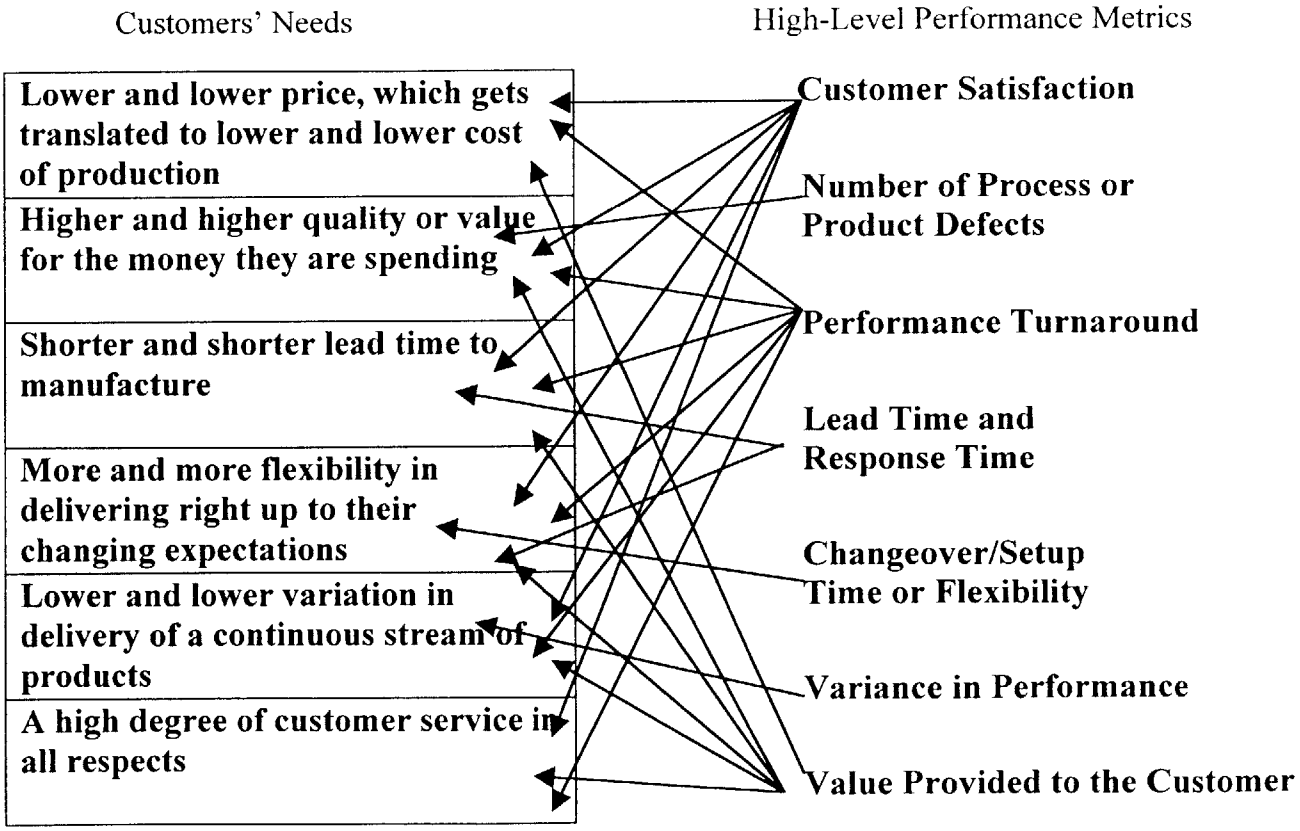
Factors Affecting the Selection of a Performance Metric

Now the question is how to select one of these seven primary performance metrics. After all, they are all appropriate and suitable from the point of view of the three factors listed on page 44. The overall goal each of these seven performance metrics leads to is long-term profitability of the enterprise. Since profitability is often a result of increased satisfaction of customers' needs, let us start from there in deciding upon what needs to be improved in a particular enterprise's operations. A customer wants the following:

- **Lower and lower price, which gets translated to lower and lower cost of production**
- **Higher and higher quality or value for the money they are spending**
- **Shorter and shorter lead time to manufacture**
- **More and more flexibility in delivering right up to their changing expectations**
- **Lower and lower variation in delivery of a continuous stream of products**
- **A high degree of customer service in all respects**

It could be argued that there are other things a customer is looking for. For example, innovation in the product, special features in the product, or convenience of delivery, or affordability. However, all these other possibilities could be translated into one of the six items listed above. Innovation and special features in the product are very much a part of the value provided to the customers. Convenience of delivery ties in with lead time and variation; affordability with cost. The following chart shows how each of these six customer needs could be satisfied by improving our seven, primary, high-level performance metrics.

Table 4.3: The Seven High-Level Performance Metrics Lead to Satisfaction of All of the Customers' Needs



It is noticeable that 'Customer Satisfaction,' 'Value Provided to the Customer' and 'Performance Turnaround' lead to satisfaction of all of the customers' basic needs. Further, the attainment of the rest of the high-level performance metrics support the attainment of these three high-level performance metrics. These are actually not high-level performance metrics, but rather overarching performance metrics that should be a part of guiding vision in every change program. As will be discussed in the next chapter, 'Performance Turnaround,' the primary performance metric of Reengineering, is so fundamental a metric that it is rather one of the two approaches for bringing about a change; the other one of the two is the incremental approach.

The remaining four of the high-level performance metrics to be chosen for a change program are: Number of Process or Product Defects, Lead Time/Response Time, Changeover/Setup Time or Flexibility, and Variance in Performance. The third one of these, Changeover/Setup Time or Flexibility, could be split into two parts:
(a)- a flexibility of the physical system of production, which is a part of our second performance metric (Lead Time/Response Time), and
(b)- strategic flexibility in coping with unexpected changes in the enterprise' internal or external environment, which again is a kind of overarching performance metric, and hence should be a part of the guiding vision of every change program.

Our final choice thus should be out of the following three: Number of Process or Product Defects, Lead Time /Response Time, and Variance in Performance. Each of these three helps meeting some of the customers' needs. The improvement programs corresponding to these three performance metrics are Six Sigma, QRM, and Variance Reduction respectively. As pointed out in Chapter 2, improvement in the primary performance metrics of each of these three programs leads to improvement in the satisfaction overall customer needs as well. For example, QRM, by reducing lead time, also improves quality of products and processes and reduces costs of production along the way. The issue then boils down to the question of which performance metric to be more focused on. After all, all of these three are measurable and quantifiable performance metrics, they are all good indicators of long-term profitability, and they are all context-specific in improving the whole enterprise or any section thereof.

In today's highly competitive, global economy, it is not possible to say that an enterprise can afford to focus more on any one of our three high-level performance metrics (Number of Process or Product Defects, Lead Time/Response Time, and Variance in Performance). Thus we say that, in general, an enterprise must always use a combination of the following three improvement programs: Six Sigma, QRM, and Variance Reduction. At the same

time, keeping in view our 'overarching performance metrics,' Lean and Agility should form parts of the guiding vision of the enterprise for continuous improvement, and the methodology for bringing about improvements could vary between TQM-type incremental and Reengineering-type radical techniques. We call this entire approach to program selection a toolbox approach. This is further elaborated upon below.

