Profit From Six Sigma

A Guide to Principles and Practice for Business Benefit

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1 Introduction

Six Sigma is one of the most important and popular developments in the quality field. It has saved huge amounts of money and improved the customer experience for a large number of organizations across the world. However, it is applied in an inconsistent and often reductive fashion in many companies, leading to confusion, criticism, and a number of abandoned implementations. This book aims to give a coherent view of the underlying principles and practical applications as well as debunking some of the myths and disinformation which surrounded Six Sigma.

The book draws on examples and experience in application to provide a robust guide to the implementation of Six Sigma, from strategic issues to practical project approaches. More detail is available in the textbook version of this book, also available on Bookboon.com.

1.1 Definition of Six Sigma

Before we study the subject of Six Sigma in any depth, we need to define the term. Perhaps unusually, Six Sigma has 3 distinct elements to its definition:

- ***A Measure***: A statistical definition of how far a process deviates from perfection.
- ***A Target***: 3.4 defects per million opportunities.
- ***A Philosophy***: A long term business strategy focused on the reduction of cost through the reduction of variability in products and processes.

A more complete definition takes these ideas further: Six Sigma creates business benefit by addressing customer value through improved product or service performance allied to reduced costs within the business (it is, of course, a strategic leadership decision in what proportion the cost reductions are shared with customers).

Six Sigma does this through a focus on reducing variation and driving out waste supported by a highly structured process, strong and clear links to business strategy and a clear support structure.

Six Sigma is continuing to evolve, with the addition of Lean principles (Lean Six Sigma) and application to design and development (Design for Six Sigma).

1.2 Background and History

There are those who will tell you that Six Sigma is radical and new. The fact is that Six Sigma (done properly) is a recognisable evolution of Total Quality Management (TQM). Six Sigma can be seen as the accumulation of principles and practices developed in management statistics and quality engineering, all of which matured significantly over the course of the Twentieth Century.

The Six Sigma approach was first developed in the late 1980s within a mass manufacturing environment in Motorola (Harry, 1998) as they struggled to meet demanding quality targets on complex manufactured products; and became widely known when GE adopted it in the mid 90s when, arguably, it evolved from being a process improvement methodology to a broader, company wide philosophy. Both companies still consider Six Sigma as the basis for their ongoing strategic improvement approach. Since the 1980s Six Sigma has become one of the most popular improvement initiatives; widely implemented around the world in a wide range of sectors (by companies such as Boeing, DuPont, Toshiba, Seagate, Allied Signal, Kodak, Honeywell, Texas Instruments, Sony, Bombardier, Lockheed Martin) that all declared considerable financial savings (Harry, 1998; Antony and Banuelas, 2001; Kwak and Anbari, 2006). Other benefits claimed for Six Sigma include increased stock price, improved processes and products quality, shorter cycle times, improved design and increased customer satisfaction (Lee, 2002; McAdam et al, 2005).

Six Sigma has undergone a considerable evolution since the early manifestations. Initially it was a quality measurement approach based on statistical principles. Then it transformed to a disciplined processes improvement technique (based on reducing variation within the system with the help of a number of statistical tools). In its current incarnation it is commonly presented as 'a breakthrough strategy' and even holistic quality philosophy (Pande, 2002; Eckes, 2001). It is now generally accepted that Six Sigma is applicable to various environments such as service, transactions or software industry regardless the size of the business, and, if successfully adopted, Six Sigma may lead to nearly perfect products and services.

In the past five years, hundreds of organizations have indicated their interest in making Six Sigma their management philosophy of choice. While many of the businesses attempting to implement Six Sigma are well intentioned and want to implement Six Sigma properly just as General Electric did, there are also those impatient executives who now look on Six Sigma in way as they look on downsizing. This quick-fix approach to Six Sigma is a sure path to the same short-term results that prevent long-term profitability.

1.3 Summary

Six Sigma is an evolution of quality thinking and has, itself, evolved considerably over the years. This is a continuing process. The key elements of Six Sigma can be summed up as:

- A focus on the strategic direction of the organization.
- Customer value as the heart of the approach.
- A rigorously structured approach to understand customer requirements, and to reduce waste and variation.
- Management by facts
- The creation of a strong supporting structure.
- Clear linkages to business benefit.

2 Why Six Sigma?

2.1 Introduction

There can be few initiatives which have been trumpeted as loudly as Six Sigma; few where the claims have been so extravagant; and few which divide the quality community so completely. While this section does not propose to investigate fully the evidence supporting the self-declared results of major corporations it does attempt to clarify the level of expectation placed upon Six Sigma programmes.

2.2 To Improve Financial Performance and Profitability

Bob Galvin (then Motorola president) was reputed to be the man who began the Six Sigma revolution by issuing a 'Six Sigma Challenge' in 1987 for a ten-fold improvement in performance in every 2 year period (Goetsch and Davis, 2010). Over the 10 years following the call, Motorola claims to have saved $414 billion, increased sales by a factor of 5 and increased profits by 20% each year (Pande et al, 2000). GE declared that for 3 years (1996-1998) Six Sigma related savings were about $2bn; Honeywell stated that its annual Six Sigma savings as around $600-700 million; and Dow Chemicals claimed $2.2bn of Six Sigma financial benefits (Lee, 2002).

It is often stated that a 'typical' company operates around the 3 sigma level (Murphy, 1998) and there have been a number of attempts to quantify the financial effects of varying sigma levels. Klefsjo et al (2001) suggest that for Six Sigma performance levels the cost of poor quality would be less than 1percent of sales, while for 5 Sigma that would rise to 5-15 percent, at 4 Sigma the cost would be 15-25 percent and at 3 Sigma levels it would equate to around 25-40 percent of sales.

There are countless other (admittedly self-reported and largely unverified) claims for the financial benefits of Six Sigma; with the savings achieved due to decrease in operational costs, reduction in scrap and rework rates, etc. (Lee, 2002). The two important ideas which support the logic of this are 'Cost of Poor Quality' and 'Waste', both of these are explored briefly below and in more detail in "Quality management in the 21st Century" also available on Bookboon.com (Knowles, 2011a).

2.2.1 Cost of Poor Quality

Perhaps the most obvious tangible benefit of quality improvement is the reduction of costs associated with non-quality. If we have to throw a product away because we have made an error in its manufacture, it is clear that there is an immediate financial impact as all the costs sunk into the product are lost. Similarly, doing an incorrect operation over again absorbs cost (operator time, power, additional materials, etc.).

Although anyone who works in an organization will be familiar with many examples of both of these issues, business accounting systems are not set up to capture these costs. Traditional accounting approaches are designed to track the inflow and outflow of money in an organization (and, by extension, to product lines or departments). There is little emphasis on whether the money in the department is spent effectively. For example, budget reporting will recognise that overtime cost £100,000 this month, but will not differentiate between responding to short lead-time customer demand and time spent correcting errors. Even when it does highlight a cost of poor quality, perhaps in an over-budget condition in material spend, it will give no clear indication of where exactly the over-spend occurred.

The lack of clarity of the cost of poor quality in organizations led to a lack of focus on improvement for many years. Six Sigma directly assesses costs of poor quality by looking at the number of defects and their associated cost on a project by project basis; providing clear motivation for improvement and an indication of expected gains, as well as measuring the actual cost benefits for each completed project. Making this clear linkage is one of the strengths of Six Sigma.

2.2.2 Waste

Understanding costs due to producing defective products is certainly helpful in generating momentum for quality improvement, however, they are, at best, a partial view of the economic benefits. The focus on failure neglects aspects of waste which relate to flow and efficiency as opposed to accuracy. For example, an operator having to wait for products from a previous process would not register as a cost of poor quality, but would clearly have an impact on the costs of the organization.

The concept of waste is fairly generic in nature and has been around for a long time. Many organisations refer to 'non-value added activities' and 'process waste'. However, these are rather broad terms and, whilst it is easy to agree that waste is bad and should be eradicated (or at least reduced) it does not much help in the process of improvement. The Seven Wastes were identified by Ohno as part of the Toyota Production System (Ohno, 1988) and have since been widely applied to process improvement, becoming particularly associated with the principles of lean manufacturing.

It can readily be seen that some of the costs associated with these activities would show up in the defect-based approach, but that some would be transparent to that system. Table 2.1 indicates the kind of financial impacts that might be caused by the types of waste. Those which would not be picked up by defect model of assessment are in bold italics.

Type of Waste	Potential Associated Costs
Waiting	***Labour cost associated with idle time.*** ***Value of lost production (if units are lost) or cost of overtime if this has to be worked to catch up.*** Cost of late delivery if overall process time affected.
Correction	Rework cost (direct and overhead if applicable). Cost of delays (as above). Inspection costs. Disposal costs if correction is not possible. Paperwork system costs.
Over-Production	***Storage costs (inc. handling costs & capital tied up).*** ***Extra material costs if excess cannot be sold.*** Deterioration/depreciation costs (if appropriate). Cost of delays (as above).
Processing	Additional processing costs (direct and overhead if applicable). Transportation costs.
Conveyance	***Additional cost of unnecessary conveyance system.*** ***Cost of late delivery if overall process time affected.*** Deterioration/damage costs.
Inventory	***Storage costs (inc. handling costs & capital tied up).*** ***Deterioration/depreciation costs (if appropriate).*** ***Obsolescence costs (if appropriate).***
Motion	***Additional labour costs (including absenteeism).***

Table 2.1. Types of waste and associated costs

The 'waste' mentality gives a much more comprehensive (and accurate) assessment of costs of existing levels of performance. It allows us to consider both the effectiveness and efficiency of our operations when deciding where to concentrate improvement effort.

The impressive financial gains associated with Six Sigma certainly account for much of its popularity, but on the downside may also be responsible for the 'quick fix' mentality which has characterised at least some of the applications.

2.3 To be Responsive to, and Focused on, Customers

2.3.1 Product Out vs. Market In

We often consider ourselves 'expert' in our customers' requirements. We, after all, have been in this business for a long time; we have much more experience than the typical customer, who may have only bought a few of our products. We are technically much more au fait with the product, and with those of our competitors.

It is easy to see how this logic leads us to take a rather patronising attitude to customers who either don't really know what they want, or don't understand the complexities of the product. Anyone who has been on the end of a customer service discussion where they have been told that they must have been misusing the product, or that it was not designed for the circumstances described, will recognise this mentality. This is known as the 'Product Out' concept where the focus is on working to specification or instruction and the product is 'pushed' from the company to the customer. The problem with a product out focus is that it is slow to respond to changing markets and customer requirements (an ever more significant aspect of the world today). The 'Market-In' approach allows for a much more responsive system and places a requirement on the organization to go and find out the customer requirements.

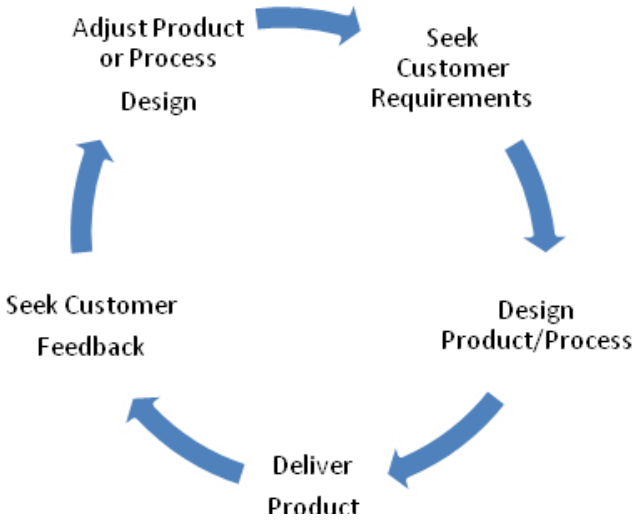

Figure 2.1. Market In Concept

Customers may not be expert in the technicalities of the product, but they do know what the need the product to do for them.

Six Sigma attempts to deploy the voice of the customer through the processes of the organization. Improvement projects should be as much about customer value as they are about financial benefit

2.4 To Improve Product and Service Performance

Clearly, a reduction in defects will be helpful to our customers in that it will reduce the likelihood that defects will escape detection and affect the final customer. However, in looking to reduce variation in product and service outcomes Six Sigma takes a step beyond the out-moded goalpost approach.

2.4.1 Taguchi Loss Function and Customer Satisfaction

The Taguchi Loss Function (Taguchi, 1986) shows how reducing product variation in relation to the tolerance band can improve customer satisfaction even if all products already meet specification. Figure 2.2 contrasts Taguchi's Loss Function and the traditional tolerance (also known as specification)-based approach to product quality.

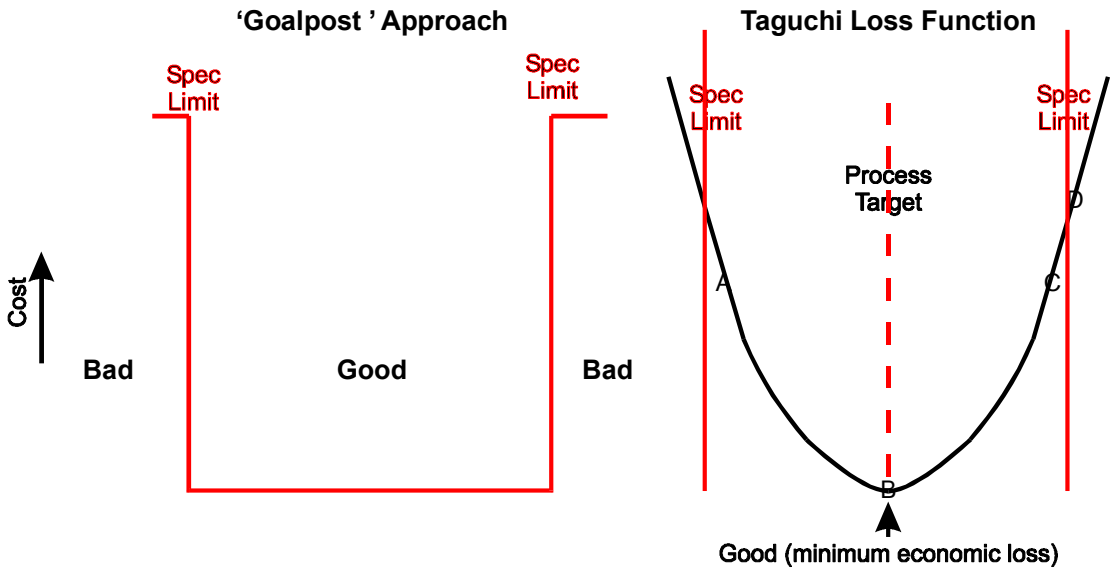

Figure 2.2. Loss function vs. tolerancing.

Traditional thinking is that any product that falls inside the tolerance limits is "good". The unspoken assumption here is that they are equally good and that no cost is incurred. Following the logic through we can see that any product falling outside the limits is bad and a cost equivalent to the full cost of producing that product is incurred (often referred to as the scrap cost). In this simple scenario we have assumed that reworking the product is either not possible or uneconomic.

The usual derivation of tolerances further throws this attitude into doubt. They are usually based upon what was done last time or the draughtsman's 'best guess', and bartering the between design and production with designers wanting to tie production down to extremely tight tolerances and manufacturing wanting to be able to drive a bus through them. Seen in this light, tolerances can be viewed as, at best, somewhat arbitrary. In any case, the specification limits will always be what is acceptable, rather than what the customer or designer wants. In most cases the ideal will be all products exactly on target; this will mean the design works exactly as intended. However, this is recognised as unrealistic, hence the use of specifications.

Taguchi states that to regard the transition from good to bad as a step change is not logical. He contends that, provided the nominal has been specified correctly, any deviation from this target value will have a detrimental effect on the performance of the product and will therefore cause an overall loss.

Variation in Gearbox Components

Back in the 1980's Ford had a joint venture with Mazda to produce a car called the Batavia. One aspect of the collaboration was that both companies produced gearboxes. After a short time in the field most customers preferred the Japanese gearboxes which were reputedly smoother, quieter and easier to use. When Ford investigated the two products they found that although the Ford gearbox components were all in tolerance, the Mazda components were much closer to target and exhibited much less variation.

Although both gearboxes met the tolerances, customers were migrating to the better performance delivered by the more consistent product.

Based on "A Prophet Unheard", BBC Video (1992)

The precise shape of the Loss Function is debatable. However the principle that deviation from the target is expensive regardless of tolerances and that the rate of deterioration of the situation increases with distance from the target is sensible. In fact, as Wheeler (1995) notes, this effectively creates a new definition of world class quality, one with capability at its heart. No longer is conformance to specification sufficient, the new definition is:

"On target with minimum variation"

2.5 Contributing to Organizational Learning

Six Sigma is inherently a learning process and, as such, has the potential to contribute to organizational learning.