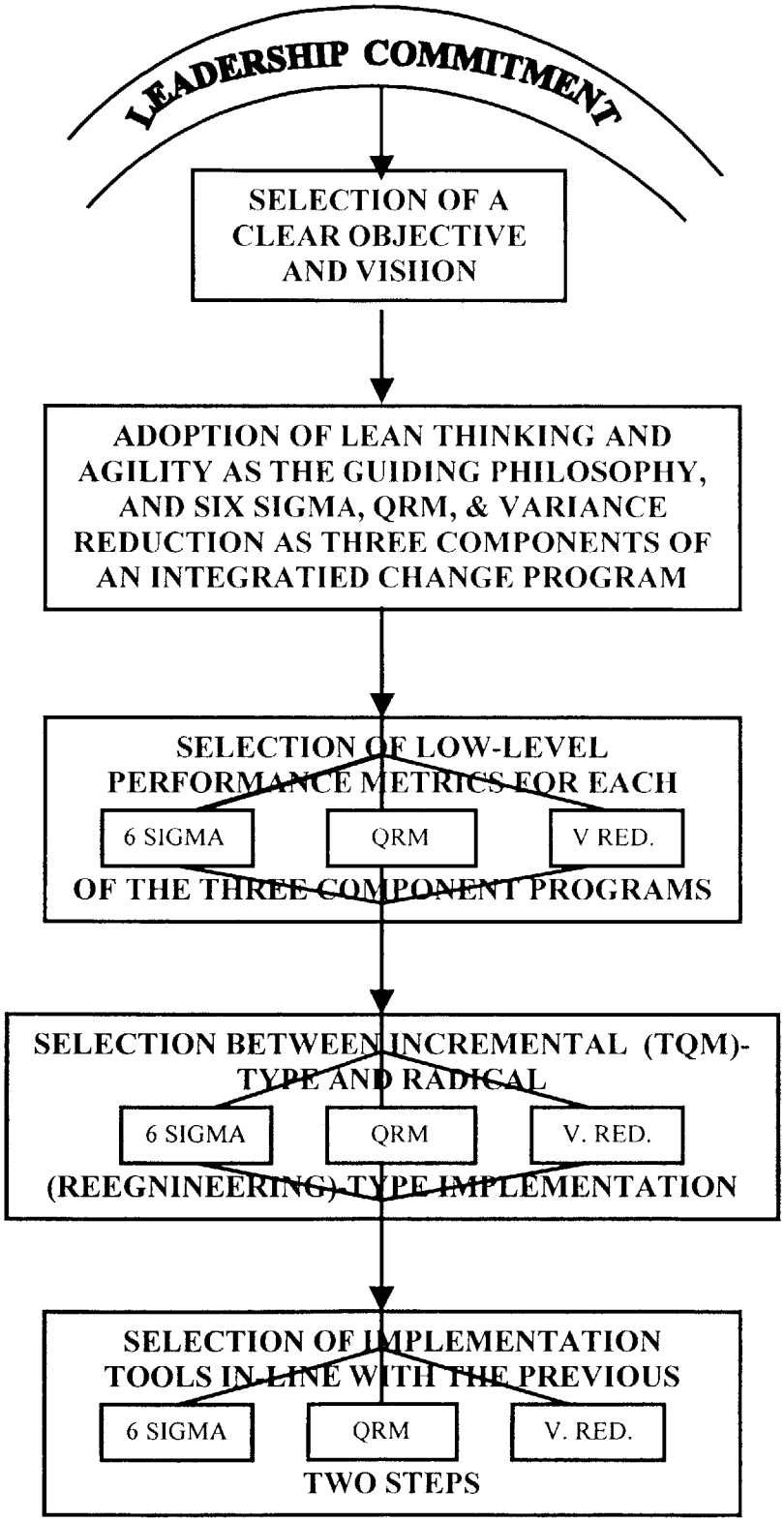
The Toolbox Approach

The toolbox approach to program selection we have developed is based on the key points we concluded from our survey analysis (Chapter 3), as well as from the role of performance metrics in the program selection process, as discussed above. The toolbox approach, as we have developed it, says that the basic foundation for the success of any change program aimed at enterprise performance improvement should be high commitment of its leadership. Once the leadership has committed to bringing about a performance improvement in the enterprise, the next step is selection of a clear objective or vision for starting a change program.

The third step involved in our toolbox approach to program selection is adoption of lean and agility as guiding philosophies for bringing about performance improvement. The fourth step involves selecting a combination of Six Sigma, QRM, and Variance Reduction's low-level performance metrics for implementing the change program. The selection of these performance metrics, and the degree of importance we assign to each one of them, should be based upon the enterprise' external and internal situation. The fifth step then is to select either an incremental-type or a radical-turnaround-type approach (these concepts are discussed in the next chapter) for improving each of the low-level performance metrics chosen in step four. Finally, the sixth step is to select implementation tools for improving each of the same chosen low-level performance metrics, in conformance with the chosen speed of change (slow/ incremental or fast/radical change).

This six-step process can be depicted graphically as represented in Figure 4.1 below.

Fig. 4.1: The Toolbox Approach

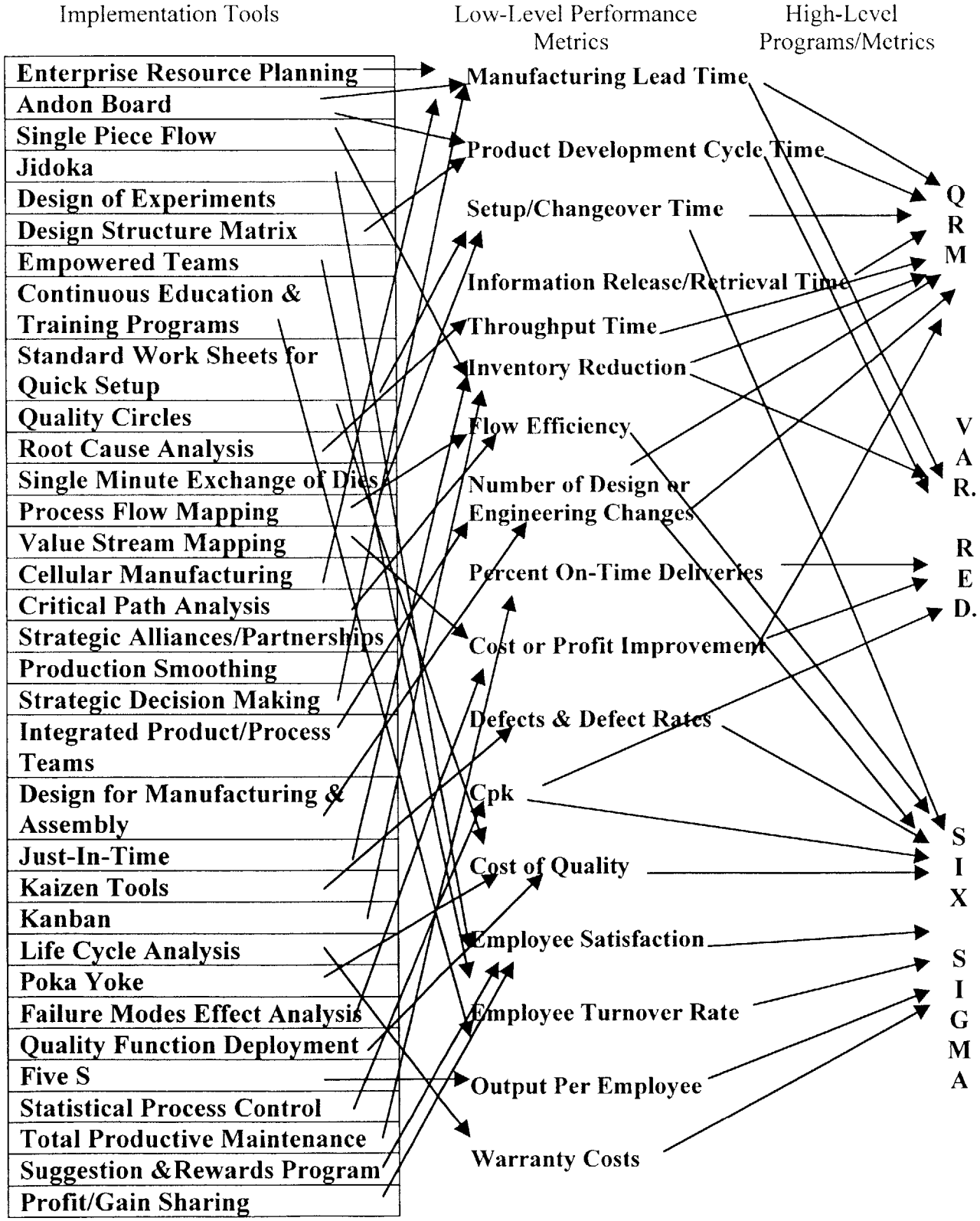


Selection of Implementation Tools

There are three decision-making points in our above-defined six-step toolbox approach process. These are:
(a)- Deciding upon low-level performance metrics for Six Sigma, QRM, and Variance Reduction. This decision will be based upon both the internal and external situation of the enterprise and is very company and situation specific. We will therefore not deal with this decision making process here.
(b)- The decision of choosing an incremental (TQM-type) implementation or radical (Reengineering-type) implementation. This kind of decision making will be dealt with in the next chapter.
(c)- The decision of choosing appropriate implementation tools in line with the above two decisions.

Whereas performance metrics serve the purpose of monitoring the progress of an improvement program, implementation tools are the actual wrenches and hammers that facilitate the bringing about of change. We conclude this chapter by presenting a list of tools generally known to improve some of the low-level performance metrics pertaining to Six Sigma, QRM, and Variance Reduction. Most of these tools are for bringing about an incremental type of slow change. A fast and radical, reengineering-type change could only be brought about by a redesign of a whole process. These concepts will be elaborated upon in the next chapter.

Table 4.4: Improvement Tools Help Improving Low-Level Performance Metrics, and Low-Level Performance Metrics Improve the High-Level Program Metrics



CHAPTER 5

DEGREE OF CHANGE REQUIRED AFFECTS THE SELECTION PROCESS

As alluded to in the last chapter, the clock speed concept presented by Prof. Charlie Fine[19] seems to be applicable to these improvement programs as well. Some of these programs are quick and radical in bringing about results while others are slow and incremental in nature. What we bring out in the next few pages is that TQM is a slow clock speed improvement program, Reengineering is a very fast clock speed improvement, and Six Sigma, QRM, Variance Reduction could be slow as well as fast. In other words, Six Sigma, QRM, and Variance Reduction could be TQM initiatives or reengineering programs, depending upon the urgency and the tools and methodologies used for bringing about the change. Further, as analyzed in both Chapter 2 and Chapter 4, all these TQM-type and reengineering-type change programs are forms of the same lean initiative, and agility should always form a part of the guiding vision, along with lean. Putting it differently, TQM, Reengineering, Six Sigma, QRM, and Variance Reduction are means for achieving the lean and agility objectives. Both leanness and agility are required for an enterprise to remain in a winning position with respect to its competitors. This philosophy could be graphically represented as follows.

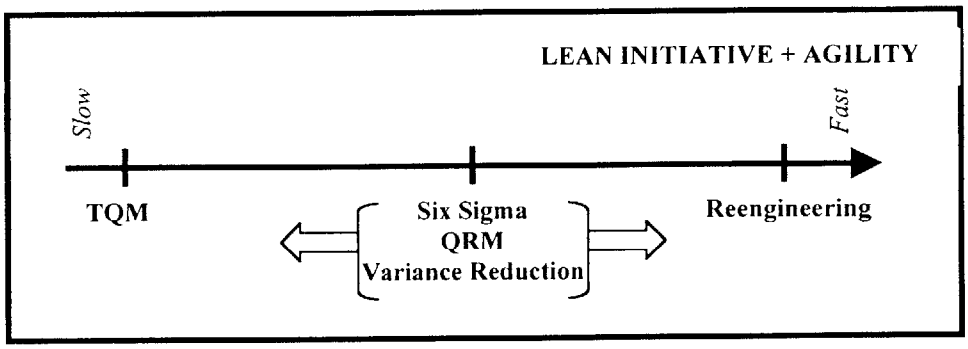


Fig. 5.1: Interrelationships Among the Seven Improvement Programs

Below we present a few examples of how a Six Sigma, QRM, or a Variance Reduction program could be a fast or slow clock speed program, and how all of these still fall under the basic concepts of lean and agility. Immediately after that we will present sample situations demanding the use of fast/dramatic and slow/incremental changes.

Fast and Slow Six Sigma, QRM, and Variance Reduction Programs

Six Sigma:

In Six Sigma, continuous reduction of defects from products and processes is the methodology for improvement. Using this approach, not only the goal of customer satisfaction is being achieved, but also the costs of production go down by continuous elimination of things which are of no value or of negative value to the customer.

Consider a small umbrella manufacturing shop in downtown Mexico City. One of the feed backs this three-year old shop has been receiving from its customers and distributors is that the umbrellas manufactured by the shop curve inward when high-speed wind blows during the rainy season in Mexico. One of the actions the shop owner took two months ago was to improve the design by adding one more clipping hook for each of the wire arches. These seven additional hooks only cost him fifteen cents extra in manufacturing each umbrella. But he rightfully expected to get much more profits as a result of improved customer satisfaction. The situation is pictured below.

Fig. 5.2: First Incremental Improvement in the Umbrella Design

The shop owner could have considered a more effective solution of improving the modulus of bending of the arches by using an improved wire material. However, that would have cost him much more and he was not sure if he would be able to get enough return out of that much investment.

The decision of adding an extra hook to each wire arch did bring in improvements. The number of customer complaints did go down rapidly. However, they did not go down to zero. Heavy rains and high-speed winds during the first week of this month proved that there is still a room for improvement. The number of complaints he got this time were one-third of what he received last time, but they are still significant. Encouraged by his last design

improvement, the shop owner is now negotiating with his supplier for increasing the diameter of wire they are supplying, from 2mm to 2.5mm. After this improvement he plans to carry out a market survey himself to see if the level of customer satisfaction (and hence his market share) has further improved or not. Sometime in future he may also introduce a better material for the wire arches.

All the actions being taken by this shop owner are an example of slow, incremental Six-Sigma improvement. A fast, radical, and reengineering-type alternative for achieving the same results could have been to come up with an entirely innovative design of the umbrella with no wire arches. Both alternatives fall under the lean and agility initiatives since they both pertain to improving value for the customer and flexibility of changing in response to customer feedback. From economic and return on investment point of view, both alternatives could have been the same, but choosing one over the other requires consideration of many internal and external environmental factors. We will discuss those factors later in the chapter.

QRM:

As pointed out in Chapter 2, time is the primary metric for performance improvement in QRM. According to this program, if we keep on removing chunks of non-value-added time from production, product design/development, and from other enterprise processes, besides reducing setup/ changeover times involved in all these, we will achieve the following four advantages. Customer delight by way of fast deliveries, customer delight by way of quick changeovers, customer delight by way of improved quality, and low costs of production by way of reduced inventories and elimination of no-value-added operations.

Suppose there is a fabrication job shop making various different kinds of automobile brake shoes. If the shop is working on a full-of-waste, old mass production system, a fast and dramatic turnaround in the shop would involve the following: changing the layout of the shop from old functional style to a cellular style, introducing work teams in place of individual persons led by a foreman, and making quick changes to dramatically reduce setup times. The last item could entail changing the location of die storage area, introducing trolleys for moving dies, and deploying some easy-to-use gauge systems. All this is obviously a fast redesigning of the shop and is thus a radical, dramatic, reengineering.

A slow, incremental, TQM-type effort, on the other hand, could have involved the following: a detailed analysis (say by Design of Experiments technique, Ishikawa diagram, etc.) of how setup times for different machines could be reduced from 11 minutes to 9.5 minutes, incremental improvements in reducing

material handling between stages of the shop, or systematic reduction in kanban inventories.

Both of these change programs conform to the QRM philosophy. The former is a reengineering-type effort; the later, a slow, TQM-type. Also, both fall under the Lean and the Agility umbrellas. This is because in both scenarios reduction of non-value-added operations is taking place with a focus on customer satisfaction (Lean initiative), and both scenarios result in improving flexibility of the system (Agility initiative).

A similar example from office operations could be reduction in accounts payable process time. A quick turnaround could be affected by slashing off the role of specialists and introducing one-window type generalist operators. An incremental turnaround, on the other hand, could involve such initiatives as introducing ink-less rubber stamps so that the time spent in pressing the stamp against an inkpad is saved.

Variance Reduction:

Consider a small company (let us call it company I.M.) supplying various injection-molded parts to a large automobile-manufacturing firm. Company I.M. has this year been put on the black-warrant list of that automobile company because of its poor delivery performance. Hearing this news, the I.M. board of directors has replaced their company's entire management team. The new management team has now started taking concrete steps for regaining its reputation.