It is clear that a Six Sigma improvement project generates learning through investigation of a process, integrates that with organizational goals and specific knowledge of statistics, etc. and interprets this to generate improvements through action. At an organizational level sharing of good practice of projects lifts the learning to a higher level. De Mast (2006) describes the ability to facilitate people at all levels in an organization to learn how processes work and to put this new knowledge to effective use as the core capability that Six Sigma can bring to an organization.

The impact of learning on an organization is to increase organizational capability by equipping it with a better understanding of processes and outcomes and to allow for the generation of new knowledge and innovation which improves the capability of the organization to respond to change and new challenges. This is, in fact, a higher order effect than simply improving processes and generates benefits including:

- Maintaining levels of innovation and remaining competitive
- Improved satisfaction and motivation of the workforce
- Being better placed to respond to external pressures
- Having the knowledge to better link resources to customer needs
- Improving quality of outputs at all levels
- Improving corporate image by becoming more people oriented
- Increasing the pace of change within the organization

In fact, organizational learning has been discussed as vital to the survival of organizations in an increasingly volatile world.

"In times of change the learners will inherit the earth, while the knowers will find themselves beautifully equipped to deal with a world that no longer exists"

Eric Hoffer

"At the heart of this [GE] culture is the understanding that an organization's ability to learn, and translate that learning into action rapidly, is the ultimate competitive business advantage"

Jack Welch

Even though it is a higher order endeavour this is, sadly, the least frequently cited reason for exploring Six Sigma.

2.6 Summary

Six Sigma has the potential to contribute to an organization in a range of ways; the common approach of focusing on financial measures alone misses some of the more important but less easily measurable aspects. Figure 2.3 shows the relationship between impact and difficulty of the various approaches to Six Sigma. Cost-reduction projects are relatively easy to implement and integrate, but provide short-term and relatively low-level benefits. Introducing customer focus and linking projects to strategy requires more cultural and structural effort and change but delivers commensurately higher impact. Focusing on developing an organizational capacity for change and improvement through the application of Six Sigma delivers significantly more organizational benefit, but requires a total cultural transformation.

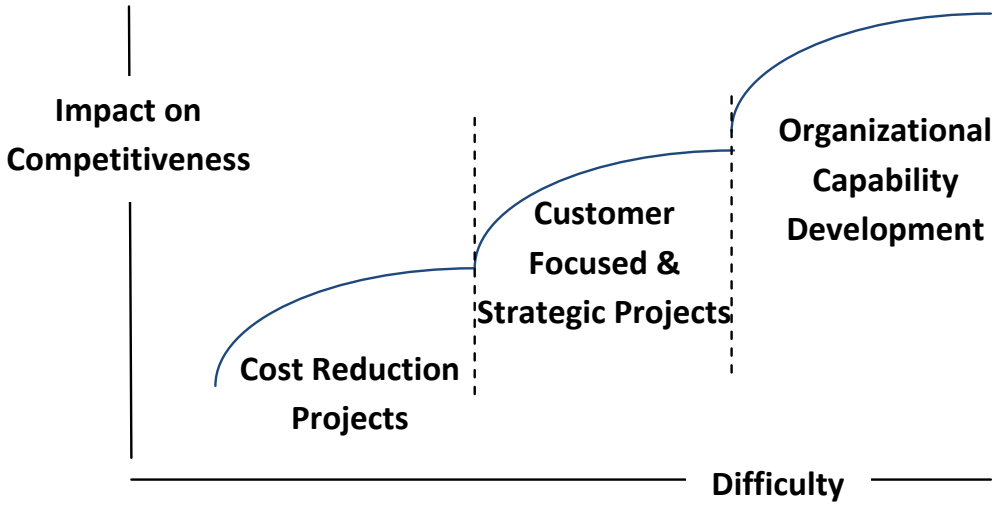

Figure 2.3. Impact on competitiveness versus difficulty for various Six Sigma approaches

3 Six Sigma: Key Concepts

There are a number of important concepts which have come together in the modern Six Sigma philosophy. These are summarised in this chapter in order to provide a sound basis for the discussions in later chapters.

3.1 A Strategic Approach

Historically, initiatives centred on quality have frequently been undertaken at a tactical level, focused on projects or cost reduction; Six Sigma activities must be supported by processes and structures to ensure they move business objectives forward.

Six Sigma focuses on quality as a strategic initiative, perhaps most famously in the person of Jack Welch who not only declared that Six Sigma was central to the way he expected GE to do business and based 40% of senior management bonuses on achievement of Six Sigma targets but also required that (as he did) senior management:

- Personally spend time in each Six Sigma training wave talking to candidates and answering their questions.
- Drop in on Six Sigma reviews (held weekly and monthly).
- Make site visits to observe first hand the integration of Six Sigma into business culture and operations.
- Monitor progress through weekly summary reports and monthly reviews with the Six Sigma implementation team.

By talking in the language of senior management (money) and by requiring hands-on commitment and direct involvement Six Sigma creates a much stronger cultural impact. By creating a governance system that links project definitions to strategic goals (rather than just doing what helps in the short term) and by assigning a senior management 'champion' to every project a good Six Sigma initiative ensures that benefits are long-term and strategic rather than short-term and tactical.

3.2 Customer Focus

A quote attributed to Ford is often used to illustrate that customer focus is over-rated:

"If I had asked my customers what they wanted, they would have said a faster horse."

Of course this merely misunderstands the idea of customer focus. What customers can (and should) be asked for is what they need, or what they would value –in this case faster movement from A to B- rather than how we should deliver the requirement – the horse versus internal combustion engine. This is not to say that at times an innovation cannot create a hitherto non-existent need, simply to say that this happens fewer times than is perhaps suggested. Did Apple truly create a new set of customer needs, or simply respond innovatively to emerging trends of mobile computing?
Six Sigma recognises the value of customers to the organization and focuses on creating value for the customer. Six Sigma initiatives which focus on cost reduction miss the point that what delivers long term profitability is happy customers, even more so than lower costs. A good Six Sigma project focuses on the customer rather than just short term financial gain (Anderson et al, 2006).

3.3 Scientific Investigation and The Define Measure Analayse Improve Control

(DMAIC) Cycle

3.3.1 Scientific Investigation

One of the key aspects of Six Sigma is that it moves an organization towards managing with facts and data, too often in the past things have been done on the whim of a leader. The heart of Six Sigma is in the scientific method as exemplified by this practical model, provided by Process Management International (Gillet and Seddon, 2009).

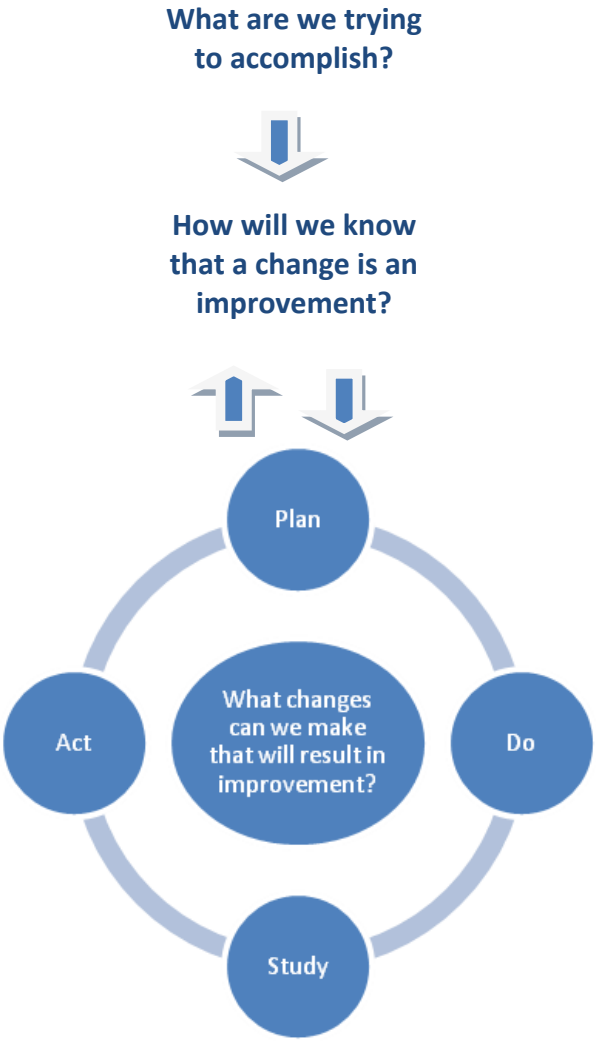

Figure 3.1. The three question model (Gillet and Seddon, 2009)

We need to begin with a goal and a clear understanding of how we will know when we have achieved it; then develop a plan as to how the goal might be achieved; the plan needs then to be enacted and the results (good and bad) observed. The analysis of these results (and our understanding of the causes) then leads us to act to modify our original plan, which brings us back to the start of the cycle and a test to see if we have achieved our goal before respinning the wheel if required.

3.3.2. The DMAIC Cycle

The Define-Measure-Analyse-Improve-Control (DMAIC) cycle is the methodology through which all Six Sigma projects are conducted, and is a specific application of the scientific method.

The DMAIC cycle is perhaps best thought of as a more detailed and prescriptive version of Deming's well known Plan-Do-Study-Act cycle. The detail and prescriptiveness may in themselves be something of an issue as we shall see later.

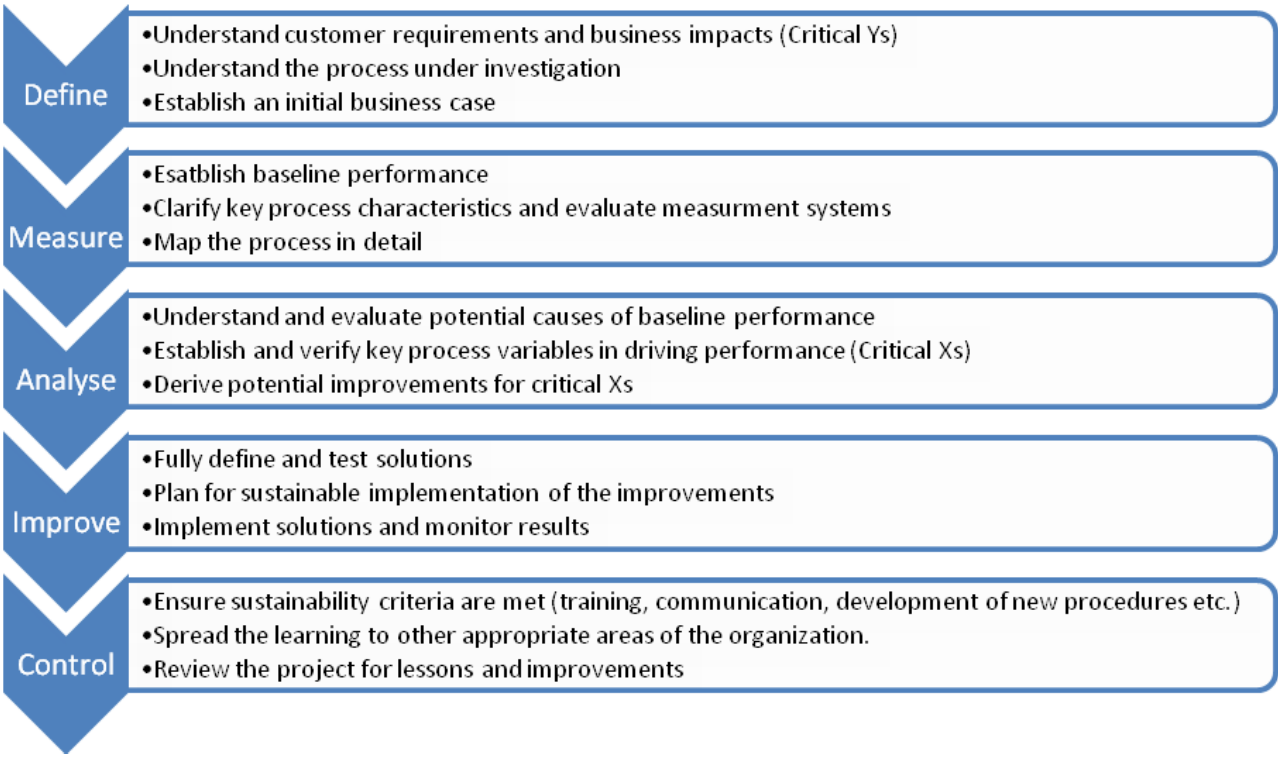

Figure 3.2. DMAIC process

3.4 Variation

3.4.1 Variation and The Normal Distribution

Variation reduction is the key mechanism for Six Sigma to deliver business benefit. By focusing on product, service or process variation (depending on circumstances) projects create consistency of performance and improved conformance to customer requirements.

Six Sigma focuses on the concept of **defects per million opportunities (DPMO).** It uses the standard normal distribution as its measurement system. From the standard normal distribution, the mean is μ and the standard deviation is denoted by σ. From figure 3.3, 68.2% of the population lies within ±1.0σ of the mean, 95.45% of the population lies within ±2.0σ of the mean and 99.73% of the population lies within ±3.0σ of the mean.

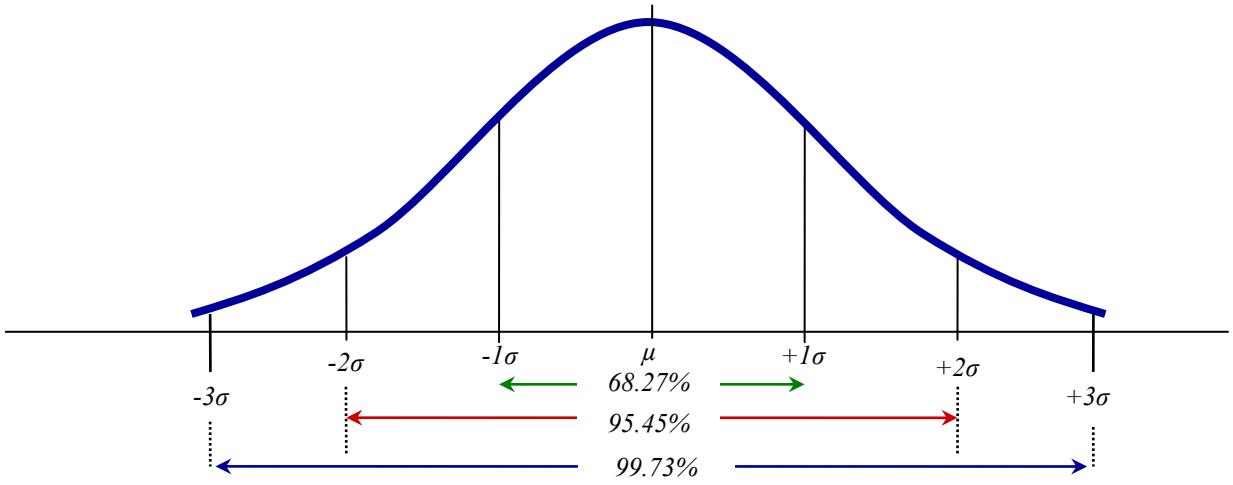

Figure 3.3. Standard normal distribution

When addressing variation it is important to remember the effects of special and common cause variation. The normal distribution and DPMO cannot apply if special causes are dominant within the process. See section 4.2.

3.4.2. Defects per Million Opportunities

Six Sigma uses the DPMO level of a process to generate a Sigma level for the process. The idea of a Sigma level is that it compares the variation in process performance to the acceptable levels set by the customer, the higher the Sigma level the better; a Six Sigma performance indicates 3.4 DPMO.

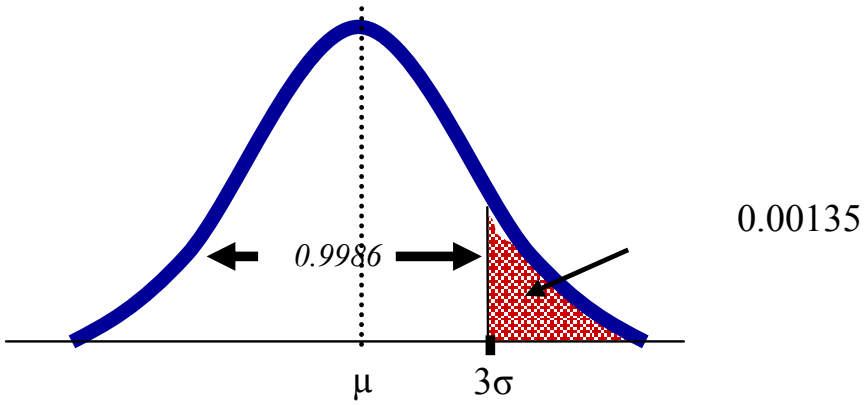

Figure 3.4. A one-sided normal distribution

So for example, from figure 3.4, when σ = 3 there are 1350 DPMO ((1-0.998)*1000000).