The present system of production planning at I.M. is based on forecasting. Because of inaccurate forecasting (inaccuracy is due to many reasons), it sometimes produces more than the monthly requirement of the auto company, resulting in on-time deliveries but high level of inventories at I.M., and at other times less than their monthly requirements, resulting in rush production and late deliveries. An incremental way of improving this situation would be to improve the forecasting methods, say by buying a new software, etc., followed by improved coordination with the auto firm, and finally going for a MRP II system. A radical and fast-clock-speed way of improving delivery performance would, however, be to completely scrap the forecasting method and start producing just-in-time. This would entail redesigning the production system as well as installing some shop-to-shop communication system between the two companies (like EDI, fax, email, etc.).

Again, both alternatives could involve the same economic tradeoffs, and they both fall under the lean and agility frameworks. Selection of one over the other is a matter of situation and need.

When Fast and Slow Programs are Needed

An enterprise starts a change program in response to either its external or internal environment. A fast change is needed when the risk of losing an opportunity or going under in face of a threat are excessive without a change being brought about immediately. A slow improvement or change, on the other hand, is desirable when there are certain risks involved in going too fast in bringing about a performance turnaround, or simply if aspirations for bringing about a quick and radical improvement do not exist. Looking from a different angle, if there is a great opportunity for improvement, a fast reengineering or redesign is desirable, but if a system or process is already good, an incremental kaizen or TQM-type effort might be appropriate and enough. Let us see in detail what kind of internal or external factors may demand a fast/radical or slow/ incremental improvement in an enterprise performance.

External Factors:

In an unstable market where competition is intense and risks of not catching up are excessive, requirements for a quick turnaround are generally high. These requirements could be due to reactive reasons, say for example to respond to a competitor's strategy; or proactive, say in an effort to race ahead of all competitors in this high risk market. Such a market condition usually exists in new-technology driven companies or when the product manufactured by the companies is new and immature. It can, however, also exist due to regulatory events, or significant changes in economic and political situations. The overall scenario in every case is that the market will be lost to the competitors or the customers will simply turn away if a quick change is not brought about in the enterprise performance.

An example[20] of such a scenario is that of the early '90s when deregulation in the financial services and airline industries led to waves of mergers and failures. In such a situation, many firms had to scramble to quickly reorient themselves to the new competitive environment. Major political changes in Eastern Europe and South Africa have had a similar impact. Similarly, when a company introduces a new product in a market, there are almost no competitors initially. But soon after the product gains acceptance, a host of competitors start jumping in[21]. In these circumstances some of the companies might need a quick turnaround to beat off the rest of the competitors. As the market matures, these few remaining winners have almost a monopoly, since jumping in a mature

market is very difficult. At this point only an altogether new idea or product can snatch away customers from these winners. A typical product life cycle showing this phenomenon is as follows.

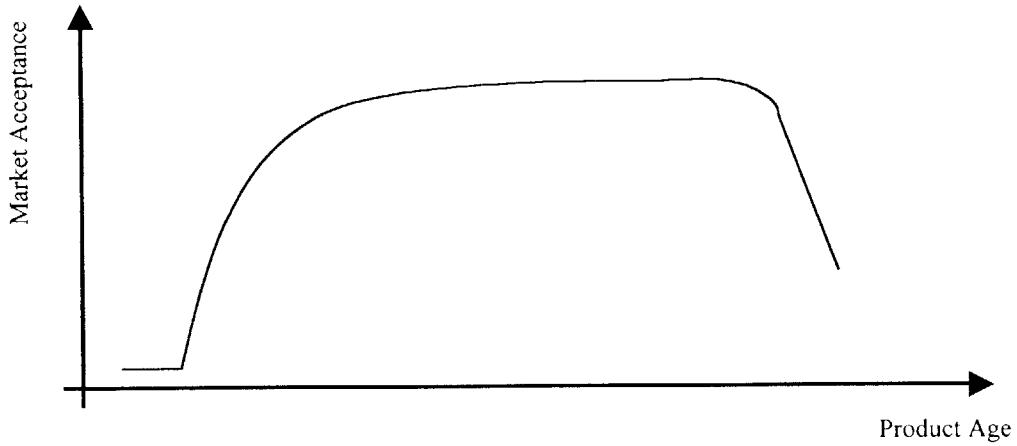


Fig. 5.3: A Typical Product Life Cycle Curve

There is one more situation likely to demand a fast turnaround. The farther an enterprise is from a high-performance ideal, the less likely a slow and incremental improvement effort is going to be effective. In other words, the wider the gap between a desired and the present state of an enterprise, the more favorable is the adoption of a radical and fast turnaround change program. It is very unlikely that a large gap between a desired and the present state will demand a slow incremental change program. The only exception could be the case when aspirations for quickly closing a large gap are low due to strategic reasons.

A slow, incremental improvement change program would be more suitable when market competition is mild, product and technology are in mature state, there are no disrupting external regulatory or economic factors in the horizon, and when the gap between desired and present performance states is not so large.

Internal Factors:

An enterprise where the internal structure and organization is too unstable to be disturbed on a large scale or where the culture is very rigid and ingrained in its past history, perhaps a slow rather than a fast change is the best choice. A more accurate analysis of the impact of internal factors is, however, given below[22].

As enterprises grow older and larger, their internal environment sees phases of evolution and revolution. An evolutionary phase is marked by steady growth

without any disruptions, while a revolutionary phase is characterized by turbulence and a need for replacing prevalent management practices with new ones. A revolutionary period is a period of such turmoil that its resolution determines whether or not an enterprise will move forward into its next stage of evolutionary growth. A slow incremental change program is suitable for an evolutionary phase of an enterprise, and a fast, dramatic change program is more appropriate for a revolutionary phase.

The evolutionary-revolutionary phases are quite general for every kind of a growing enterprise. The theory is actually found quite logical if analyzed carefully. An organization's life cycle could be described as composed of five stages of growth. Each stage in turn is composed of an evolutionary phase characterized by a dominant management style used to achieve growth, and a revolutionary phase characterized by some dominant management problems which must be solved before growth can continue. These five stages, as shown in the graphic below, are called Creativity, Direction, Delegation, Coordination, and Collaboration.

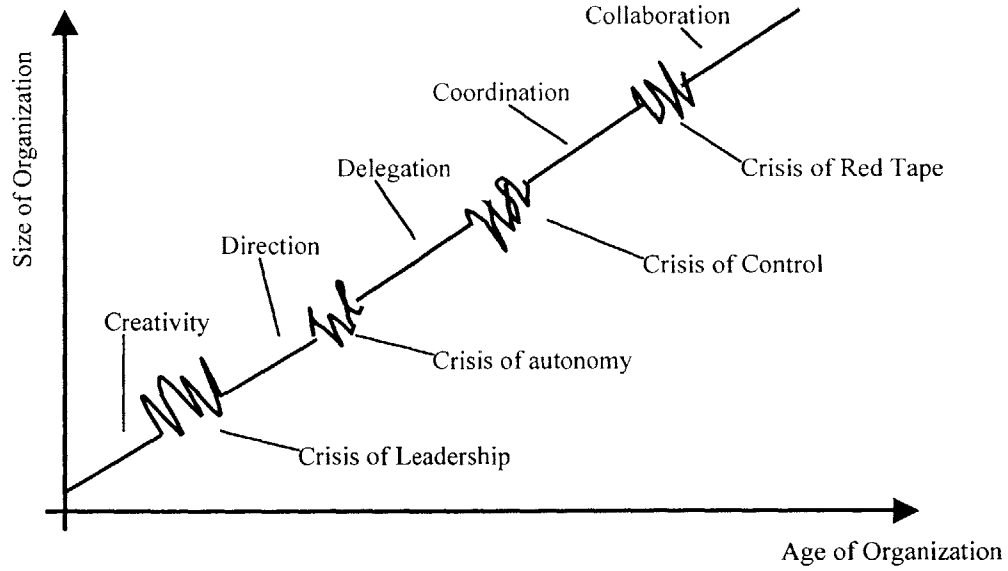


Fig. 5.4: The Evolutionary and Revolutionary Phases of an Organization

The Creativity stage is the birth stage of an organization. In its evolution phase, the top leadership of the enterprise is focused on creativity with respect to making and selling a new product. The company is small in size, and communication among employees is frequent and informal. As the enterprise grows, there grows a need to shift the management focus to production efficiency and managing increasing number of employees through informal communication channels. Thus occurs a *crisis-of-leadership* situation, the first revolutionary or turbulent phase of the enterprise life cycle. This phase is required to be resolved

quickly by installing a strong business management acceptable to the founders and that can pull the organization together.