According to the standard normal distribution a process a six sigma performance would actually produce a DPMO of 0.002, but Sigma levels are calculated using an inbuilt 1.5 σ shift for the process average. This is effectively an allowance for the natural propensity of processes to drift and, although debate still rages as to the validity of the exact assumption this is the commonly used approach.

The basic idea is to create a process quality metric which allows comparison of any type of process; Goh (2010) described this as one of the six triumphs of Six Sigma. The DPMO are calculated first and then translated into a Sigma value via a conversion table (see table 3.1 below).

Process Sigma	DPMO (shift=1.5 σ)	Process Sigma	DPMO (shift=1.5 σ)	Process Sigma	DPMO (shift=1.5 σ)	Process Sigma	DPMO (shift=1.5 σ)
6.0	3.4	**4.5**	1,350.0	**3.0**	66,810.6	**1.5**	501,350.0
5.9	5.4	**4.4**	1,865.9	**2.9**	80,762.1	**1.4**	541,693.8
5.8	8.5	**4.3**	2,555.2	**2.8**	96,809.1	**1.3**	581,814.9
5.7	13.4	**4.2**	3,467.0	**2.7**	115,083.1	**1.2**	621,378.4
5.6	20.7	**4.1**	4,661.2	**2.6**	135,686.8	**1.1**	660,082.9
5.5	31.7	**4.0**	6,209.7	**2.5**	158,686.9	**1.0**	697,672.1
5.4	48.1	**3.9**	8,197.6	**2.4**	184,108.2	**0.9**	733,944.5
5.3	72.4	**3.8**	10,724.1	**2.3**	211,927.7	**0.8**	768,760.5
5.2	107.8	**3.7**	13,903.5	**2.2**	242,071.4	**0.7**	802,048.1
5.1	159.1	**3.6**	17,864.5	**2.1**	274,412.2	**0.6**	833,804.3
5.0	232.7	**3.5**	22,750.3	**2.0**	308,770.2	**0.5**	864,094.8
4.9	337.0	**3.4**	28,717.0	**1.9**	344,915.3	**0.4**	893,050.4
4.8	483.5	**3.3**	35,931.1	**1.8**	382,572.1	**0.3**	920,860.5
4.7	687.2	**3.2**	44,566.7	**1.7**	421,427.5	**0.2**	947,764.9
4.6	967.7	**3.1**	54,801.4	**1.6**	461,139.8	**0.1**	974,042.6

Table 3.1. Process sigma table

The precision of the numbers in this table is something of an illusion as they are based on a perfect normal distribution which, being infinite never occurs in practice.

3.5 People and Learning

Eckes (2001) identifies culture as the most important (and most often forgotten) component of successful Six Sigma implementations. One of the keys to Six Sigma success at GE was the fact that, through activities such as the 'workout' process, Jack Welch set out to turn it into a learning organization before implementing Six Sigma. Welch himself is on record as seeing this as a vital precursor to Six Sigma, but as a much more complicated, difficult and less immediately accessible concept many consultants and organizations have air-brushed it out of the implementation process.

Without the active acceptance of the vast majority of the organization Six Sigma will never deliver its potential. Many companies fall into the trap of seeing resistance to change as problematic, rather than natural. The focus on overcoming resistance – seeing those who resist as a problem in effect – exacerbates the potential 'them and us' attitudes of the Six Sigma evangelist. If you see life in this binary fashion those outside the Six Sigma cadre will, at best, be ambivalent and at worst hostile. Inclusivity is the key at both strategic and project levels.

The first thing in almost every text book or article on Six Sigma is a list of financial benefits and impressively large savings (yes, I know I've done it too!). Whilst this is great for generating enthusiasm it represents one of the dangers to successful implementation. It has led to many organization implementing Six Sigma as a cost reduction initiative; ironically, the more single-minded you are in pursuing cost reduction the less likely you are to achieve it in the long run.

There are a number of key roles in Six Sigma:

- ***The Steering Team***: Led by the CEO and focused on the strategic application of the Six Sigma approach.
- ***Champion***: Senior managers assigned to each project to provide links to the steering committee.
- ***Black Belt/Green Belt***: Qualified full/part-time Six Sigma specialists who run improvement projects.
- ***Master Black Belt***: Highly experienced Six Sigma professionals who mentor project black belts and support training and deployment of the initiative.

These roles together make up the human resource side of Six Sigma and they must all be appropriately trained and developed for the roles. For example, a green belt will typically undergo two weeks of training in DMAIC cycle and process improvement tools and demonstrate capability by delivering one or two projects prior to qualification. For a black belt there are an extra two weeks of training in more advance statistical tools and at least one further project involving the application of some of these tools.

4 Variation Reduction: The Heart of Six Sigma

4.1 Introduction

Variation is the critical central idea of Six Sigma; as such it merits its own section. Let's start by considering the traditional approaches to delivering output quality. Figure 4.1 is the standard approach to achieving quality. This is the make-inspect approach which is still prevalent in much manufacturing.

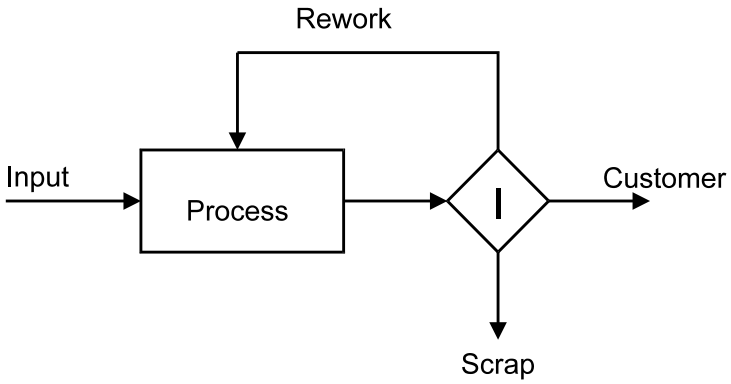

Figure 4.1. A process using 100% inspection.

There are four major problems that can be identified with such a system:

- ***It doesn't work***: 100% inspection is not 100% effective. No matter how good the inspector, some good products will always be rejected or sent for rework due to fatigue, boredom or a dozen other factors. More significantly, bad product will get shipped to customers.
- ***It is expensive***: The system is costly in terms of manpower; enough inspectors must be employed to ensure that inspection does not become a bottleneck in the production system.
- ***It is too late***: Products have already been made before diagnosis, and often there is sufficient lag between production and inspection that any feedback would be meaningless.
- ***It misplaces responsibility***: Responsibility for quality devolves from the person making the item to the inspector of the item whilst the control of quality remains where it always will remain, with the person in control of the production process. Thus, the only one with the ability to affect the final quality of the finished product has no incentive to pursue such improvements.

The logical way to overcome the problems associated with this type of system is to apply preventative techniques at the operation stage to ensure that the product is produced to the required quality. This means that we need to understand the variation in a process and manage it on that basis. The long-term aim is to minimise variation in processes so that customer requirements are more closely met than before.

4.2 Special and Common Cause Variation

Variation is part of our everyday lives. Both at work and in our private lives we make allowances for its effects from the process of getting to work in the morning to the output of a complex manufacturing system. However, whilst a seat-of-the-pants approach to deciding how long we allow ourselves to get to work may be perfectly adequate, a similarly haphazard approach to managing processes at work is not desirable. We need to get a **quantitative** feel for the variation in our processes. There are two basic elements to this variation: the central tendency and the spread. We need to have a handle on both these since they are vital to a successful process. It's no good being the right temperature on average if, to achieve this, you've got one foot in the fire and one in the fridge!

At this stage it is important to note the two potential causes of variation that can affect a process, these will be illustrated by means of a simple example of driving to work in the morning: even when we set off at exactly the same time, following the same route, in the same car it is apparent that arrival time will vary.

Common Cause (Unassignable) Variation: This is variation that is inherent in the process; it is always there. In the process of getting to work this will mean things like waiting time at fixed traffic lights, or the driver's mood and condition, or weather conditions. Only fundamental action on the process can change common causes. For example, changing route to avoid the traffic lights will remove that cause of variation.

Special Cause (Assignable) variation: This is variation due to transient causes outside the process norms and can usually be traced back to the specific cause. In the journey to work example this would include road works, breakdowns etc. In many cases action can be taken to achieve a reduction in the future effect of these 'transient problems'. For example, better maintenance to avoid breakdowns, which does not fundamentally change the process.

The difference between the two types of variation is crucially in their effect on the process. Common cause variation affects the overall spread of the process (so, for example, a journey with a lot of traffic lights would tend to have a wide variation as the variation caused by red or green at each light would add up), it would not affect predictability. A process which is subject to only common causes will be predictable (within limits), so we know that our journey to work might take between 20 and 30 minutes provided that nothing odd happens. We cannot, of course, predict the exact time it will take tomorrow, but we can make sensible decisions with regards to process management.

On the other hand, a special cause will tend to not only increase variation but also to destroy predictability. For example, if you were involved in a road traffic accident you would expect the journey to take longer. It would not, however, be possible to estimate the effect; it might be 10 minutes to exchange insurance details with anyone else involved, or if the car was no longer fit to drive you might miss the whole day at work. If a process is unpredictable it is not possible to make any sensible management decisions; you could not, for example, know to allow an extra 30 minutes for your journey time if you knew you were going to have an accident!

Accordingly, a process which is subject only to common cause variation is described as being ***"In Statistical Control"***. This is sometimes reduced to ***"In Control"*** or described as ***"Stable"***. This essentially means it is predictable, and we know what is coming (within limits). When a process is under the influence of special causes it is described as being ***"Out of Statistical Control"***, ***"Out of Control"*** or ***"Unstable"***.

4.3 Shewhart Charts and Process Control

To effectively manage a process we need to be able to distinguish between In Control and Out of Control conditions. A process which is not predictable allows us to make no assumptions about output and we must therefore inspect every item to ensure it is acceptable for the customer. If a process is in control then we can plan because we know what is coming. Unpredictability – and hence special cause variation – is the enemy of process management.

Process Control Charts (Shewhart Charts) use the history of the process to establish the natural limits of the process and to distinguish between common cause variation (inside the limits) and special cause variation (outside the limits). For those who are interested, the statistical basis for this and the calculations can be found in the corresponding Bookboon.com textbook on Six Sigma which gets into more detail.

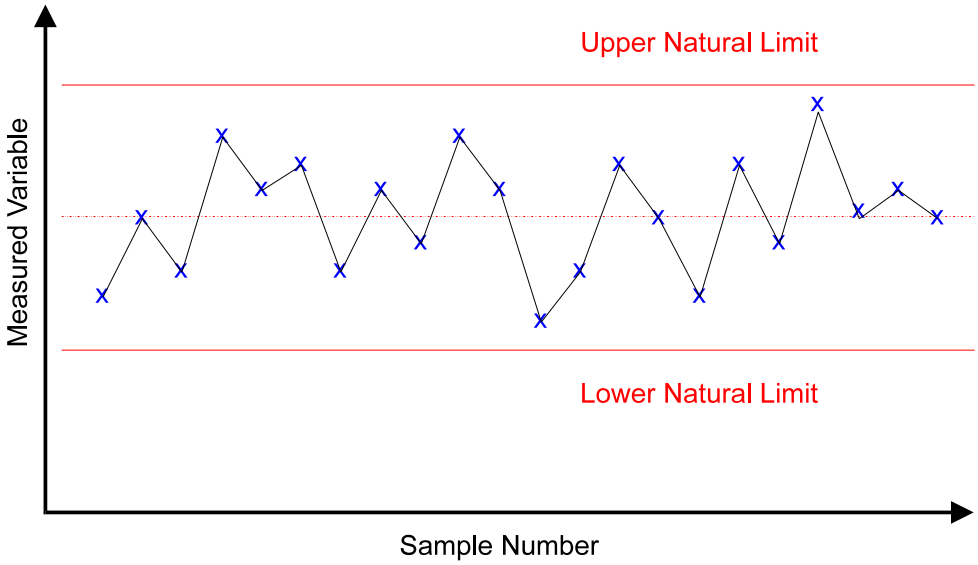

Figure 4.2. A control chart

Special causes identified on the chart need to be treated as problems to be solved and a mini DMAIC cycle is run to establish causes and put in place actions which ensure the cause will not recur.

4.4 Process Capability

Once a process is stable, it is necessary to determine whether the outcomes of the process can meet customer expectations – as described by tolerance limits in most product oriented applications and service level agreements in service oriented applications.

The importance of understanding process capability cannot be overstated. If we are to attempt at any level to design for manufacture we need to understand not only the requirements on the process (effectively our specifications) but also what the process is able to achieve (capability). Without both sides of the equation we are not able to make sensible decisions about how to manage our processes at an appropriate stage in the product lifecycle and we doom ourselves to fixing and fire-fighting when we actually try to make the product. A similar argument could be made for supplier selection.

Capability evaluation is the method by which we determine whether a process is up to the job of meeting the specifications set for it. It is important, before attempting to establish the capability of a process to ensure that the process is stable. The key issue is that if a process is not stable the capability will be constantly changing due to the transient effects of special causes and will hence be uncertain.

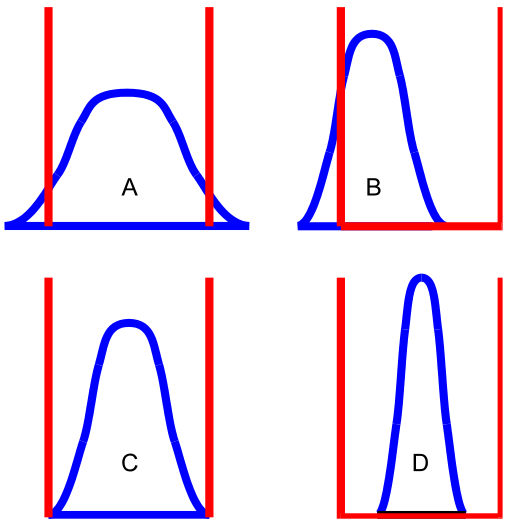

Figure 4.3. Process capability diagrams

Consider the four processes shown above with the specification limits. Clearly, process A is producing many components both above and below tolerance; process B is offset and is, as a result, producing components below the bottom tolerance limit; process C is producing almost all components within tolerance and process D is operating well within the tolerance limits.

Given the information provided in the above diagram we can act upon the process (resetting process B, for example, or attempting to reduce the spread of process A), without such information we would be making such decisions in the dark. Similarly, this information would be of use in selecting suppliers having these capabilities. If we do not understand the capabilities of processes at an early stage in the product lifecycle we give ourselves little chance of making appropriate decisions about which processes to use as they are and which to work on. If we find this out when we reach volume production we incur additional costs. Indices may be calculated to quantify capability, but these are not dealt with here.

4.5 Juran's Quality Trilogy

Broadly speaking variability reduction in a given process has 3 phases:

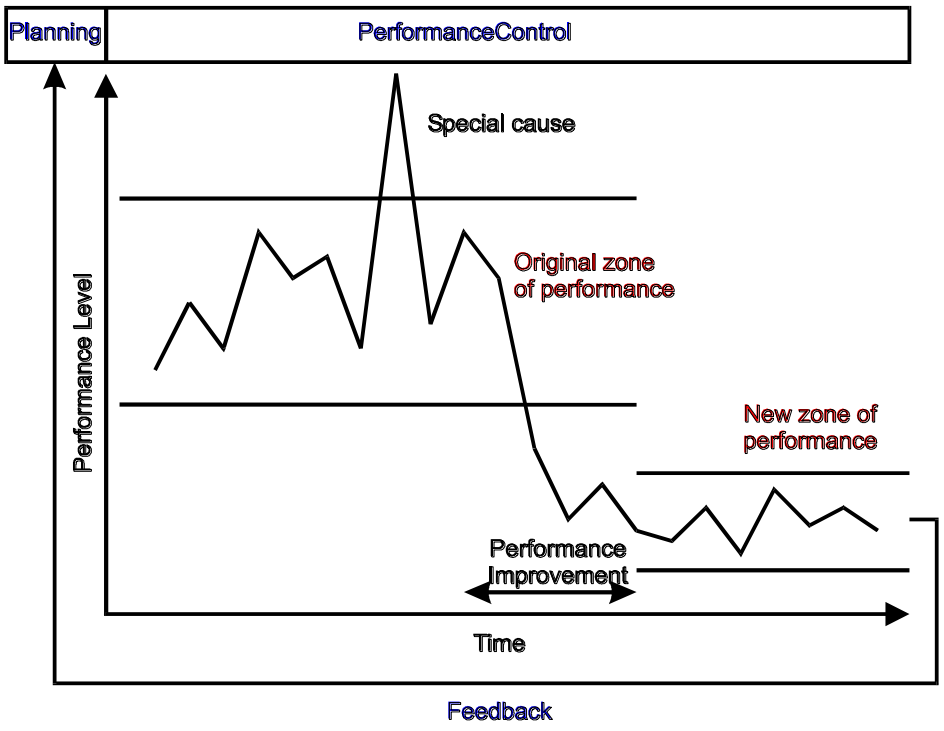

Figure 4.4. Juran's Quality Trilogy (Modified from Defoe and Juran, 2010).