Once this first turbulent phase is resolved, another stable or evolutionary phase (Direction) takes hold. The management in this phase is mostly focused on directing different functional processes of the enterprise and in organizing them through informal and impersonal communication channels. Lack of decision-making powers in the lower levels of management and employees soon starts a feeling of discomfort in the organization, as it grows further. The lower-level employees find themselves torn between following procedures and taking initiatives on their own, and a *crisis of autonomy* results: the second revolutionary phase. A natural way of coming out of this turbulence is to enter the next evolutionary phase, i.e. Delegation.

An enterprise successfully entering a "Delegation" phase, follows the policy of decentralization. During this phase the enterprise grows further by acquisition and otherwise, and lower level managers and employees are generally motivated to make it grow even further. A serious problem, however, eventually emerges when the top-level executives start feeling that they are losing control over a highly diversified field operation. Autonomous managers, on the other hand, start playing their own shows without coordinating with the rest of the organization. This results in a *crisis of control*: the next revolutionary or unstable phase. Enterprises recouping from this crisis logically enter the next stable phase of Coordination, in which top-level executives start initiating and administering new systems for improved coordination. Further growth occurs as a result of improved coordination until the resulting bureaucratic system, ridden with excessive coordinating channels, becomes a burden. This leads into yet another crisis or turbulent phase, leading successful enterprises into the final phase of collaboration. This era marked by teams, simplified systems and procedures, and innovation continues to make the enterprise even stronger and bigger. Enterprises who manage to come through all these stages have probably grown too far to either split apart into smaller newer enterprises or they enter entirely new markets to reap even more profits.

Each evolutionary phase described above may last from eight to fifteen years on average. During this phase, policies regarding enterprise performance are already set and management generally does not like to disrupt them by starting radical change programs. Hence these evolutionary phases are more likely to support slow incremental type of change programs. Revolutionary phases, on the other hand, because of the tension and discomfort with the status quo, are ripe for introducing radical and dramatic changes. Hence these phases probably are more appropriate for implementing a fast and radical performance improvement program.

A Possible Decision Tree

Based on an analysis of the above-described external and internal factors, the following decision tree could be modeled for making a choice between fast and slow improvement programs.

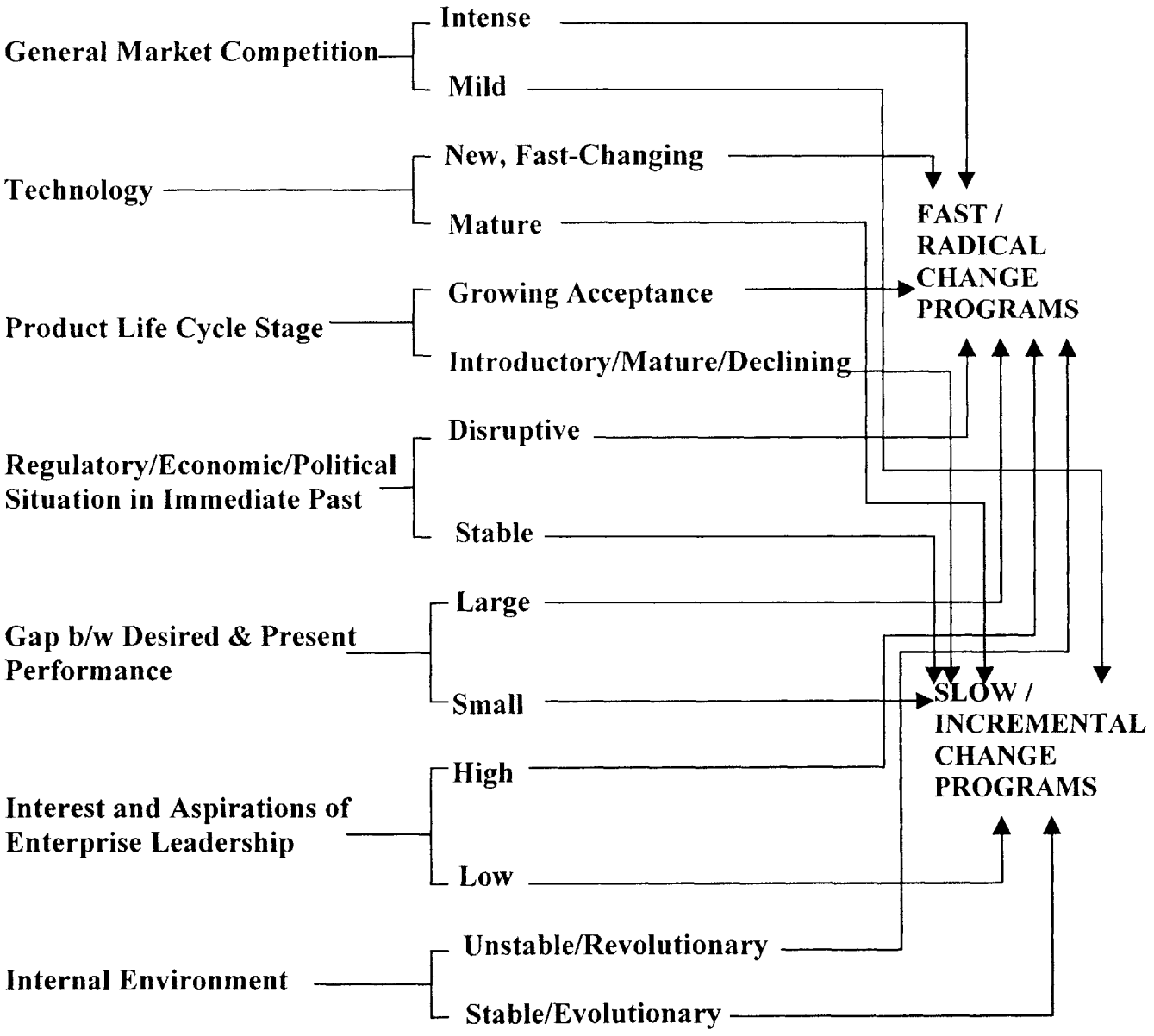


Fig. 5.5: A Decision Tree for Making a Choice Between Fast and Slow Improvements

In this tree, all top choices lead to a fast/radical change program selection, and all bottom choices lead to a slow/incremental program selection. Assigning a value of 1 (unity) to all top choices and a value of 0 (zero) to all bottom choices, the following scoring chart could then be filled out and a 'sum-value' decision score calculated by assuming equal weights for all of these seven factors. In that case, if the final score comes out to be less than 3.5 (i.e. 0, 1, 2, or 3), an incremental change program should probably be favored. If the final score comes out to be greater than 3.5 (i.e. 4, 5, 6, or 7), a radical breakthrough change program should be favored.

Table 5.1: A Sample Scoring Chart for Choosing B/w Fast & Slow Improvement

FACTORS AFFECTING THE DECISION	CHOICE VALUE
General Market Competition	
Technology	
Product Life Cycle Stage	
Regulatory/Economic/Political Situation in Immediate Past	
Gap Between Desired & Present Performance	
Interest and Aspirations of Enterprise Leadership	
Internal Environment	

Final Score = _____

As an example, suppose a company is currently in the following state:

- the general market competition is Intense (value = 1),
- product and process technology being used is mature (value = 0),
- product life cycle stage is that of growing acceptance (value = 1),
- regulatory/economic conditions in the immediate past have been disruptive (value = 1),
- the gap between present and desired performance is large (value = 1),
- interest and aspirations of the company's top management in bringing about a change are high (value = 1), and
- internal environment of the company is unstable (value = 1).

In this case, the sum total of all the decision values is 6, and therefore a fast/radical change program needs to be selected.

The mathematical decision making process suggested above is, however, very objective and would not work if the assumption of an equal degree of importance for all the seven factors cannot be made. Nevertheless, in that case the scoring technique outlined above could be modified by adding a "weights" column in

Table 5.1. The weights multiplied by the choice values (0 or 1) would give weighted scores that in turn could be summed up to give a final score. Similarly, if it is not clearly known which of the two categories some or all the factors fall in for a given situation, an intermediate category with a corresponding value of 0.5 could be defined. Despite them being so objective, these techniques could still prove to be a good supplement to a subjective decision making process.

It must be noted that individual divisions or functional processes within an enterprise may also make use of the same decision tree just like an entire enterprise. Whereas the first four factors in our tree would remain uniform across an enterprise, the last three may vary from division to division or from process to process.

CHAPTER 6

ROLE OF LEADERSHIP AND EFFECTIVE CHANGE MANAGEMENT IN THE SUCCESS OF AN IMPROVEMENT PROGRAM

All the decision steps relevant to our toolbox approach to program selection and integration (Fig. 4.1, Chapter 4) have been discussed in detail now, except for the roles played by leadership commitment and clarity of objectives and vision. In this chapter we are presenting some guidelines on what it takes to have a high-commitment from leadership, and on how to manage the entire change process in terms of creation of a clear vision and motivation of the people.

Bringing about a turnaround in the performance of an organization is almost entirely a game of human behavior and leadership. Selection of an appropriate improvement program/s and having clear concepts about their similarities and differences is only one step in the change process. Taking an organization to the height of performance excellence is mostly dependent upon how well the change program is being managed and whether the change champions have the desired leadership skills. Below is a brief discussion on how these two factors affect the success of a change program[23].

Role of Leadership

It is said that successful transformation effort is about 70 to 90 percent leadership. In essence, the role of leadership in bringing about a change in an organization is:

- defining what the future should look like,
- aligning people with that vision, and
- inspiring them to make it happen.

Such a role not only requires sacrifice, dedication, and creativity, but also an ability to adapt oneself and others to changing circumstances: a skill that has been traditionally rare in corporate managers.

Because of the principles large corporations were built upon over the last one hundred years, and also because of the unique economic environment prevalent at that time, the skills then valued in a manager were those required to keep a corporation just running. Thus planning, budgeting, organizing, staffing, controlling, and problem solving became both functions as well as job requirements throughout the management structure across all corporations. The "management-focused" corporate culture thus created was sluggish, inward-focused, and functionally segregated, and it kept all of the corporate employees from adapting to any change in their systems and environment.

In present times, however, change is the order of the day. Studies have shown that for at least several decades into the future, globalization of the economy will

continue forcing corporations to make dramatic improvements, not only to compete and prosper, but also to merely survive. To sustain such a continual transformation of corporations, a high quality leadership is needed. Only abilities of sacrifice, dedication, creativity, and a power to motivate armies of employees to overwhelm all sources of inertia and to march towards an indigenously created vision, can bring about such corporate transformations. Role of leadership commitment in the success of a change program has been confirmed from our industrial survey (see Chapter 3). Similar surveys using even larger samples and sophisticated statistical techniques also prove that there is always a positive correlation between top leadership commitment and the success of a change program[24].

Contrary to popular thinking, the leadership abilities and skills described above are not a divine gift of birth granted to a small number of people. Leadership is something that can and should be learned, developed, and nurtured. Life-long learning based on listening with an open mind, trying new things, reflecting honestly on one's successes and failures, and a drive to compete helps people actualize whatever leadership potential they possess.

A successful change program in an organization could begin with just one or two people. But in anything but the smallest of organizations, that number needs to grow and grow over time. The solution to the change problem is not one larger-than-life individual who charms thousands into being obedient followers. Modern organizations are far too complex to be transformed by a single giant. Many people need to help with the leadership task, not by attempting to imitate the likes of Winston Churchill or Martin Luther King, Jr., but by modestly assisting with the leadership agenda in their spheres of activity.

Effective Change Management

High quality leadership, though essential, is not enough for guaranteeing the success of a change program. The forces of inertia in a corporation or enterprise are too strong and adamant to be removed by good leadership qualities alone. Years of observation, experience, and research on change management has revealed that the three basic roles of leadership for bringing about a corporate change need to be followed in a sequence of eight well-defined steps in order to guarantee a defeat to the corporate inertia and resistance. These eight steps are listed below. In Nadler and Tushman's terminology[25], they form the unfreeze-change-freeze cycle, with the first four steps corresponding to the "unfreeze" action, the next three steps to the "change" action, and the last one to the "freeze" action. Together with the improvement-program selection and integration plan presented in the previous chapters, these eight steps form the basis for effectively managing the change process in an enterprise.

(i)- *Establishing a Sense of Urgency*: This involves making the employees feel deep in their heart how necessary bringing about a change is, and clearly identifying the crises that will ensue if the change is not brought about immediately.

(ii)- *Creating a Guiding Coalition*: This step involves putting together a group with enough power to lead the change. This must consist of the Chief Executive and at least a majority of all the powerful executives in the corporation.

(iii)- *Developing a Vision and a Strategy*: A target to be reached has to be established for the masses. This provides the general employees with a high-level aim to compare their present state with. This comparison then creates the desired tension to pull them towards the vision[26]. A roadmap for attaining the vision must also be defined, but not detailed out, in the vision.

(iv)- *Communicating the Change Vision:* Using every vehicle possible to constantly communicate the new vision and strategies. Informal modes of communication have been found to be even more effective than formal modes in this regard. Also, the guiding coalition must model the behavior they are expecting of the employees in their vision.

(v)- *Empowering Broad-Based Action*: This involves getting rid of obstacles, changing systems or structures that undermine the change vision, and encouraging risk taking and nontraditional ideas, activities, and actions.

(vi)- *Generating Short-Term Wins*: This step consists of planning and creating short-term performance improvements or "wins" that would model the achievement of the entire vision. This step should take place soon after the completion of step five, so that confidence of employees in the change process could be built up. People making these short-term wins possible must also be rewarded and visibly recognized.

(vii)- *Consolidating Gains and Producing More Change*: In this step, the credibility achieved in the previous step is used to change all systems, structures, and policies, in line with the vision. Change is sunk deep down into the culture.

(viii)- *Anchoring New Approaches in the Culture*: This final step involves rooting new behaviors in the social norms and shared values so that they don't revert back to the old behaviors as soon as the pressures associated with the change effort are removed.

In addition to following this systematic methodology for bringing about a change, there are certain factors that facilitate the success of a performance

improvement change program. These include creating an environment of security and trust for the employees, imparting them training whenever that is required, encouragement of creativity at all levels, and using a broad-based measurement / feedback approach to performance improvement[27]. These in turn tie in with the leadership effectiveness issue discussed earlier in this chapter.

CHAPTER 7

CONCLUSION

This research, being the first comprehensive attempt at comparing all the popular improvement programs in the aerospace industry, has largely been rudimentary in character. A few of the observations and outcomes, however, are particularly interesting, and are therefore worth a reiteration. These are:

- **A comparison chart, which enumerates the similarities, differences, and interrelationships among the seven most popular improvement programs, has been developed. This is displayed as Tables 2.1 and 2.2 on pages 23 to 26 in this report.**

- **A survey of Lean Aerospace Initiative (LAI) consortium members yielded several interesting insights (detailed in Chapter 3):**
  - **--- The leadership commitment and clarity of goals/vision is more critical in the success of an improvement program than the specific program selected.**
  - **--- The fundamental importance of an integrated approach to program selection/adoption was shown to be a key factor in success.**
  - **--- Seemingly disparate improvement programs can work in concert with one another if tightly integrated to overall enterprise objectives.**
  - **--- Few, if any companies, link enterprise metrics and improvement tools to "theoretical" improvement program metrics and implementation tools.**

- **Current trends in the selection of performance metrics and implementation tools have also been examined. These are discussed in pages 35 and 38 of this report, and they can be very useful in further development of process-improvement decision models for the industry.**

- **A step-by-step decision process (shown in Fig. 4.1, Chapter 4) has been developed for improvement programs' selection and integration. This will hopefully be of some assistance to the industry in resolving the issue of selection of a new improvement initiative and in integration of multiple preexisting improvement programs.**

- **Another new and useful concept presented is that the Six Sigma, Quick Response Manufacturing, and Variance Reduction improvement programs could be implemented in a slow/incremental as well as fast/dramatic fashion. This concept has been graphically presented in Fig. 5.1. It also leads to the conclusion that implementation tools for the same program need to be different depending upon whether a slow or a fast change is required.**

- **Finally, the decision tree presented in Fig. 5.5 (along with its sample scoring chart, Table 5.1) will also hopefully prove to be useful to the industry in selecting a slow or a fast approach for its various change initiatives.**

In summary, this research has contributed to reducing the degree of confusion prevalent in the manufacturing industry regarding similarities, differences, and selection or integration of the various different performance improvement programs. It has also presented the industry with a unique decision model for incorporating a new change initiative for performance improvement.