- ***Planning***: The planning phase should be driven by the learning from previous product, process or service implementations. We plan the new system in the light of what we learnt improving the previous one so that it should be closer to the improved state rather than the original.
- ***Control***: In the control phase we learn about the new product, service or process performance by monitoring variation and establishing a stable baseline performance by removing special causes.
- ***Improvement***: Once the process is stable, we have a basis to experiment. We can reduce the common causes of variation to produce an improved stable zone of performance; nearer to target and with reduced variation. The learning from this phase should feed back into the planning phase for future products, services or processes.

5 Stage Zero: Pre-Six Sigma Basics

5.1 Introduction

5.1.1 Start Before the Beginning

Most of the books on Six Sigma start from the decision to implement, this is far too late. If Six Sigma (or any of its variants) is to be implemented successfully there are certain building blocks which need to be in place. Without attention to these then it will be hard for Six Sigma to be a sustainable success.

5.1.2 Beware the 'Low Hanging Fruit'

We need to be clear here; the irony is that by failing to have the basics in place before we start to deploy Six Sigma the early projects will appear to deliver more improvement than if the basics are attended to first. This is often described as 'low hanging fruit', or even 'ground fruit'; the things that are obvious, no-brainer decisions. If, for example, you do not have a clear understanding of how processes work, a Six Sigma project that addresses this deficiency will doubtless deliver significant improvement – how could it not? It would not, however, be necessary to use Six Sigma to address such a basic failing, and the message for the organization is that Six Sigma does the obvious stuff and takes credit for it. This will create a credibility gap for Six Sigma. It also means that projects are likely to take much longer if they are to address more intractable problems.

5.2 Basic #1: Have a Clear and Communicated Strategy

Too often I have witnessed boards of directors discussing the pros and cons of implementing Six Sigma as if it were an end in itself. Six Sigma can be a part of strategic management, but it is not a strategy. To understand what this means we need to define some terms:

- ***Strategy***: Is a plan of action to achieve organizational goals, usually related to performance in the market place.
- ***Strategic Management***: is the development, deployment and execution of strategic plans. It involves the development of organizational mission, vision, values and goals; the development of policies and plans, their execution and evaluation.

Six Sigma has often been used effectively as a tactical approach to address some of the levers of competition. This would mean reductions in cost or improvements in the quality of product or service delivered to the customer (effectively reduction in DPMO and variation in Critical to Quality aspects of the product or service). This provides a competitive advantage, but the strategic potential is far greater; as part of a strategic management cycle Six Sigma can help organizations develop "Organizational Capability" to change and adapt as required by the changing world. It does this by fostering a capability in learning and change management. To be effective it needs to link to the other aspects of strategic management.

5.2.1 Vision

Corporate vision is essentially a tone setting idea, which is designed to align and inspire the stakeholders in an organization (principally and crucially those who work for it). It should be concise, easily understood and stirring. Vision statements vary in length and content. One of the best known was the vision statement for Fuji Film:

"Kill Kodak"

It can be seen to fulfil all the requirements above in two words. Vision statements which are this succinct are rare, but this should be the aspiration. Below are further interesting examples:

"Democratize the automobile" Ford Motor Company (1900s)
"To be the number one athletic company in the world" Nike
"To make people happy" Walt Disney Corporation
"Become the company most known for changing the worldwide poor quality image of Japanese products" Sony (1950s)

Again, they capture an inspiring vision for the organization at the time, of course, vision can change over time. The vision for GE set by Jack Welch was:

"Become the most competitive company in the world by being number one or number two in every business in which we compete"

Note that there is no mention of Six Sigma. The vision statement is what we need to achieve, not how we plan to achieve it.

5.2.2 Mission

Mission statements add detail to the vision statement. It captures who the organization is and what it will do to achieve its vision. Examples are:

> *"Google's mission is to organize the world's information and make it universally accessible and useful"*
> *Google*

> *"McDonald's vision is to be the world's best quick service restaurant experience. Being the best means providing outstanding quality, service, cleanliness, and value, so that we make every customer in every restaurant smile" McDonalds*

Leaving aside any personal views on the organizations concerned it can be seen that these develop the vision to suggest more practical aspects of strategy and set boundaries, be they industry sector, geographic, or temporal.

5.2.3 Values

Alongside vision and mission it is important to develop organizational values. These are the things in which the organization espouses belief. They are an indication of the way in which missions will be delivered. Values add nuance to vision and mission statements, but are actually more enduring than either; while external circumstances may affect the vision or mission of an organization the values should be unchanged in most circumstances. Values might be things such as: respect for employees, integrity in business dealings, data driven decision-making amongst other things.

5.2.4 Strategic Objectives

Strategic objectives need to be developed from the vision, mission and values of the organization. These need to be a few significant items which are clearly stated, relatable to all levels and challenging, but not impossible. In order to be number one or number two in every market GE recognised the need to drive extraordinary levels of improvement in quality, cost and timeliness of delivery to customers. This is where Six Sigma came in.

"Should We Do Six Sigma?": The Wrong Question!

Six Sigma is a way of addressing strategic objectives. As such, the question "Should we implement Six Sigma?" starts in exactly the wrong place. To discuss means before objectives is a recipe for disaster. This is not helped by the keenness of many management consultants to sell Six Sigma (or Lean Six Sigma) programmes to organizations. the first question needs to be: "What do we wish to achieve as an organization?". Only when we are very clear on our strategic objectives should we consider the means by which they might be achieved. And, of course, Six Sigma is one option, but not the only one. Look for strategic and cultural fit before implementing. It is entirely possible that Six sigma is not for you, now or possibly ever. Toyota, for example, have decided that the elitist nature of the Six Sigma Black Belt Structure is a poor fit with their organizational values and culture, and have decided against implementation.

5.2.5 Strategic Planning and Execution

The vision, mission and values of the organization need to be enacted through an effective planning and execution cycle. This is the only way in which the slightly intangible concepts and promises can be made manifest. The primary role of strategic planning is to set the right objectives for the business, determine the best means of achieving the objectives and to facilitate the effective implementation and review of the means as the plan is executed. This requires that planners should work in the context of higher-order purposes of the organization, which are usually very specific to its own situation including the needs and desires of the owners and stakeholders.

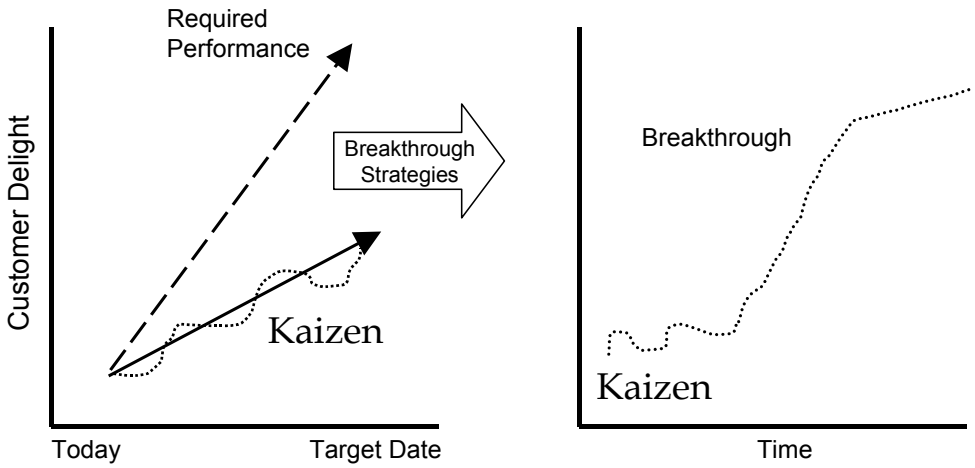

Figure 5.1. Breakthrough Performance

An example of a higher order purpose may be to provide the best products and services to society, with specific objectives of introducing four new products next year. Strategic management is needed in addition to strategic planning in order to translate the strategic intent through a reliable execution methodology into planned results. The planned results can be in the form of incremental or breakthrough improvements. A plan to achieve the strategic vision must take account of both sets of activities. Incremental activities improve current business processes through use of facts and analysis to solve recurring problems. These activities are often associated with simple tools of quality improvement (brainstorming, cause and effect analysis, etc.). But some performance gaps are large and require a much more fundamental approach and more sophisticated tools and techniques.

Incremental improvement (sometimes referred to as Kaizen) relates to isolated process improvements to solve fundamental problems. Breakthrough improvement often requires a company-wide process redesign to solve chronic problems. Six Sigma projects can be conceived to act at either level, as long as there is clarity on goals and timescales.

5.3 Basic #2: Become Process Focused

5.3.1 Definition of a Process

A business process, simply defined, is any activity, or set of activities designed to change one or more inputs – which may be physical or information- into one or more outputs. It is desirable, although not universally true, that a process should in some way add value to the inputs so that the output is worth more than the combined value of the inputs and the processing. Figure 5.3 shows this in diagrammatic form.

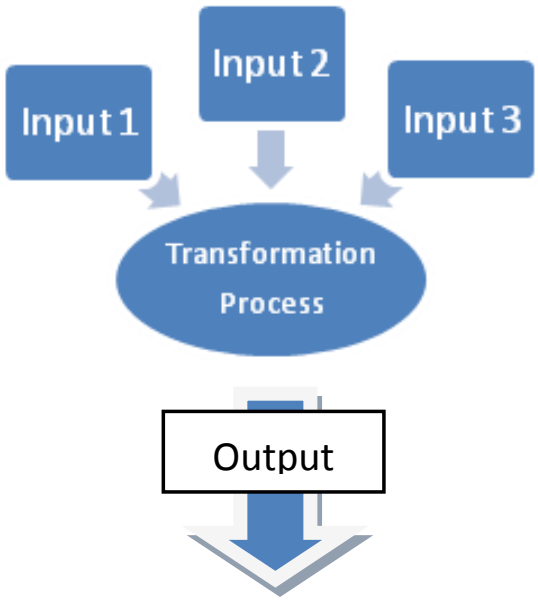

Figure 5.3. A process

Based on this definition, a process can refer to a physical manufacturing process or to a virtual or service operation where the output is not a physical product – a doctor's advice, or the transfer of funds between bank accounts for example.

5.3.2 Production as a System

Deming's (1990) model shows business as a process (figure 5.4).

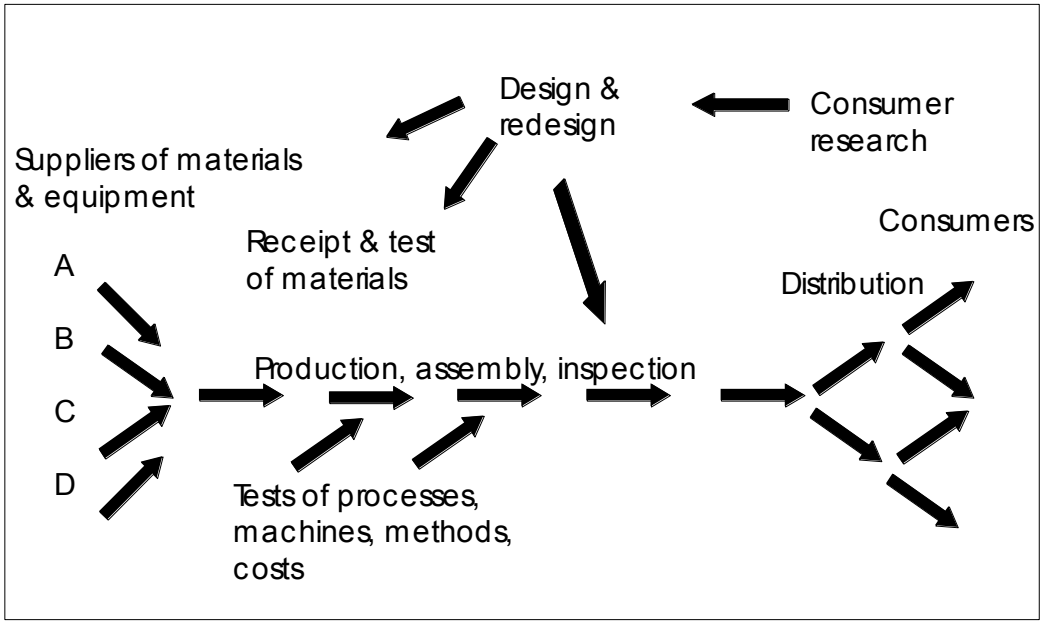

Figure 5.4. Production as a system (Deming, 1990)

The model looks initially chaotic, but simply reflects the myriad activities that go on within a production environment. This concept is hardly revolutionary now and, indeed, the wording of the model may look rather dated. However, the recognition that outputs of a process are clearly driven by inputs was the vital first step on the road to managing processes rather than outcomes. It may also be worthy of note that, even today, many management approaches spend more time focusing on the outcome than the means to achieve them (MBO and performance appraisal are perhaps chief amongst these).

Deming made some supplementary points on viewing production as a system. He noted that 'the system must have an aim' (defined by the customer of the process). An obvious comment, but it is amazing how often we lose sight of the end goal of the process in the endless debates over precedent and practicality which attend most manufacturing processes. Deming also noted that in the increasingly competitive production environment of recent years it is necessary to improve the system 'constantly and forever'.

Perhaps the most insightful of his comments is that:

"Every organisation is perfectly designed to achieve the results that they do" (Deming, 1990)

This encapsulates the fact that processes drive results, and that if you wish to change the results you need to change the processes. Process design and management are thus seen as key to performing on all business measures. This demands a purposeful and planned approach to defining and refining the system with which we attempt to achieve our aims.

5.3.3 Business Processes: The Reality

Although Deming's model is intuitively logical it can be seen that in many organisations the reality is that there exist 'functional silos' within the process. This is due to different departments or groups of experts 'owning' parts of the process and often having measures which conflict with each other.

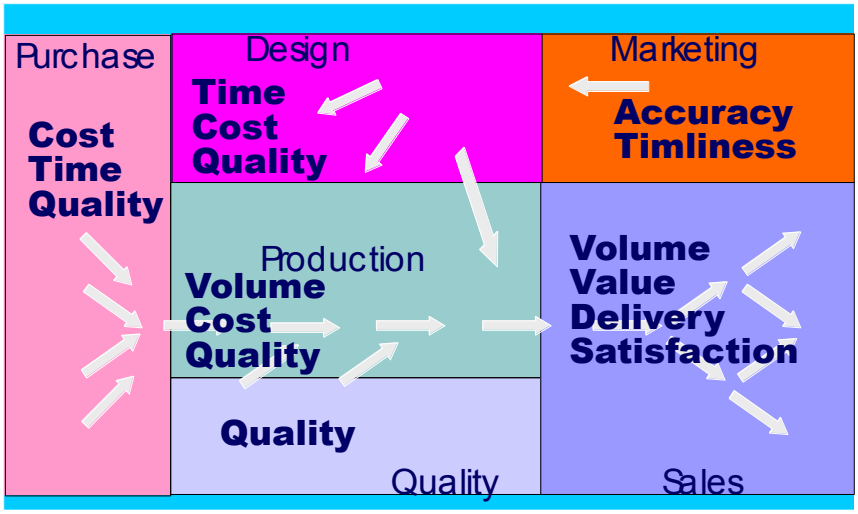

Figure 5.5. The Reality of Responsibility & Measurement in a Process

Figure 5.5 shows this schematically. The typical 'owner' departments are shown in each coloured segment and indications of key measurements that might be applied are shown in bold. The interfaces on this diagram require careful management if conflict is to be avoided. This, in effect, is where the continuous process model is most likely to break down, with sub-process optimisation and local goals taking precedence over the broader picture. This picture is why the cry "I can't believe they work for the same company as me!" is so common, everyone is being driven by different goals so that the commonality of purpose one might reasonably expect breaks down.

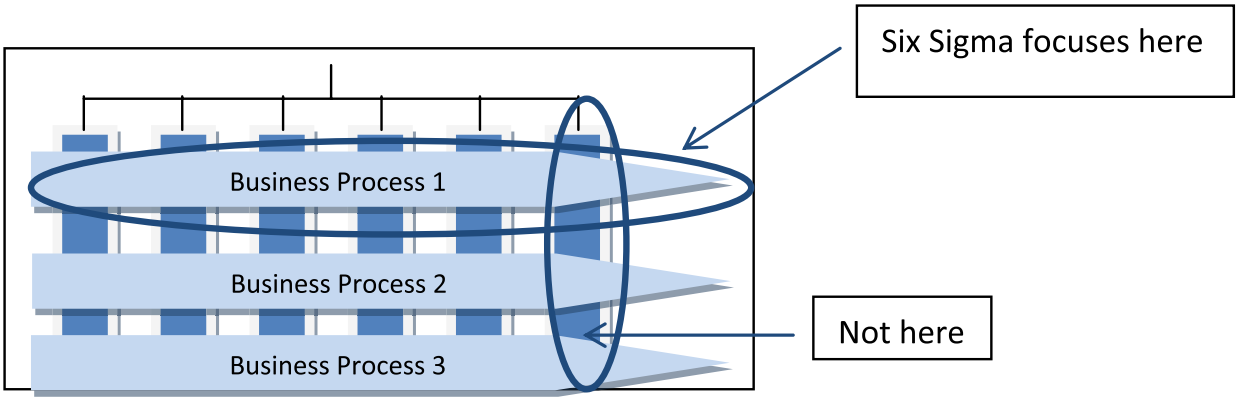

Figure 5.6. Business process versus functional organization focus for Six Sigma projects

Until departments can look beyond their own boundaries conflict will always exist. It can be argued that this integrating function is, perhaps the key function of management. Developing the vision and buy-in required to make this a reality can be supported by the application of Hoshin Kanri planning systems and Six Sigma projects which focus on horizontal processes rather than vertical functional silos (figure 5.6).

In process terms it is important to understand the linkages between the purpose of the process (effectively customer requirements) and the key elements of the process which deliver the purpose. In Six Sigma terms we talk of the Critical Y's and Critical X's.

5.4 Basic #3: Understand and Practice Customer Focus

The jargon of 'customer satisfaction' is now very prevalent in most organizations, which is clearly a good thing. However, there is significant evidence that the practice of customer focus lags behind the rhetoric. Six Sigma is no exception in this regard, with the customer focus trumpeted in many texts being often superseded by cost considerations.

5.4.1 Kano Model of Quality

The Kano model of quality (see Figure 5.7) indicates that the simplistic view of customers having requirements which improve satisfaction in a linear fashion depending upon the degree to which they are met does not fully reflect the complex nature of the process of satisfying customers.

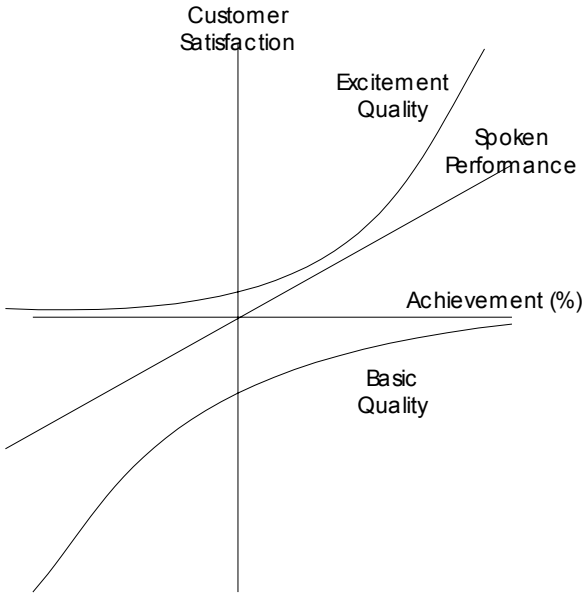

Figure 5.7. The Kano model of quality (Adapted from Kano et al, 1984)

Spoken performance issues will be of the form "I would like the product/service to achieve this level of performance". If the performance meets or exceeds this level the customer will be satisfied on that issue. If it does not then the customer will be dissatisfied on this issue. There will be a roughly linear relationship between performance against the specified criteria and customer satisfaction in that area. However, this does not cover all eventualities. Basic quality is related to items that a customer will not specify performance levels for since he assumes these levels will be met as a matter of course. In effect, these are the assumptions that he/she makes about your product or service and if you achieve all these you will not greatly impress them. The big but, though is that if you fail to fully satisfy one of these criteria you will have a very dissatisfied customer on your hands. Excitement quality refers to giving the customer something he didn't know he wanted (witness the leap-frogging of each generation of smart phone with functions which most people couldn't have asked for but which they can now not do without). Clearly, no customer can be dissatisfied because you didn't give them something they didn't know they wanted but if you do then you have a chance of obtaining extraordinary customer satisfaction.

From the above we can see that, although spoken performance issues are important, the real areas where you may lose (basic quality) or win (excitement quality) large amounts of customers are in areas where the customer will not generally volunteer the requirements but where there is a need to get inside his/her head to understand in more detail how they view the product or service.

In marketing terms you might think of 'Basic Quality' as 'Order Qualifiers' – without them you are not even in the game. 'Spoken Performance' would be more like 'Order Winners', where you compete with the competition for best customer value. 'Excitement Quality' features are a competitive advantage; they are game-changers, such as the first smart phone, or the first electric window on a car. Your customers will think you know what they want before they do (Apple are arguably the most consistent users of 'Excitement Quality' features at present) and competitors will come under pressure to follow your lead. And the beauty is that, even if they create better versions of these features you are still in the customers mind as the innovators.

This has important implications for how we obtain the data as simple market research tends to focus more on spoken performance criteria.

5.4.2 Customer Satisfaction to Customer Value

Customer satisfaction is a cherished notion, but it is rather reductive in its conception. Customer value might be a more useful concept.

RESULTS – EXPECTATIONS = VALUE

For this equation, if results exactly match expectations, customer value is zero. This implies that satisfaction is the absolute minimum that should be expected, and that its achievement does little or nothing to enhance company performance in terms of retention of customers, or profitability. Exceeding expectations (and thus generating positive value) needs to be the goal.

Only when the customer sees value in our product will they actively choose it over others. Similarly, the concept of customer loyalty is not helpful. This is because customers are not loyal in any meaningful sense. They will stick with a brand as long as they perceive value there, but desert it as soon as they see more value elsewhere. This is most obvious in fashion-driven markets where this year's hot designer is next year's nobody, but is true of all markets. Our goal needs to be to create (and maintain) customer preference for our offering. The implication of this is that we need to constantly refresh that offering in the light of new market data, with the aim of staying ahead of the results minus expectation equation, given the fact that better results will automatically drive up future expectations.

Value is a complex measure which is shaped by a number of factors:

1. Freedom from faults.
2. Degree to which requirements/expectations are met.
3. Emotional engagement with the product/service.
4. Quality of contact with the supplier.
5. Cost of the product or service.

Freedom from faults speaks for itself, the product or service must be delivered to the customer as specified. Failure to do this reduces value as the customer will be dissatisfied. However, removing a cause of dissatisfaction only returns the customer to a neutral state; it does not actively satisfy them. If our response systems simply remove the causes of dissatisfaction we do nothing to address creating a positive experience for customers. The degree to which customer needs and expectations (basic quality, spoken performance and excitement quality aspects) are met is significant to the value the customer will place upon the product. More complicated is the emotional engagement with the product or service; this is a combination of things such as: ergonomics, perceived social and cultural cachet, brand perception, aesthetics, linkage to self- image, etc. A product which looks beautiful (to the customer in question), fits their values (for example, eco-friendly), is seen as aspirational in the media and popular opinion, is easy (or ideally elegant) to use, and is associated with a brand which has high value for the customer will score highly on this element. Quality of contact with the supplier (whether web or direct) is also a major factor, customers often cite feeling important and cared for as a crucial factor in their decision to do business with a particular organization. Again, this is itself a complex issue with ease of interaction, perceived competence and degree of responsiveness of staff playing a part, among other things – this is dealt with in more detail in chapter 14 of "Managing Quality in the 21st Century" (also available from Bookboon). Finally, cost is important in assessing value; importantly, this does not just mean purchase price, customers are often sophisticated in assessing longer term costs (running, taxation and insurance costs for cars are a good example).

To add to the complexity the five factors interact in ways which are sometimes obvious, and sometimes not. For example, it is reasonably clear that if you buy a cheaper car, you may accept a few more faults, but how important is usability for a more aspirational product? For example, the Apple iPhone 4 saw no dip in popularity, despite issues with reception and signal strength when initially launched (PCWorld.com, 2010).

5.4.3 Six Sigma and Customers

Traditionally, Six Sigma projects engage strongly with points 1 and 5; 3 and 4 would often (perhaps correctly) be seen as out of scope; but many Six Sigma projects fail to make as effective a contribution to improving the degree to which customer requirements and expectations are met. To counter this, the strategic links to the value proposition for the organization need to be clear at the start of the project and value in assessing projects needs to be given to customer impact as well as to financial benefits. The difficulty of measuring this impact – especially in the short term – is an issue for an initiative where measuring is a key part of the mindset, but this should not be an excuse for not trying.

5.4.4 Assessing Customer Focus

The problem with customer focus is that often behaviours lag the rhetoric. No one is going to challenge the notion of being customer focused – it is so obviously a good thing. What you need to consider are measures of behaviours as opposed to rhetoric. Here are some good indicators:

- ***How often do the senior team mention customers?*** The more subordinates hear their superiors talking about something, the more it lodges in their mind as significant. When they are mentioned is also important, they should be at the top of the agenda in meetings, not the bottom.
- ***How often do we talk to customers?*** The more people at all levels get to meet customers the more personal customer satisfaction feels.
- ***How do we measure customer satisfaction?*** Regular measurement of how happy the customers are and dissemination of the results helps to keep focus. It is especially useful if feedback (positive or negative) makes its way back to specific areas where issues or good performance occurred. It is important to include positive feedback or we begin to associate customers with pain!
- ***How clearly do we prioritise customers?*** How often are there examples of other concerns (especially cost) being subordinated to the needs of customers. One example of a manager saying, 'this is more expensive, but it helps the customer, so we'll do it' is worth a dozen executive speeches about customer focus. How often are senior staff seen to personally go out of their way to improve customer satisfaction?

5.5 Basic #4: Create an Improvement Culture

Six Sigma is effectively a breakthrough improvement initiative which is designed to deliver rapid performance improvement in targeted areas. This has the maximum potential for impact when the organization is already actively involved in incremental (Kaizen) improvement. If basic improvement is ongoing then it prepares the organization in several ways for more radical improvement like Six Sigma:

1. ***Familiarity:*** Broad familiarity with concepts and processes of change reduces the amount of 'selling' for Black Belts seconded to areas for specific projects.
2. ***Change Readiness:*** Change as a process is an emotional experience and this can be difficult and uncomfortable for most people. By creating an environment where most people experience change fairly frequently it allows them to get used to the idea that, no matter how difficult the experience of change is, there is generally a positive experience at the end – or at least a return to the emotional status quo. This means when confronted with change individuals are more able to trust the process, and resistance to the concept of change is reduced (although, of course there may still be resistance to the actual change proposed).

3. ***Skills:*** As a large proportion of the employees will have been active participants in change projects they are likely to have useful skills in completing some of the tasks associated with a Six Sigma project. Delegation of, or involvement in these tasks allows for greater buy-in (everyone accepts much better change which they have been involved in creating).

A classic ways of doing this would involve something like Kaizen in Toyota, where everyone (both as individuals and within teams) is expected to work on improvement as an intrinsic part of their job. This is a long-standing and firmly embedded practice at Toyota and will take time to become so in any organization. An alternative is an approach such as 'work out' as practice at GE under Jack Welch (see panel).

GE Workout

One of the approaches Jack Welch used at GE to prepare the organization for Six Sigma implementation, and to create a 'Learning Organization' was 'Workout'. This is where a whole section or department is taken offsite for several days and presented by their manager with a problem (or problems) to solve. The team are provided with training, facilitation if required and resources to complete the task. They are given autonomy and the manager does not interfere until the group presents their worked through solution; at this point she has a right of veto, or to further investigate implications of the proposed solution, but must clearly explain any misgivings to the team.

This approach served to create an understanding and experience of change processes, and tools, and to motivate and empower staff to undertake change, creating a fertile environment for further change, and particularly the implementation of Six Sigma.

5.6 Summary

To have maximum sustainable impact Six Sigma needs to be implemented in a fertile environment. Failure to create such an environment will lead to increased resistance, improvements which do not 'take' and frustration for both Six Sigma personnel and others. The creation of such an environment is about culture change and will take time and effort, but generates a far greater cultural capacity for change (whether related to Six Sigma or not). Many text books and consultants fail to mention this important aspect of implementing Six Sigma in favour of the 'instant pudding' of a big bang introduction. It is, perhaps, unsurprising that those least ready for change have the least successful Six Sigma programmes.

Before you begin to actively implement Six Sigma ask yourself:

1. Do we know what we hope to achieve by implementing Six Sigma? Are we clear on our strategic objectives, and how Six Sigma will help to achieve them?
2. Are we a customer-focused organization?
3. Do we focus on the process of achieving results, rather than just on the results themselves?
4. Do we have a culture of improvement allied to regular and frequent involvement in change for the vast majority of our workforce.

6 Sustainable Six Sigma Deployment

This section builds upon the principles discussed in the previous sections to consider how to deploy Six Sigma in a sustainable fashion.

6.1 Deployment Principle #1: Remember Why You are Doing This

Large-scale initiatives such as Six Sigma can easily become self-sustaining and self-referencing. In effect, we do this because this is the way we do things. The somewhat evangelical nature of many Six Sigma specialists and the aura around the approach can exacerbate this tendency. It is therefore vital that deployment is grounded in linkages to the strategic cycle of the organization.

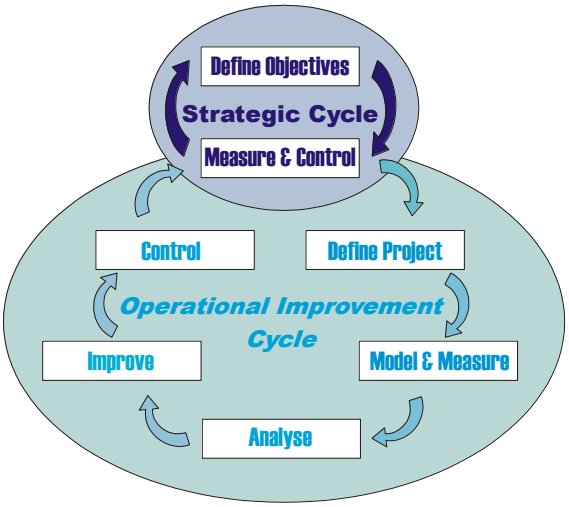

Figure 6.1. The Supply Chain Conceptual Improvement Model (Adapted from Knowles et al, 2005)

The schematic in figure 6.1 above shows how Six Sigma is about operationalising our goals. That basically means deriving appropriate actions and behaviours to deliver those goals. Figure 7.2 shows a simple example of the process of operationalisation.

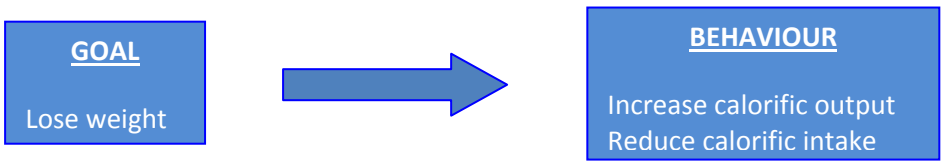

Figure 6.2. A simple operationalisation

The goal is **what** we wish to achieve, the behaviour is **how** we can achieve it. Note that this would effectively be the kick off for a project (in fact probably two with one looking at increasing calorific output and the other reducing calorific intake); so the **what** for one project would be "Increase calorific output" which might lead them to the next level of **how** as being, for example, "join a gym". While this is perhaps trivial in this example, it is much less so with more complicated corporate goals. Hoshin Kanri is one way of effectively deploying corporate goals throughout the organization.

6.1.1 Hoshin Kanri: Key Principles for Six Sigma

Hoshin Kanri is a planning system developed in Japan, and is believed to be dramatically superior to other forms of planning, particularly for integrating Six Sigma or similar improvement initiatives with the business plan of an organization.

Hoshin planning is not a strategic planning tool in itself, but can be thought of as an execution tool for deploying an existing strategic plan throughout the organization, although it can facilitate the strategic planning process. It does depend on having a clear set of objectives articulated by the Chief Executive/Company President. Application of Hoshin Kanri will then translate the strategic intent into required day-to-day actions and behaviours.

Hoshin planning principles are formulated around companies knowing what their customers will want in five to ten years, and understanding what needs to be done to meet and exceed all expectations. This requires a planning system that has integrated Deming's *"Plan-Do-Study-Act"* language, and activity based on clear long-term thinking. The measurement system needs to be realistic, with a focus on process and results and identification of what's important. Groups should be aligned with decisions taken by people who have the necessary information. Planning should be integrated with daily activity underpinned by good vertical and cross-functional communication. Finally, everyone in the organization should be involved with planning at local levels, to ensure a significant buy-in to the overall process. The major elements of the model can be summarised as:

- ***Five-year vision:*** A clear statement of the vision from the senior team

Figure 6.3. A five year vision statement

- ***Linking goals to processes:*** It is important to understand what processes will deliver the required goals. This creates a high-level understanding of the 'hows'. They can then be mapped against the strategic goals.