Overall, this research has also opened a new door to further research and investigation in this important discipline of industrial and systems engineering. The manufacturing industry in general, and Lean Aerospace Initiative (LAI) member companies, in particular, are encouraged to examine, apply, and reinvestigate the ideas presented here.

It is also solicited that academicians interested in this area further develop the decision models presented in this report. Further, there is a need to keep the improvement programs' comparisons presented here, up to date. This is necessary because the programs themselves are continually evolving and even new improvement programs keep surfacing out of the research and implementation of improvement processes.

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APPENDIX I

AN INDUSTRIAL SURVEY FOR COMPARING VARIOUS IMPROVEMENT STRATEGIES

This survey has been designed to support a research project currently in progress at the Lean Aerospace Initiative, MIT. The objectives of this research are:
(a)- to compare several widely used system improvement strategies, and
(b)- to develop a structured decision process for the manufacturing companies for selecting and integrating these improvement strategies.
There are seven such improvement strategies currently in practice in manufacturing companies: Total Quality Management (TQM), Reengineering, Six Sigma, Quick Response Manufacturing (QRM), Agility, Variance Reduction, and Lean. Choosing among the multiple initiatives for performance improvement is not only confusing for these industrial enterprises and their employees, but also puzzling for suppliers, customers, and other stakeholders. This research will address the similarities, differences, and interrelationships among these improvement strategies.

Please answer the following questions in support of this development effort. Feel free to continue on additional sheets wherever you need more space for responses.

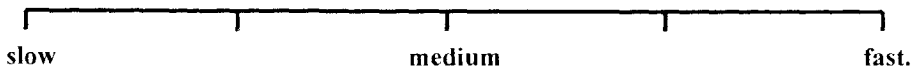
1)- Which of the following performance improvement programs is the predominant one currently being pursued by your company? Please check one of the boxes or write down any other generic name the company has given to the program.

Strategy	Please Check	Strategy	Please Check
Total Quality Management		Agile	
Six Sigma		Variance Reduction	
Reengineering		Lean	
Quick Response Manufacturing		Other Generic Name (Pls. Identify)	

2)- For how long has this program been in existence? Please indicate approximate dates. Do you consider it slow, i.e. evolutionary and incremental, or fast, i.e. revolutionary and dramatic? Please tick mark on the scale provided.

How Long ? _____

Rate of Change?



3)- What is the extent of application of this improvement program within the enterprise? That is, how broad-based across the enterprise is this strategy? Please check all that apply.

Limited to a Few Core Processes like Manufacturing, Design & Development, Supplier Relations, etc. _____

_____ *(Pls. Identify Processes)*

Spans over all Core Processes as well as Support Processes. _____

Encompasses all Core Processes, Support Processes, and Enterprise Leadership Strategic / Planning Processes. _____

4)- What circumstances triggered the introduction of this particular improvement program/ strategy? Please elaborate briefly.

_____

_____

_____

5)- Please identify any specific objectives for the adoption of this program.

_____

_____

_____

6)- Who initiated this program, and who has been championing and leading it? What were the real motivations driving them?

Program Champions	Level	Function	Motivation
Who Initiated?			
Who Provided Leadership?			

7)- What role did the top enterprise leadership play in supporting this program?

_____

_____

_____

8)- What are some of the performance metrics which are intended to be improved (either explicitly or implicitly) as a result of this program? Please check all that apply and mark them with P (primary metric), S (secondary metric) or T (tertiary metric). Also, feel free to add any others that you employ, but are not listed.

Performance Metric	Please Check & Mark	Performance Metric	Please Check & Mark
Manufacturing Lead Time		Customer Satisfaction	
Product Development Cycle Time		Employee Satisfaction	
Setup/Changeover Times		Employee Turnover Rate	
Flow Efficiency (Actual Work Time/ Total Flow Time)		Inventory Reduction	
Information Release / Retrieval Time		Cost of Quality	
Throughput Time		Output Per Employee	
Percent On-time Deliveries		Warranty Costs	
Cost or Profit Improvement		Shareholder Value	

Performance Metric	Please Check & Mark	Performance Metric	Please Check & Mark
Return on Assets			
Defects and Defect Rates			
Number of Design or Engineering Changes			

9)- Are the performance metrics identified by you above improving at the rate you anticipated? Please answer for each of the metrics identified by you above, on the scale provided.

Performance Metric	Resulting Improvement	Performance Metric	Resulting Improvement
	Nil low medium high		Nil low medium high
	Nil low medium high		Nil low medium high
	Nil low medium high		Nil low medium high
	Nil low medium high		Nil low medium high
	Nil low medium high		Nil low medium high

10)- What tools or techniques are being used for the implementation of this program/strategy? Please check all that apply and mark them with P (primary tool), S (secondary tool), or T (tertiary tool). Feel free to add any not listed.

Implementation Tool	Please Check & Mark	Implementation Tool	Please Check & Mark
Activity Based Costing (ABC)		Heijunka (Production	
Andon Board (Visual Control Device)		Hoshin Kanri (Strategic Decision Making)	
Capability of Process Equipment (Cpk)		Integrated Product /Process Teams (IPPT)	
Chaku-Chaku (Single-Piece Flow)		Design for Manufacturing and Assembly (DFMA)	
Jidoka (Autonomation)		Just-In-Time (JIT)	
Design of Experiments (DOE)		Kaizen	
Process Flow Mapping		Kanban (Pull Operations)	
Empowered Teams		Life Cycle Analysis (LCA)	
Continuous Education & Training Programs		Poka-Yoke (Mistake Proofing Device or Procedure	
Enterprise Resource Planning (ERP)		Failure Modes Effect Analysis (FMEA),	
Standard Work Sheets for Quick Setup (SWS)		Quality Function Deployment (QFD)	
Quality Circles		Five S's	
Strategic Alliances/ Partnerships		Statistical Process Control (SPC)	
Single Minute Exchange of Dies (SMED)		Total Productive Maintenance (TPM)	
Design Structure Matrix (DSM)		Suggestion and Reward Programs	
Value Stream Mapping		Profit/Gain Sharing	
Cellular Manufacturing			
Critical Path Analysis			
Root Cause Analysis			

11)- Describe, along with a brief rationale, whether you consider this improvement program as a success or a failure.

_____

_____

_____

_____

_____

12)- How many of the improvement programs listed in question 1 have been tried by your enterprise in the past? Please mention dates between which they remained in practice. What caused your enterprise leadership to drop/change them to the current one?

Please Check	Strategy	Dates	Reasons if Changed / Dropped
	Total Quality Management		
	Six Sigma		
	Reengineering		
	Quick Response Manufacturing		
	Agile		
	Variance Reduction		
	Lean		
	Other Generic Name (Pls. Identify)		

Other Comments: _____

_____

_____

13)- (a)- Which of these programs are still active to some extent in the enterprise?

_____

(b)- Has your enterprise been able to reconcile these different programs? If so, how?

_____

_____

_____

(c)- What problems / issues arise in running these different programs simultaneously?