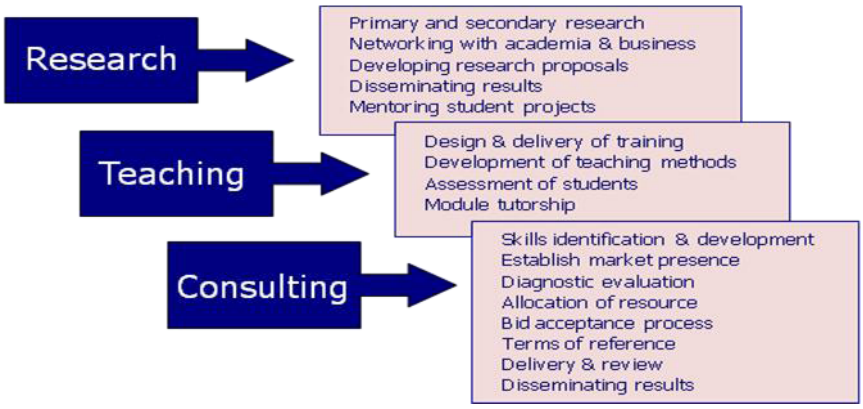

Figure 6.4. Key processes to deliver the goals in each of the areas from the vision

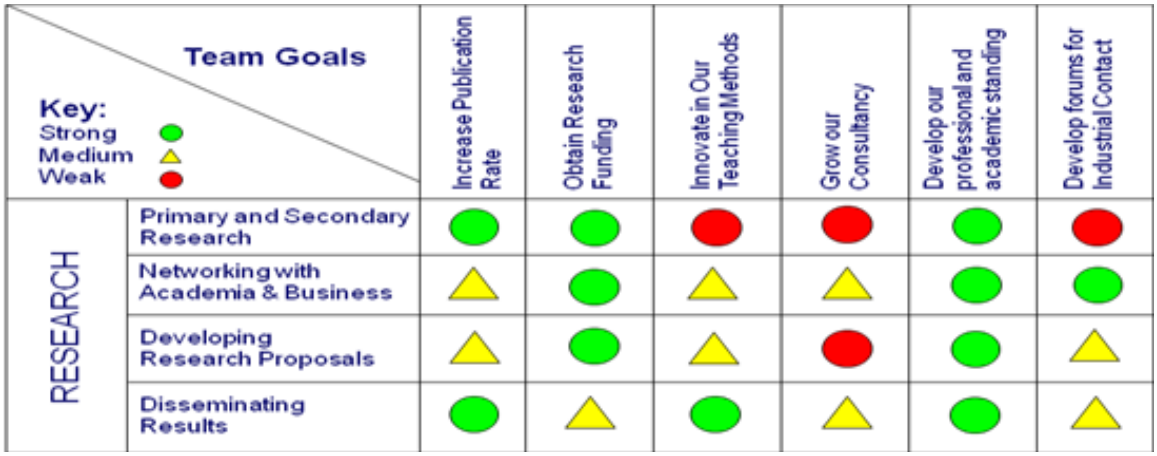

Figure 6.5. Mapping goals to processes with strength of relationship for research goals.

- ***The Five-year plan:*** Develop credible milestones for delivery of the plan. This effectively deploys the goals of the organization against the processes which will deliver them.

PROCESS GOALS & PLANNED DATE	2007	2008	2009	2010	2011
Increase our Publication Rate			*28 international papers submitted*		*28 international papers published*
Obtain Research Funding	*2 proposals submitted*	*2 team members register for PhD*	*2 research Projects in progress*		*3 research Projects in progress*
Innovate in our Teaching Methods	*1 module delivered by Web*	*4 team members complete the WTC course*		*Web element to All modules*	
Grow our Consultancy	*Create marketing material*		*5 days per team member per year*		*10 days per team member per year*
Develop our Professional & Academic Standing	*Team members select and register*	*Submit proposal for research centre*	*All course notes annually up-dated*		*Fellows of relevant institutions*
Develop Forums for Industrial Contact		*Develop partnerships with 20 organisations*	*Start workshops in Q&R methods*	*Host one international conference*	*Run quarterly workshops in Q&R methods*

Figure 6.6. Five year plan for the activities.

- ***The one-year plan:*** This involves the selection of activities based on feasibility and likelihood of achieving desired results. Ideas are generated from the five-year vision, the environment and ideas based on last year's performance.

- ***Deployment to departments***: Having a clear understanding of key processes and goals at the organizational level the goals are deployed to the individual departments having responsibility for the key processes. The process known as "Catchball" is crucial here and in further deployment down to team and even individual levels. "Catchball" is named for the children's game and represents the dialogue process where lower levels develop their own response to the goals deployed from the upper levels. They are free to decide how they will deliver the goals and even to challenge the goals if they are not feasible, or require special resources or approaches. The original goals may be modified or contingency plans put in place to ameliorate the concerns. The dialogue produces a much better understood set of goals and more commitment from the departments who have contributed to their development rather than having them imposed.
- ***Detailed implementation***: This is the implementation of the deployment plans. The major focus is on contingency planning. The steps to accomplish the tasks are identified and arranged in order. Things that could go wrong at each stage are listed and appropriate countermeasures selected. The aim here is to achieve a level of self-diagnosis, self-correction and visual presentation of action.
- ***Monthly diagnosis***: This is the analysis of things that helped or hindered progress and the activities to benefit from this learning. It focuses attention on the process rather than the target and the root cause rather than the symptoms. Management problems are identified and corrective actions are systematically developed and implemented.
- ***President's annual diagnosis***: This is the review of progress to develop activities which will continue to help each manager function at their full potential. The president's audit focuses on numerical targets, but the major focus is on the process that underlies the results. The job of the president is to make sure that management in each sector of the organization is capable. The annual audit provides that information in summary and in detail.

The approach is designed to create a single vision for the organization, align all departments with the vision and to develop self-diagnosis of performance, linking to process management and improvement actions.

6.1.2 The Benefits of Hoshin Kanri/Six Sigma Combination

The benefits of Hoshin Kanri as a tool for Six Sigma compared with conventional planning systems include; integration of strategic objectives with tactical daily management and improvement projects; the application of the plan-do-check-act circle to business process management; parallel planning and execution methodology; companywide approach and integration of projects into wider plans; improvements in communication; increased consensus and buy-in to goal setting and project definition; cross-functional-management integration. Taken together, these reduce the propensity for opportunistic application of Six Sigma projects for short-term financial gain, and bend them to the strategic purpose of the organization. The transparency of the approach and the catchball system should also have the effect of reducing resistance at both the initiative and project level as Six Sigma becomes a tool to help areas address their goals rather than an initiative imposed from outside.

6.2 Deployment Principle #2: Maintain a Learning Focus

Six Sigma is a learning friendly process; improvement without learning is impossible. The deployment of strategy is a learning process, the Hoshin catchball process is a key way of getting feedback on the sense and practicality of the strategy. But things will evolve; strategy will change in the light of new circumstances and challenges; unexpected consequences of changes may offer new opportunities, or create new threats; resource availability may be unexpectedly constrained, etc. The dialogue around strategic goals, delivery processes and resources must be maintained throughout the deployment of the strategy.

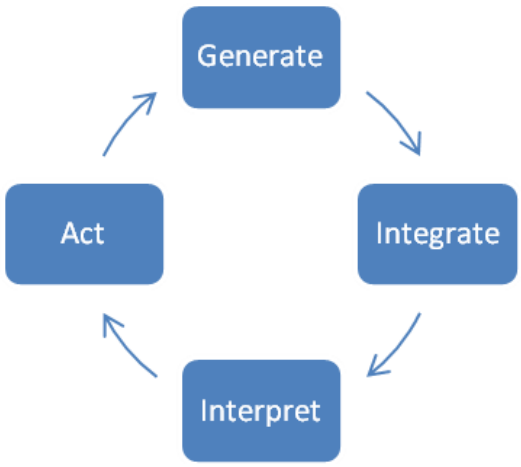

Figure 6.7. The Organizational Learning Cycle (Dixon, 1994)

An organizational learning cycle can be identified, which is similar to the PDSA cycle, which is the basis for DMAIC. Dixon (1994) described such a cycle.

- Experiences need to be spread throughout the organization in order to *generate* learning.
- Reflection, requires the *integration* of the experience into an organizational context.

- To create shared concepts and mental models collective *interpretation* of the contextualised experience takes place.
- *Action* is required to test the analysis, which underpins the interpretation.

Organizational learning can take place at a number of levels; it can apply to small teams (such as Six Sigma project teams), departments or the organization as a whole. This can account for the apparent inconsistencies in behaviour and ethos between departments in the same organization. The models and behaviours, which form the essence of the departmental culture, are the results of learning mechanisms that have taken place over time in those departments.

At the initiative level, the task is to create an environment which is conducive to learning, and which supports not only the learning cycle for individual projects, but also the development of wider organizational learning based upon the sharing of knowledge. There is more detail on creating a Learning Organization in "Managing Quality in the 21st Century" on Bookboon.com (Knowles, 2011a)

6.3 Deployment Principle #3: Think Systemically

The aim is to improve the whole organization, think about the system not just individual processes. This is the importance of the annual diagnosis; individual projects and processes are managed throughout the year, but at least annually a holistic appraisal of progress and future direction must be undertaken to ensure that the systemic effect is as envisaged or wished.

6.4 Deployment Principle #4: It's About People

Remember that acceptance of the Six Sigma initiative is vital to its success. Don't forget the emotional journey that change takes people on. Help them to make sense of the proposed change, but expect some reaction to be emotional rather than purely logical. Help them to feel better about what they are losing and see the benefit in what they are gaining. Do not see people as a problem.

In my experience of Six Sigma deployments, the best results were achieved by companies which did the best job of changing how they selected and developed their people. It is also recognised as probably the most variable aspect of Six Sigma implementation.

One of the 'Six Triumphs' of Six Sigma cited by Goh (2010) is the clear assignment of roles and responsibilities within the initiative. Although the mantra of 'quality is everyone's responsibility' is correct in principle, the Six Sigma approach adds some focus in assigning specific roles to certain job titles.

6.4.1 Steering Team

Generally chaired by CEO and containing members (ideally all) of the senior team. As the team responsible for the strategic cycle they need to:

- Lead the Six Sigma transformation by generating vision and mission and linking this to the programme in a visible manner.
- Monitor and motivate the progress of projects.
- Have an integrated view of the projects and their links to strategic objectives.
- Co-ordinate cross-functional activities such as training.

6.4.2 Champion

This role is a non-executive role within the project team; the champion is a senior manager who supports the project and provides a bridge to the steering team (and hence the strategic cycle).

The most important role of the champion is to address barriers that are beyond the team's authority or scope. This is important to ensure teams feel supported and do not lose momentum. They will also be held responsible for this aspect of the project as well as the effective operation of the team (although not the outcomes).

6.4.3 Master Black Belt

As experienced and successful Black Belts the role of the Master Black Belt is to provide subject leadership and project mentoring to the Black Belts and Green Belts running projects. They also liaise with Champions to provide effective support.

6.4.4 Black Belt/Green Belt

Lead the project team in improving the process. Responsible for delivery of the project outcomes and for facilitating the team through the application of the DMAIC process. According to Keller (2001) the characteristics of a successful BlackBelt include:

- ***Positive Thinkers***: Upbeat and optimistic about programme success. Self-confident without being overbearing or defensive.

- ***Risk Takers***: Comfortable as change agents, happy to be leading, pleased to be at the leading edge of change.
- ***Good Communicators***: As the technical hub of the team they need to communicate details of tools to less well trained individuals. More importantly change is difficult for team members and the Black Belt will need to listen to concerns and respond positively to ensure buy-in to the project methods and outcomes.
- ***Respected by Peers***: Credibility is key.
- ***Leaders***: They are central players in the improvement and need to accept the leadership role.

6.4.5 Belt System Issues

Goh (2010) comments on the 'obsession with personal attainment' associated with the Six Sigma belt system. Too many practitioners, he feels focus on this as an end in itself. There are also issues around reward systems which sometimes give bonuses to Black Belts based on savings made. This may encourage game playing and over-claiming of benefits.

The second issue with the 'Belt' system is that by creating a parallel structure in the organization responsible for (and often rewarded based on) improvement activities that the rest of the organization is largely isolated from Six Sigma, except as occasional secondees on projects or as 'victims' of experts parachuted into their area. This may cause resentment in the wider organizational context. Further than that, it can lead to improvement being seen as the preserve of the Six Sigma elite and discourage others from making (perhaps simpler, lower level) improvements to their processes as they are not experts.

6.4.6 Emotional Aspects of Change

Six Sigma is about change, at all levels. The textbooks on Six Sigma focus very much on the process of change but Six Sigma requires attention to both methodology and behaviours (people). This is, in large part, conspicuous by its absence in both practical and scholarly literature. Where change is considered as a topic at all it is usually considered in a mechanistic, process focused context with resistance being seen as a problem. The most common title of chapters in this respect is 'Overcoming Resistance' which clearly cast resistance (and resistors) as a 'problem' to be solved. Logic and clear communication is often seen as the way to address the 'irrational and emotional' responses of the non-initiated.

Much of being an effective manager of change comes down to understanding these 'emotional' reactions in others – where do they come from, what do they hope to achieve through it and most importantly, what can you do to help them move forward.

The starting point is to begin to develop a high degree of self-awareness – what is your motivation, why do you maintain the beliefs and values that you hold dear, what drives your behaviour and what effect does this have on others? Remember also that you are dealing with individuals – terms such as 'the shop floor', 'the workers', 'the management', 'the front office' and so on are generalisations that hide a multitude of attitudes, emotions, motivations and behaviours. They do not describe the individuals that work within these units.

Figure 6.7 is adapted from the grief curve defined by Kubler-Ross. This recognises that all change involves loss. In an organizational sense this can be loss of expertise, status, connections and contacts, or control. The initial response is to deny the need for change, followed by resistance (which can be active or passive), then engagement with the change and exploration of possible effects followed by commitment to the new status quo. However, it should be noted that this does not occur at the same rate for all and that adverse interactions can send an individual back to an earlier phase.

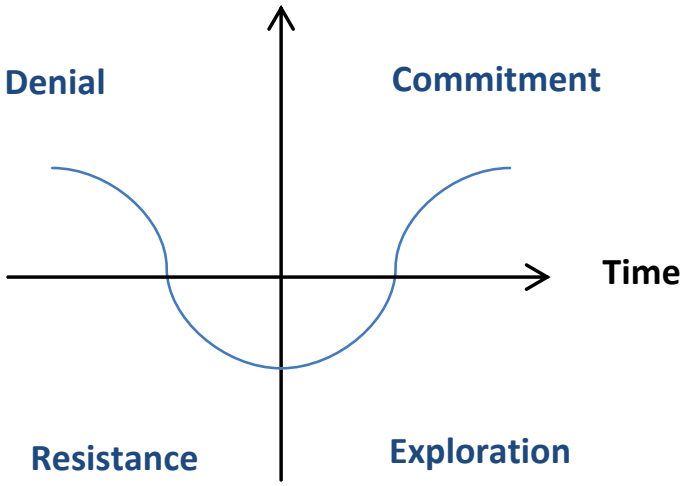

Figure 6.7. The emotional phases of change (adapted from Kets de Vries and Miller, 1984)

As a leader of change it is important to understand that all those involved go through this process (even you!) and that your job is to help them (and you) work through the emotional side of the change as well as the practical one.

Focusing on the individuals in change is an essential element of success. However we are talking about organisational change so we need to also consider the effect of the organisation. In the literature on change you will find a good deal of discussion of the relative merits of top-down and bottom-up change. Naturally there are strong arguments for both. Top-down change provides a framework for the organisation through the use of strategy, strong vision and the provision of enablers for change – such as resources, money, time, external support and so on. The down side is that often the requirements for the change are not fully understood at a local level, the message is lost on the way and the individuals in the organisation can feel uninvolved and therefore are unlikely to be motivated towards effective implementation. This would fit the typical Six Sigma deployment, as we shall see later.

Bottom-up change ensures that the change is based on a good understanding of local conditions, the needs of a particular unit of the business and the skills and interests of the people within it. A major benefit of a bottom-up approach is that through involvement you can gain understanding and commitment. The down side of bottom-up change is that it can result in sub-optimisation of processes if the scope of the project is not great enough, and of course it can meet with opposition from above if it is not seen to be supporting the goals of the business – or the goals of the individuals who have the right of veto.