_____

_____

14)- Additional Comments:

_____

_____

_____

_____

15)- Please provide a contact point in the event we need to clarify any of your responses.

Name: _____ Title: _____

Phone: _____ Email: _____

16)- Please indicate below if you would like to get a copy of our research outcomes.

Yes? Or No?

The information provided by you in this survey will remain strictly confidential. Only summary results will be released.

Please return the completed form by COB Monday, April 9th, 2001, to:

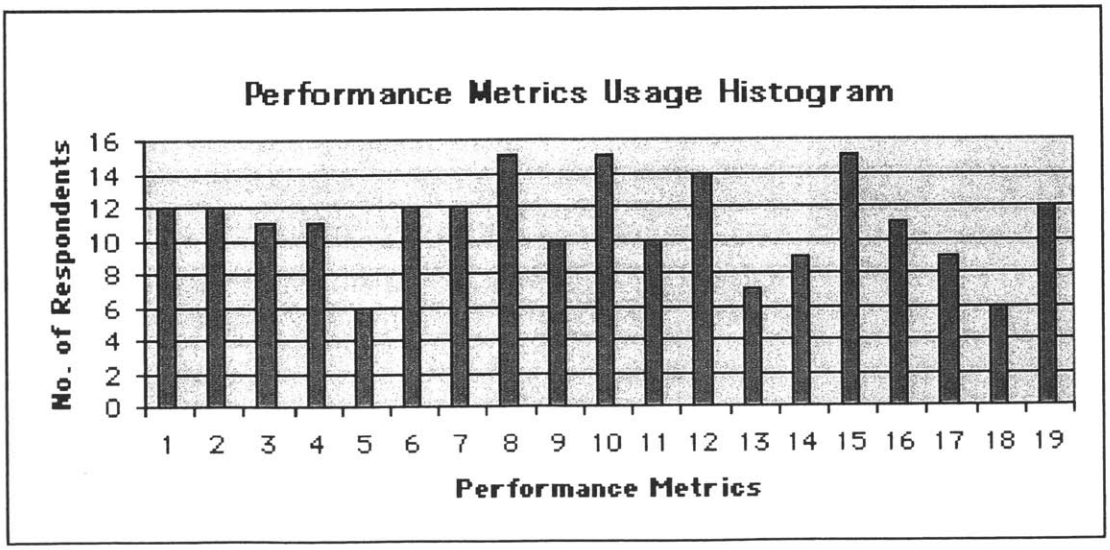
Uzair, Khusrow
Research Assistant, Lean Aerospace Initiative, MIT
Room 205, Building 41, 77 Vassar Street,
Cambridge, MA 02139
Phone: 617-225-9710
Email: kuzair@mit.edu

Feel free to contact me with questions or if you would like to discuss in more detail. Thank you in advance for your participation.

APPENDIX II

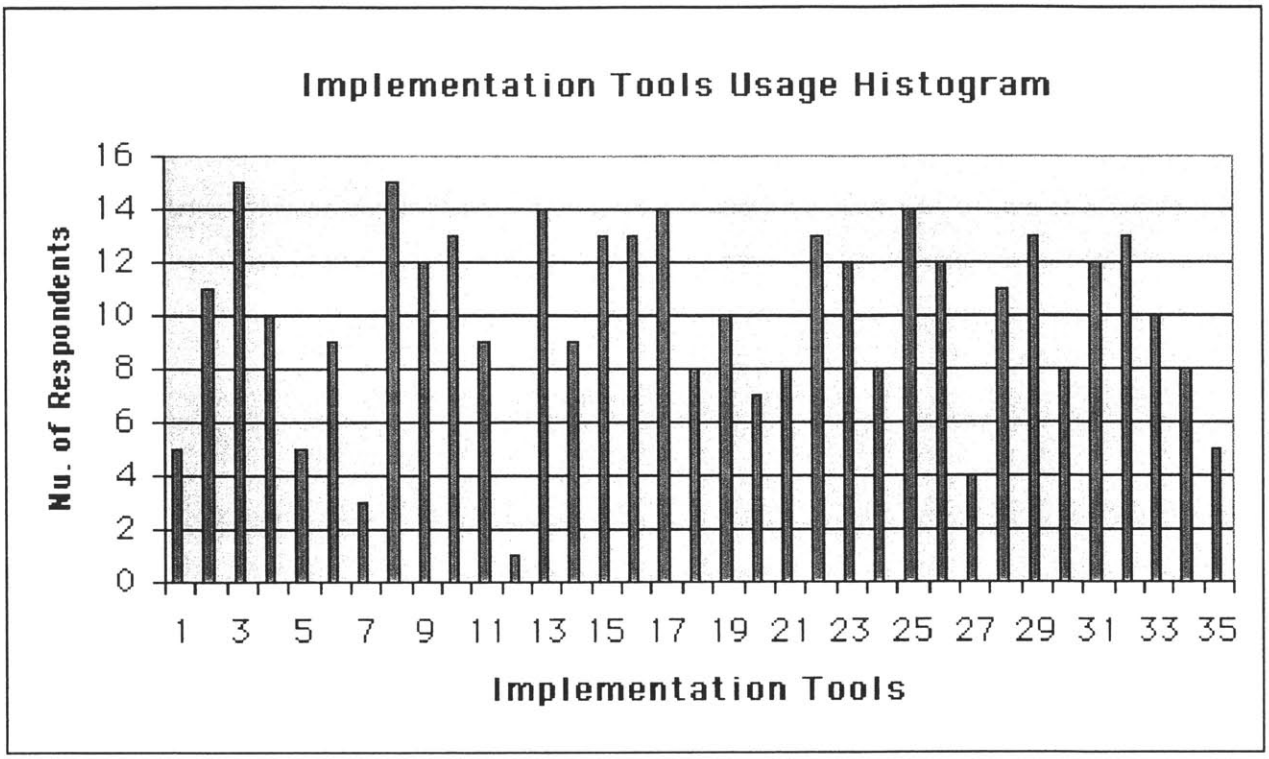
(A)- *Performance Metrics Usage Frequency*

S#	Performance Metric	No. of Respondents Citing It
1	Manufacturing Lead Time	12
2	Product Development Cycle Time	12
3	Setup/Changeover Time	11
4	Flow Efficiency	11
5	Information Release/Retrieval Time	6
6	Throughput Time	12
7	Percent On-Time Deliveries	12
8	Cost or Profit Improvement	15
9	Return on Assets	10
10	Number of Defects/Defect Rates	15
11	Number of Design or Engg. Changes	10
12	Customer Satisfaction	14
13	Employee Satisfaction	7
14	Employee Turnover	9
15	Inventory Reduction	15
16	Cost of Quality	11
17	Output per Employee	9
18	Warranty Costs	6
19	Shareholder Value	12



(B)- *Implementation Tools Usage Frequency*

S#	Implementation Tool	No. of Respondents Citing It
1	Activity Based Costing	5
2	Andon Board	11
3	Cpk, Process Capability Index	15
4	Single Piece Flow	10
5	Jidoka	5
6	Design of Experiments	9
7	Design Structure Matrices	3
8	Empowered Teams	15
9	Continuous Education/Training	12
10	Enterprise Resource Planning	13
11	SWS for Quick Setup	9
12	Quality Circles	1
13	Root Cause Analysis	14
14	Single Minute Exchange of Dies	9
15	Process Flow Mapping	13
16	Value Stream Mapping	13
17	Cellular Manufacturing	14
18	Critical Path Analysis	8
19	Strategic Alliances/Partnerships	10
20	Heijunka	7
21	Hoshin Kanri	8
22	Integrated Product & Process Teams	13
23	Design for Manufacturing Analysis	12
24	Just in Time	8
25	Kaizen	14
26	kanban	12
27	Life Cycle Analysis	4
28	Poka Yoke	11
29	Failure Mode Effects Analysis	13
30	Quality Function Deployment	8
31	Five S	12
32	Statistical Process Control	13
33	Total Productive Maintenance	10
34	Suggestions and Reward Programs	8
35	Profit / Gain Sharing	5


Implementation Tools Usage Histogram
Nu. of Respondents
16
14
12
10
8
6
4
2
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Implementation Tools