As with many aspects of change the answer is of to do both. This approach has been described as 'Need-down, How-up'. That is the strategy and direction are provided from above (top-down) whilst the solutions and approach to change is generated locally and fed back up the hierarchy (bottom-up). I have seen this approach work well in an organisational context with directors providing the strategy and a multi-functional, multi-level project team providing the solutions – presented back to the directors as "This is what we are planning to do and this is the support we need from you in order to achieve it". The Hoshin model of deployment essentially fits this model.

Successful change is achieved through the changing behaviour of individuals and groups within the organisation. This change in behaviour only follows if people are motivated towards it – they need the answer to the question "what is in it for me?" This motivation comes through creating meaning. The key to creating meaning is involvement – that is, when people are fully involved in creating change than they are given a real opportunity to develop their own understanding of what it means for them.

If you are not able to fully involve everybody in the change then you will have to rely on effective communication to spread understanding and meaning. There are many way to communicate information but the most important aspect is to remember that it is a two way process. The meaning of the communication is in the response it elicits and different people will need different approaches – don't guess what makes people tick, build relationships based on trust and mutual understanding.

6.5 Deployment Model: Kotter

There are a large (and growing) number of deployment models and associated guidance available in the literature, and there will be an ISO standard for Six Sigma published soon. In many cases they are simply about selling of individual consultancies rather than having significant differences. This text will not be following any of them, but will consider more generic approaches. Kotter's (1996) 8 step model is perhaps the most commonly used generic change model:

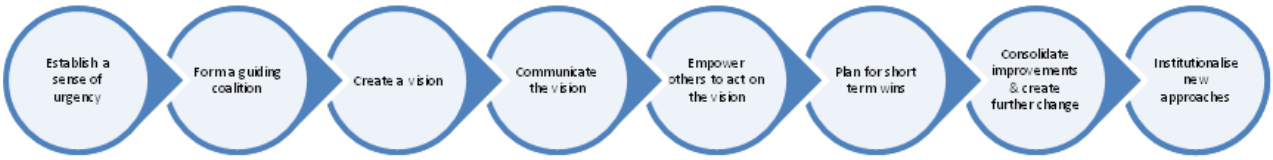

Figure 6.8. Kotter's change model (adapted from Kotter, 1996)

6.6 Steps 1 to 3: Envisioning the Transformation

The first step in transforming an organization is the recognition that current approaches and levels of performance are not sustainable in the long term. The senior team needs to recognise that something can be done, and that something must be done. The need for change needs to be clear and communicated. The usual form that this takes in Six Sigma is a litany of current failings and comparisons to superior competitors in order to create dissatisfaction with the status quo. However, this may have a negative impact on the early phases of the emotional journey of change; we are all invested in our existing processes to some extent and beginning change by attacking them may harden the initial denial and resistance phases. Also, being told you are no good tends to sap the energy of an organization. An alternative which is often more effective is to explore what the future vision might feel like and discuss aspects of the organization which currently work well. This can generate a motivation towards the desired state rather than away from the current one.

It is helpful if management do not arrogantly assume they know the ills of the organization; this can create a parent child relationship rather than create a coalition of the willing (to borrow a phrase rather discredited by recent history). A good place to start is by asking what is frustrating individuals in the organization, this again helps with buy-in and meaning for the individuals concerned and allows them to commit more easily to change as they can see what is in it for them. It also means that the senior management view of the problem is likely to be more complete and accurate, and thus the beginnings of the initiative more genuinely congruent with the issues.

Some are concerned that the bottom up element here might drive changes which are not in the strategic interests of the organization. This is to miss the point; firstly, if the strategy has been correctly deployed then it is very likely that the things which frustrate individuals at their organizational level are strongly related to their inability to do the job they wish for in the organization. Sarmiento, Beale and Knowles (2007) show that there is a positive and significant association between job satisfaction and performance. In short, what makes people unhappy is likely to be what is inhibiting performance. Also, the job of the top team is to make sense of the feedback and to create a strategic approach which effectively marries top down and bottom up issues.

This approach recognises a wider definition of the guiding coalition than is the norm. This is usually seen as being the 'top team' or a range of senior execs and managers. Clearly, these are important people who will drive the process, but if we build a coalition which ranges from the top to the bottom of the organization then we make their job much easier by giving them allies in every part of the business. Of course, it is naive to think that everyone will be engaged by this process, but it is about generating a critical mass, and this is much more likely achieved through engagement than through preaching.

Once the senior team has digested the feedback from around the organization it is time to develop a vision and mission which will motivate the whole organization to move towards the desired future state.

6.7 Steps 4 to 7: Enacting the Transformation

6.7.1 Create the Environment for Transformation

Communication of the vision is the first part of making it happen. It is important to ensure, as in the previous phase that the communication is not just one way, and that the way the strategy is deployed connects it to the local area and to what people are expected to do differently.

We need to engage a wide range of people actively in the transformation to be successful, and to become active in any change people need 3 things: Will, Focus and Capability (Smith and Tosey, 1999). Traditionally, Six Sigma initiatives are good at the focus and, for Black and Green belts at least, the capability; but outside the belt community the will is often addressed only by haranguing with facts and data.

Figure 6.9. The Will-Focus-Capability model

For individuals to act they need the will, this will be bound up with their personal motivations, and the culture and politics of the organization. They also need the capability; this will mean they need to have the skills, techniques and experience that allow them to deliver change. But to make it an attractive proposition to act they must perceive that this is a priority for the organization; leaders and managers must encourage and create an environment where the desired behaviours are supported by systems and procedures as well as their own actions and statements.

Many organizations try to begin Six Sigma with a campaign to win hearts and minds and lots of training. However, if there is no immediate organizational focus on action once the training has been conducted they will lose momentum. If we stir up interest with a campaign and set up appropriate systems but fail to show people how they can make a difference then we have the kind of top-down initiative which does not work because most people don't know what action to take. Finally, unless we address changing the culture and motivating individuals, process change and training will not make much difference; they could act, but the likelihood is they will not. For an effective transformation, the three elements need to be kept in balance throughout the process.

6.7.2 Develop Improvement Projects

Earlier we noted that under the Hoshin Kanri approach there are two types of improvement which might be required to achieve strategic goals, dependent on current performance, these are:

- ***Breakthrough***: where significant improvements are required.
- ***Incremental***: where continuous improvement will be sufficient.

Six Sigma projects are, in general suitable for the former and some 'beachhead' projects should be quickly set up to help deliver early and significant benefits to generate momentum. However, if this is all you do then the rest of the organization will feel side-lined, or that the initiative is not going anywhere as it will practically be invisible to them. Also begin to encourage lower level actions in respect of continuous improvement with a limited Six Sigma toolset and volunteer teams working on continuous improvement of their processes. Ensure resources are provided to support all improvement projects as an early failure will prove a large barrier to moving on with the deployment. The following is a sound process for this stage:

- ***Set up initial projects***: They must be clearly linked to business and customer priorities and to closing the gaps identified in the earlier analysis. Ensure that they are also in line with staff issues to further cement the idea that this is something that staff can own and influence.
- ***Identify and train staff***: Avoid a 'sheep dip' approach to training all staff, this is never effective and absorbs huge amounts of resource. Train those immediately involved in projects and those who might be affected by them to an appropriate degree. Train on a just-in-time basis so that skills are used very soon after they are trained.

- ***Generate quick wins***: Although projects may be systemic and long term in nature try to find quick highly visible improvements which can establish the potential and usefulness of the overall project. Publicise these quick wins.

6.7.3 Review, Measure and Evolve

Again, mindful of the principles of learning, measure the success of the process, look to build learning into individual projects as well as the wider initiative:

Measurement and Incentives: Goodhart's Law

Measurements and associated incentives are generally designed to support the goals of the organization, and to promote behaviours which fit the company's principles. But, if not properly thought through they can have unintended consequences. Goodhart's Law say that, in general, a good measure becomes a bad measure as soon as it is treated like a target.

Targets for waiting times in accident and emergency units in British hospitals have led to some hospitals reclassifying waiting trolleys as "beds with wheels" and other hospitals to request ambulances carrying patients to wait outside for a while to reduce the measured waiting time.

I have personally seen examples of inflated estimates of benefits from Six Sigma projects to allow Black Belts to meet their targets, and declaration of simple, regular improvement activities as Six Sigma projects to meet organizational targets on numbers of completed projects and money saved.

- ***Review projects***: Make sure that progress is reviewed regularly. Encourage reflection and self-assessment in the project teams and place emphasis on honest reporting rather than meeting goals. This is important at all times, but more so in the early phases when we are learning about the deployment and need to ensure the correct approach is being taken. Encourage 'double loop' learning where governing ideas as well as processes are challenged.
- ***Measure results***: Be honest about what results are being achieved, it is tempting to be over-optimistic to encourage acceptance, but people will soon learn the truth. Use the measures to learn; if we did not achieve what we expected to, why not, and how can we do better in the future? Never use measures to punish or reward as this will distort behaviours (see panel). Ensure measures of acceptance and feelings are recorded rather than just numerical results.
- ***Measure engagement***: How do people in the wider organization (as well as those directly involved) see the initiative? Are they supportive? More importantly, are they actively involved? This is a leading measure of how things are going; disengagement or disillusion will be the precursor for lower completion rates and reduced results.
- ***Celebrate success and learn from projects***: On successful conclusion it is important to recognise the efforts of those involved and publicise not only the benefits but also the things that have been learned.

- ***Review the initiative and realign priorities***: on project completion it is important to update the higher level and re-assess where priorities now lie for the next set of improvement activities. Making the connection between the tactical and strategic cycles. Build on what works and modify what doesn't.

At this point it is entirely possible that it becomes apparent that Six Sigma does not really work for your organization. If this is the honest outcome (at whatever point in the deployment) it is a valid response to exit and try something else. Clearly, tenacity is required for such a major transformation, but a head-in-the-sand approach helps no-one.

6.8 Step 8: Institutionalise the New System

As Jack Welch said, Six Sigma has to be seen as integral to the organization, it has to become the way you do business. This happens in a variety of ways:

- ***Talking the talk***: Managers need to ensure that Six Sigma is on the agenda at all meetings. It should become part of the key metrics of the organization and, as such be seen to drive policy.
- ***Walking the walk***: Never underestimate the power of visible and active involvement of senior execs and their first line in actually doing projects, supporting training etc.
- ***Embedding in daily life***: In GE Black Belts were expected to spend only 2 to 3 years in that role full time and then rotate back into management roles in the business so that, over time, more and more projects are run by qualified people within the main business structures rather than experts from the Six Sigma community.
- ***Keep Measuring, reviewing and evolving***: As your organization and environment evolves so should your Six Sigma initiative.

7 DMAIC Projects: Practical Details

7.1 Introduction

7.1.1 The DMAIC Cycle

This chapter looks at the DMAIC (Define, Measure, Analyse, Improve, Control), which is the methodology at the centre of Six Sigma.

7.2 The Define Stage

7.2.1 Purpose

The Define Phase has a number of key purposes:

- ***Links to the strategic cycle***: Firstly it links to the strategic cycle (see section X) to assess the current project against the strategic objectives and ensure that it something which has the potential to contribute to strategic goals.
- ***Project definition***: Once the project is cleared as aligned to the corporate strategy the project scope, objectives, sponsors, schedule, deliverables and team members should be identified.
- ***Team formation***: As with all change projects a team of knowledgeable and motivated individuals should be formed and supported in developing an agreed understanding of the project.
- ***Assess the potential benefits***: An initial understanding of the benefits of the project (financial or otherwise) needs to be developed and agreed with sponsors. Develop measures of success relevant to this project.
- ***Learn about the process***: In the define phase we need to understand how the process works and who it affects and links to; in particular customers and suppliers of the process (internal or external) need to be considered along with what they get from, or provide to the process.

7.2.2 Actions

The Define Phase has a series of interlinked actions, the numbers imply a sensible order, but this may well be an iterative process:

- ***Review strategic plan***: Build a clear understanding of how the project contributes to organizational goals. Is this a good use of resources when considered strategically. Identify appropriate sponsors and champions to support the project. Select appropriate measures
- ***Review the opportunity***: What do the customers want? What is the current performance of the process? Realistically, what is the opportunity for improvement? Is the effort involved in improvement likely to be repaid by the benefit?
- ***Canvas support***: Build links with the people who are going to have to live with the change early in the project. Is there an appetite for change? Can changes be made in a way which is a good cultural fit with the area and create a win/win situation?

- ***Form the team***: Blend expertise in process improvement with process knowledge and ensure that aspects such as motivation and linkages to the rest of the process stakeholders are considered (leaders, whether official or de facto need to be incorporated for example).
- ***Agree timing plan and review process***: The team need to agree the timescale for the project and conclude a rough project plan so that progress can be effectively monitored. Agree what feedback is required, to whom, and when it will occur.
- ***Learn about the process***: Gain deep knowledge of how the process works by interaction with people involved in the process and observation of the process in action. Ensure that the picture you build up is accurate by testing it with key fact holders. Clarify principal customer requirements and review the measures identified in step 1 for consistency with these requirements.
- ***Streamline and standardise the process***: Take advantage of any 'quick wins' to ensure that obvious sources of variation and waste are removed.

7.2.3 Principal Tools and Techniques

The list is not meant to be definitive, but indicates the sort of tools/techniques which will be relevant.

- ***Review strategic plan***: This step does not require specific tools, ideally this should be developed from the Hoshin Kanri process (see chapter 5) and comparisons with strategic objectives and action plans.
- ***Review the opportunity***: Cost of quality approaches, waste analysis, customer satisfaction questionnaires, etc. approaches to identify opportunities for improving cost, speed or customer satisfaction.
- ***Canvas support***: No specific tools required, but appropriate direct involvement with local staff. Approaches such as appreciative enquiry or stakeholder analysis might help to build support.
- ***Form the team***: Belbin team analysis may help, although the reality is often that the team will be built from the willing and the knowledgeable rather than the optimum blend of character types. Developing a project charter helps to gain commitment to the objectives and means. Ensure team members are trained and confident in the methodologies proposed for the project.
- ***Learn about the process***: Use a variety of flow charting techniques to develop an understanding of the process flow (A high level process map is often useful to start with, a Supplier-Input-Process-Output-Customer Diagram helps to understand process linkages and more detailed process flow charts may be used later if required). Listening to the voice of the process will require a data collection plan, the use of appropriately selected control charts, and process capability analysis.
- ***Streamline and standardise the process***: Simple tools such as cause and effect, pareto etc. and standard operational definitions can be used to help this process.

7.3 The Measure Stage

7.3.1 Purpose

The Measure Phase has a number of key purposes:

- ***Establish metrics and measurement system***: What are the Critical to Quality (CTQ) elements? How should they be measured? Is the measurement system capable of discriminating to an appropriate level?

- ***Listen to the voice of the process*** : Understand present levels of performance in detail. Is the process stable? If so, what is the level of capability?

7.3.2 Actions

The Measure Phase has a series of interlinked actions, the numbers imply a sensible order, but this may well be an iterative process:

- ***Select metric and measurement system***: Remember to review the question being asked and to generate the most appropriate measure. This may not always be as obvious as it first appear (see info box).
- ***Run control charts***: Control charts are the only effective way of establishing whether a process is stable or whether it is under the influence of special causes.
- ***Assess process capability (sigma level)***: Using DPMO measures we can establish a notional sigma level for the process, or using conventional process capability approaches we can calculate a Cp or Cpk value. Of course, the assumption of normality means that we need to establish stability before either of these metrics can usefully be calculated.

Measuring Safety

Supposing we wish to measure the safety of rail travel in a particular country:

1. We could measure the number of deaths per departure. However, this neglects the fact that some trains carry more passengers than others, so…
2. We could measure the number of deaths per passenger journey. However, this weights short and long journeys the same, which does not seem fair, so…
3. We could measure the number of deaths per passenger kilometre travelled. However, this is confused by the fact that some trains travel faster than others, so…
4. We could measure exposure to risk by number of deaths per passenger hour on a train. However…

As you can see, we can make a cogent argument for (or against) any measure which we consider. And this is before we consider whether risk of death is the best measure of safety. Would risk of injury be better? How do we weight the different types of injury…?

7.3.3 Principal Tools and Techniques

This is pretty self explanatory, to establish process stability it will be necessary to apply some form of control chart, the actual combination selected will depend upon the situation. Measurement System Analysis or Gauge Repeatability and Reproducibility Studies would normally be associated with ensuring an acceptable measurement system is used, and Process Capability Analysis or DPMO/Sigma level calculations will effectively assess the current process capability with respect to customer requirements.

7.4 The Analyse Stage

7.4.1 Purpose

The Measure Phase has a number of key purposes:

- ***Analyse the value stream***: What are the necessary steps to deliver value for the customer?
- ***Analyse the sources of variation*** : What are the potential sources of variation in the process for both special and common causes? How can they be verified as significant (or otherwise)?
- ***Establish key process drivers***: What are the critical x's which contribute to the achievement of the CTQs?

7.4.2 Actions and Associated Tools

The appropriate actions for the analyse phase will depend upon the outcomes of the measure phase (obviously) and on the issue being tackled so this is a broad guide only.

- ***Value stream analysis***: Establish the process steps which create value for the customer. Understand which elements of the existing process add value and which do not, reduce non-value add.
- ***Analysing sources of variation***: Initially seek to understand all potential causes of variation by use of tools such as brainstorming and cause and effect analysis. Establish those which seem to be common and those which are likely to be special. Simple analytical tools like pareto diagrams can be used to establish the most frequent causes. More sophisticated tools such as design of experiments, correlation plots and hypothesis testing can more rigorously establish the significance of effects or relationships.
- ***Establish key process drivers (sigma level)***: The same tools are used here as in bullet point 2 above.

7.5 The Control Stage

7.5.1 Purpose

The Measure Phase has a number of key purposes:

- ***Standardise the new process***: Document the new process, test with the staff to ensure they are happy with the solution. Train everyone and investigate opportunities to standardize across products, sites etc.
- ***Create new measurement and control regime*** : Set up measurement regimes which are aligned with the new process and required behaviours. Put in place control mechanisms such as SPC to ensure that improvements are maintained. Verify and re-verify the savings and benefits of the change.
- ***Document lessons learnt***: No project can be completed without the team learning about both the process they are working on and the process they employed to do it. Conduct an after-action review and document lessons learnt.

7.5.2 Actions and Associated Tools

The appropriate actions for the control phase are listed below:

- ***Flowchart and map process***: To clarify the new process.
- ***Run workshops***: To test the solutions with the wider population.
- ***Set up controls***: As required to provide ongoing control.
- ***After-action review***: To understand key learning points.

7.5.3 Principal Tools and Techniques

This is pretty self explanatory; flow charts, SPC charts (of whatever type is useful) and after action reviews as required.

7.6 Summary

This chapter gives a broad overview of how the DMAIC cycle operates. It is necessarily rather mechanistic, but subsequent chapters will build on this rather anodyne base to consider specific aspects in more detail.

8 Successful DMAIC Projects

DMAIC projects are really microcosms of the larger initiative, so the principles for sustainable deployment are applicable here too, however, there are a few further points worth making.

8.1 Project Selection

Projects need to be clearly linked to strategy, have the potential to deliver significant benefit and be motivating for the team involved, sponsors and other stakeholders.

8.2 Black Belt Skills

The technical, project management and, perhaps more crucially, change leadership skills of the project Black Belt are one of the most crucial contributors to success.

8.3 Local Involvement

Expertise in the problem under consideration always lies in the local area. The ability to mobilise and involve the local workforce is crucial. Their contribution to the project not only improves the chance of a comprehensive solution, but also of the solution being accepted.

8.4 Appropriate Application of the Process and Correct Tools

The DMAIC process is a tried and tested approach, supported by rigorous logic. Skipping steps or changing the order is not sensible or effective. There are clear indications of appropriate tools at the various stages and these need to be used effectively. Remembering, of course, that it is important not to use tools just because you have them – use the simplest appropriate toolset for the problem in hand.

8.5 Project Team Learning Environment

8.5.1 Develop Dialogue Within the Team

An open environment is required to allow for genuine dialogue. Dialogue is about exploration and openness. Team members must feel free to challenge ideas and decisions and to express opinions. Team leaders need to utilise the knowledge and expertise available to them to develop a comprehensive understanding of a situation, and to do what Weick et al (2005) described as "sense-making". The team leader draws upon the views of multiple informants to create a 'map' of the topic area. The map may not be the objective truth in a complex situation, but it represents the best combination of existing knowledge, and therefore the best basis for decision making. A leader making decisions might consider the following model of communication:

"This is how I see the situation. Does anyone see something I've missed, or have a different view?"

"Based on the understanding I have outlined, these are the options I can see. Does anyone see any other options?"

"These are the criteria I think are relevant (and their relative importance) to make the decision, and this is why. Does anyone disagree with these criteria, or feel there are any to add?"
"So this is my conclusion on what to do. Does that make sense? What have I missed?"

This encourages contributions and co-creation of strategies and often brings to the ore tacit knowledge which the holder was unaware might be significant.

8.5.2 Share Information

There can be a tendency to see the Black Belt as the expert and the holder of knowledge, it is tempting to hold information until it is needed. The principle is to share as much as possible, as soon as possible. It is impossible to know how and when people will use information, and too little is far more of a problem than too much.

8.5.3 Create a Reflective Space

Too often projects are driven by deadlines and outcomes. All discussion focuses on delivery and goals. This does not allow the team space (either individually or as a group) time to reflect on what has happened, and what it means. Valuable learning opportunities are lost. The Black Belt needs to create regular space or reflection and perhaps prompt it by the use of learning logs and discussions. Research shows strongly that writing something down increases your understanding, and that discussing it with someone else increases it still further.

8.5.4 Use Metrics and Goals Formatively

Targets and milestones are often used in a judgemental way, with laggards being chastised and those who are on target praised. However, this kind of behaviour leads to dishonesty and game playing, thus starving the team of the opportunity to learn. Use missed targets and goals (as well as achieved ones) as an opportunity to learn. Encourage honesty and support open discussion of how to do better.

8.6 Summary

Sis Sigma DMAIC projects are often conducted in a rather mechanistic way with an undue focus on tools and process. Of course these things are important, but if the softer aspects are not considered and appropriate approaches applied chances of success are compromised. Eckes (2001) amongst others notes that the majority of Six Sigma projects that fail will do so because of the human element.

9 Six Sigma: A Critique

9.1 Introduction

Six Sigma literature tends to present overwhelmingly 'how to' techniques along with the positive aspects of this approach and, with very few exceptions, avoids discussing its problems and failures. Much of the literature lacks critical appraisal, and this section is designed to address some of the issues.

9.2 Accepted Strengths of Six Sigma

These have been discussed at some length already, but a few bullet points will serve to remind:

- Strong links to strategy.
- High levels of management focus.
- Key roles allocated to create focus supported by structure and skills training..
- Linking improvements in quality to business benefit.
- Focus on customers.
- Focus on variability.
- Process driven.

9.3 Reasons for Failure

There is beginning to be some recognition that Six Sigma does not always work. Gupta (2008) suggests that as many as 60% of all Six Sigma initiatives fail to yield the desired results. Zimmerman and Weiss (2005) note that less than 50% of aerospace companies are satisfied with their Six Sigma programmes. It should be noted, however, that detailed information about Six Sigma failures is rather scarce and is mainly found on the web sites of consultancy critiquing approaches by 'other' companies. Common suggestions are:

- Lack of commitment from top management;
- Using part-time instructors;
- Having projects tied to insignificant criteria;
- Setting incorrect targets, perhaps based on the number of people trained and certified rather than on bottom-line results;
- Poor project management;

My experience would suggest that a lack of cultural readiness (see Chapter 6) and in particular poor attention to the softer aspects of change make for less sustainably successful implementation.

9.4 Critical Success Factors

- ***Senior Management Commitment:*** The most important factor in initiative success is the direct engagement of the senior team. Six sigma is not a spectator sport. Active participation in driving the process needs to be encouraged by all means.
- ***Effective Training:*** As Six Sigma relies upon the leverage of an expert resource it is not sensible to skimp on developing that resource. Evidence suggests that resource spent on training black Belts pays back several-fold.
- ***Black Belt Selection:*** As per the previous point this is very important. Personality, project management skills, skills in managing a multidisciplinary team, and communication skills are all important for effective black Belts.
- ***Communication:*** Communication is an extremely significant factor for Six Sigma success. An ideal Six Sigma implementation plan implies early communication to all the employees the necessity for change and benefits that this change may bring to the company. Goldstein (2001) illustrates this point, saying 'if the program launch makes the general employee population feel left out, it will be difficult to gain its support and contribution when the need arises later on—and it will arise'.
- ***Cultural Change:*** Cultural change is often named as the ultimate aim of Six Sigma in many publications which makes it being a critical success factor somewhat tautological, however, the importance of cultural issues is supported by research suggesting that if company has already practiced TQM, Lean or SPC the implementation of Six Sigma is generally more successful.

The table below summarizes Six Sigma CSFs and separates CSFs that influence the overall success of Six Sigma initiatives from the factors that mainly affect the success of Six Sigma projects:

6 Sigma CSFs	Corresponding Causes of Failure
Initiatives CSFs	
Top management involvement and commitment	Lack of commitment from top management
Understanding Six Sigma tools and the quality of training given to the employees	Using part-time instructors
Linking Six Sigma projects to the company overall strategy and the customer needs;	Having projects tied to insignificant criteria; Setting incorrect targets - number of people trained and certified rather than on bottom-line results
Selecting of BBs	Wrong team
Organizational structure that supports communication teamwork culture	n/a
Linking Six Sigma to HR policies	n/a
Cultural issues should be addressed and lead to a cultural change	Treating Six Sigma as another "quality" initiative, which creates cynicism
Implementation should be 'right' –gains people's commitment	Using part-time instructors; poor implementation that does not gain people's commitment;
Projects CSFs	
Project leadership and management	Having projects tied to insignificant criteria; poor project management
Project should be focused on the essential business processes	Having projects tied to insignificant criteria;

Table 9.1. CSFs and reasons for failure

9.2 Inherent Conceptual Issues

The last section looked at CSFs and considered how to get the best from Six Sigma, but it behoves us to also consider whether there are inherent issues in the approach. Many companies such as Motorola, Kodak, Honeywell that achieved considerable savings and improvements in quality, nevertheless, have been facing declining revenues and loss of market share (Abramowich, 2005). At the same time quality-leading companies like Toyota choose not to adopt Six Sigma. Additionally, despite the declared savings, Six Sigma does not significantly affect company stock price (Goh et al, 2003). So what are the inherent issues?

9.2.1 Creativity and Innovation

Six Sigma focuses on optimising what you have, potentially at the expense of innovating for the future. This statement may be illustrated by several examples describing how new innovative products such as computer scanners, email, electronic photography, digital imaging, colour printers, computer networking have pushed quality enhanced by Six Sigma copiers, film and phones made by Xerox, Kodak, Polaroid and Motorola to the margins (Shelley and Wilson, 2002). Another example may be the history of International Business Machines Corp. (IBM); Gilbert (2002) claims Six Sigma was almost a religion there in the early 1990s and the focus was almost solely on improving products quality. That resulted in winning a Malcolm Baldrige Quality Award at the facility in Rochester. However, it did not help the company to stay in business due to the fact that 'IBM was, in many cases, building the wrong products' (Gilbert, 2002). For example, while IBM was reducing the defects in its networking equipment, Cisco Systems Inc. introduced a new type of networking equipment, known as routers. While IBM was making incremental improvements to its disk drives, EMC Corp. was developing a completely new approach (known as RAID) for redundant arrays of inexpensive disks. As a result Cisco and EMC experienced unprecedented growth and took the leading position in the markets away from IBM.

Anderson (2006) notes that the economic focus of Six Sigma distracts from customer satisfaction, leading to a focus on only current static CTQs and lack of attention to unexpected or 'delighting' features (as in the Kano quality model); little reference to varied customer expectations or lifestyles; not anticipative of technological, social, or business changes (Goh, 2002). This fact was admitted by several Six Sigma practitioners. For example, GE CEO Jeff Immelt (2005) claimed 'we want to make it O.K. to take risks and do things that aren't just going to [produce results] this quarter'. All these factors result from the fact that Six Sigma in its current form not only lacks innovation and creativity but may even suppress it.

9.2.2 Limiting Learning

Six Sigma can negatively affect various aspects of learning within an organization. First of all, Six Sigma may reduce learning options only to single-loop learning (i.e. fixing problems) rather than double-loop learning which challenges norms and produces breakthroughs. This happens due to the fact that Six Sigma projects are overwhelmingly focused on fixing problems and providing quick financial benefits (an average Six Sigma project lasts about six months) rather than exploring long-term perspectives (Abramowich, 2005). The research done by Juran Institute had studied several companies that practice Six Sigma shows that 'benefits are being generated almost entirely on an internal cost reduction basis' (Juran Institute, 2003).

Finally, it seems that Six Sigma is able to create a certain atmosphere that prevents learning and open discussion. There are several factors that lead to this. First of all, the implementation of Six Sigma initiatives is usually highly top down. The company top management having made considerable investments in creating Six Sigma infrastructure, expects to receive a good return on these investments through Six Sigma projects. These expectations create pressures on the employees that lead to the situation where savings due to Six Sigma are over counted, but management has made people afraid to speak their true opinions. Those who do so risk damage to their careers and are labelled 'not team players'. Thus, expectations of high ROI often inhibits open discussions that are an integral element of the learning environment.

Secondly, Six Sigma due to its focus on 'low hanging fruits' often creates a culture of 'if it is not broken, don't fix it' (Abramowich, 2005) that implies that projects are initiated to fix the problems that are visible and obvious. This also inhibits discussion on the issues that require long term efforts or do not promise instant results.

Finally, another major contribution to inhibiting learning is made by Six Sigma management system that may be characterized as command and control management system (Seddon, 2006). Seddon (2006) describes Six Sigma as 'hierarchical direction (command) and reporting (control) structures'. Such principles of management mitigate against an organizational learning environment that requires people's involvement in making decisions and implementing them. Thus, this system may isolate the employees from several stages the learning cycle. Besides, due to highly stressed financial focus this system can often facilitate frauds in reporting. As Seddon (2006) claims people 'learn to report any good news as related to a Six Sigma project' in order look good in reports that look 'as though things are improving'. However, add Seddon (2006) such 'improvements' 'are nothing compared to changing the system and often the 'improvements' are actually making things worse'. This situation is reflected in a difference in perception of Six Sigma by management and by workers noticed by some scholars (McAdam & Lafferty, 2004) and that can be more vividly revealed by reading the blogs of the employees who experience Six Sigma implementation (some examples are collected by Shelley and Wilson, 2002).

9.2.3 Anti-Involvement

Often touted as a way of involving everyone in an organization in improvement some scholars (e.g. Klefsjo, 2001) suggest that the opposite is true due to an over-reliance on Six Sigma belts structure at the expense of total involvement.

Despite the comments by many scholars, for example Kwak and Anbari (2006), on the importance of continuous education and training for every employee (not only for belts), Six Sigma can limit learning among the employees to development and education of only the belted employees. According to several researchers this happens quite often and in many Six Sigma companies learning is mainly limited within the group of Six Sigma specialists (McAdam, 2005; Wiklund and Wiklund, 2002). Even for Master Black Belts and Black Belts learning is often reduced to training (McAdam, 2005) that reduces the learning capacity of the system to the learning capacity of Six Sigma belts. As Bicheno and Holweg (2009) pointed out, the perceived elitism of Six Sigma was a key reason for Toyota regarding it as not appropriate for their high quality organization.

9.3 The Future

Six Sigma is constantly evolving. New combinations spring up in seemingly endless numbers. Some are superficial in the extreme and appear to be more about giving consultants something new to sell than about improving the Six Sigma Paradigm. Into this category I would place Lean Six Sigma (and the variant titles); for the most part it is bolting Lean tools into the Six Sigma framework in a way that savvy practitioners had already done informally. It fails to engage with the aspects of Lean which challenge Six Sigma (mass involvement versus expert leads, for example). Design for six Sigma appears to offer more hope, but closer examination shows that in a lot of applications it stifles innovation just as much as Six Sigma can by focusing on strict processes for risk reduction rather than supporting innovation.

Perhaps the most promising ideas are those that attempt to genuinely address the issues raised with six sigma in this chapter, these tend to revolve around combination with bigger concepts such as Excellence Models or TQM principles, which are much more challenging and promising on issues of leadership, people, innovation etc. Of most interest are the attempts to combine Six Sigma with Organizational Learning principles. There does seem to be a genuine synergy between these two approaches. And this logic, while not perhaps bringing us full circle, leads us back to the work of Jack Welch at GE. He has stated time and again that he had to turn GE into a learning organization before it was ready for Six Sigma; the GE workout process was a critical pre-cursor to Six Sigma (Ulrich et al, 2002). Sadly, few appear to have heeded his words despite lauding his contribution.

9.4 Summary

Despite the real benefits Six Sigma can, and does bring, to organizations Kwak and Anbari (2006) point out that it is not the solution to all business problems. Used appropriately as part of the way organizations tackle business transformation and in conjunction with broader principles, it has much merit. Unfortunately it has often been hijacked by reductive thinkers who see short term problem solving and cost reduction as the way to drive organizational success. This makes Six Sigma just another way of squeezing more out of our creaking processes and, worse, our people.

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