University of Nottingham
MMME3049 Management and Professional Practice
Quality Management
2022-2023

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Learning Outcomes

This lecture addresses LO1 of Module MMME3075

Understand the basis of modern techniques of Project, Programme and Quality Management

At the end of this lecture you should have a basic understanding of Quality Management including:

- What quality is
- The principles of quality doctrine
- Statistical process control
- The concept of six-sigma
- DMAIC
- Robust design in the context of quality management
- Zero defects

What is quality?

What is quality?

Car for sale

- New tyres
- Low mileage
- Toyota hybrid
- Energy efficient
- Zero vehicle tax
- One careful owner

What is quality?

What is quality?

The customer buys a car

The car is reliable
It performs as expected
The finish is as expected
It is robust & the car remains in good condition
The running costs are

Is this quality?

What is quality?

The customer posts a letter

The letter arrives on time
The letter arrives in the right place
The letter arrives in good condition
The cost is acceptable.

Is this quality?

What is quality?

A colleague asks me to provide a list of e-mail addresses for a marketing project

The list is accurate
The list is in a readable format
It include all the addresses required
It does not contain any inappropriate addresses
It contains no outdated email addresses

Is this quality?

What is quality?

There are many definitions of Quality…

Judgments by an individual, organization or other entity
Fitness for purpose
The ability of a product to satisfy the users
Acceptable performance
The product meets its requirements (a systems engineer's perspective)
Whatever your customer says it is! (An American restaurant perspective)

What is quality?

The Perception of Quality

One problem that besets Quality Managers is the perception of quality.
For example, some people will pay a considerable premium to buy a washing machine or other white goods from a high end brand, such as Miele, AEG or Bosch.

What do customers expect for the premium price?

More particularly, what quality issues would cause the customer to transfer their loyalty to another brand?
It is likely that each customer will have their own criteria.
This is known as **Individual Quality Experience (IQE)**

What is quality?

Producers and customers typically think in terms of:

- Innate excellence – do we perceive it as quality?
- fitness for intended use
- Performance, reliability and / or durability
- Level of technology
- Convenience of use
- Attractive appearance and style
- Value, or the ratio of performance to cost
- Customer service before and during sales
- On-time deliveries
- After-sales service

Quality Doctrine

Quality Doctrine

Principle 1

Quality is the responsibility of everyone involved

Thus quality is the responsibility of:

- Engineers
- Mangers
- Accountants
- Production workers
- etc.

However, it should be led from the top

Quality Doctrine

Principle 2

- Quality requires continuous improvement in all areas
- There are always opportunities to improve the way we operate. It is essential for progress that these areas are identified and steps taken to improve
- The world changes. If we don’t continually improve, our quality is decreasing

Quality Doctrine

Principle 3

Quality comes from prevention at the earliest possible stage in the system

- Simply detecting a defect is not quality
- If you find a defect you have already paid for it
- The cost of quality
- How do we restore our image?

Quality Doctrine

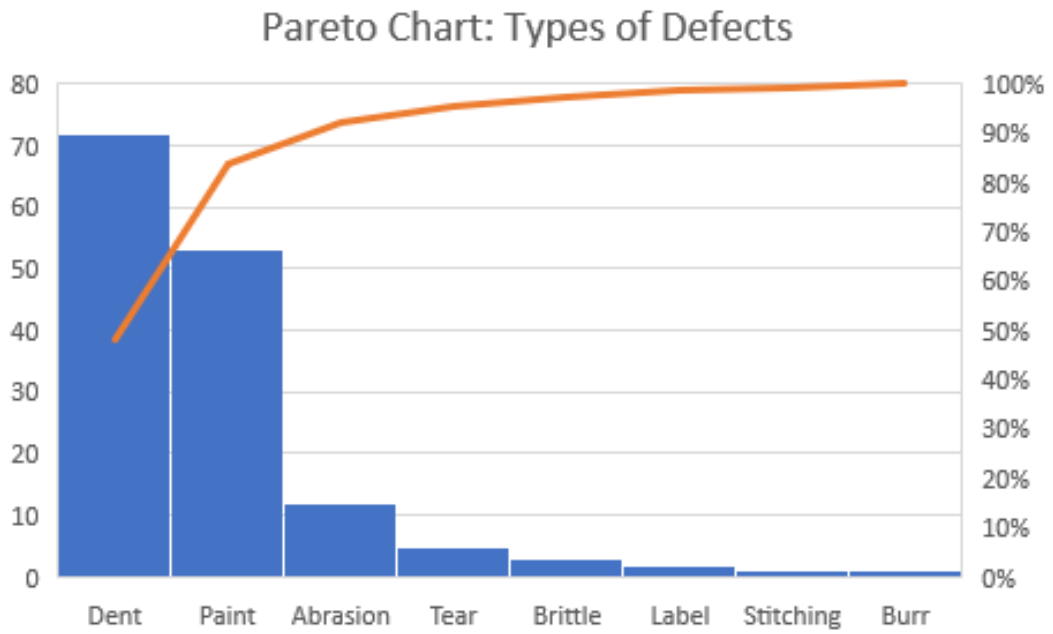
Principle 4

Prioritise improvements for maximum system benefit

- Select the process for improvement which will bring about the largest increase in system quality
- Pareto
- Prioritisation matrix

Quality Doctrine

Principle 4



Statistical Process Control

Statistical Process Control

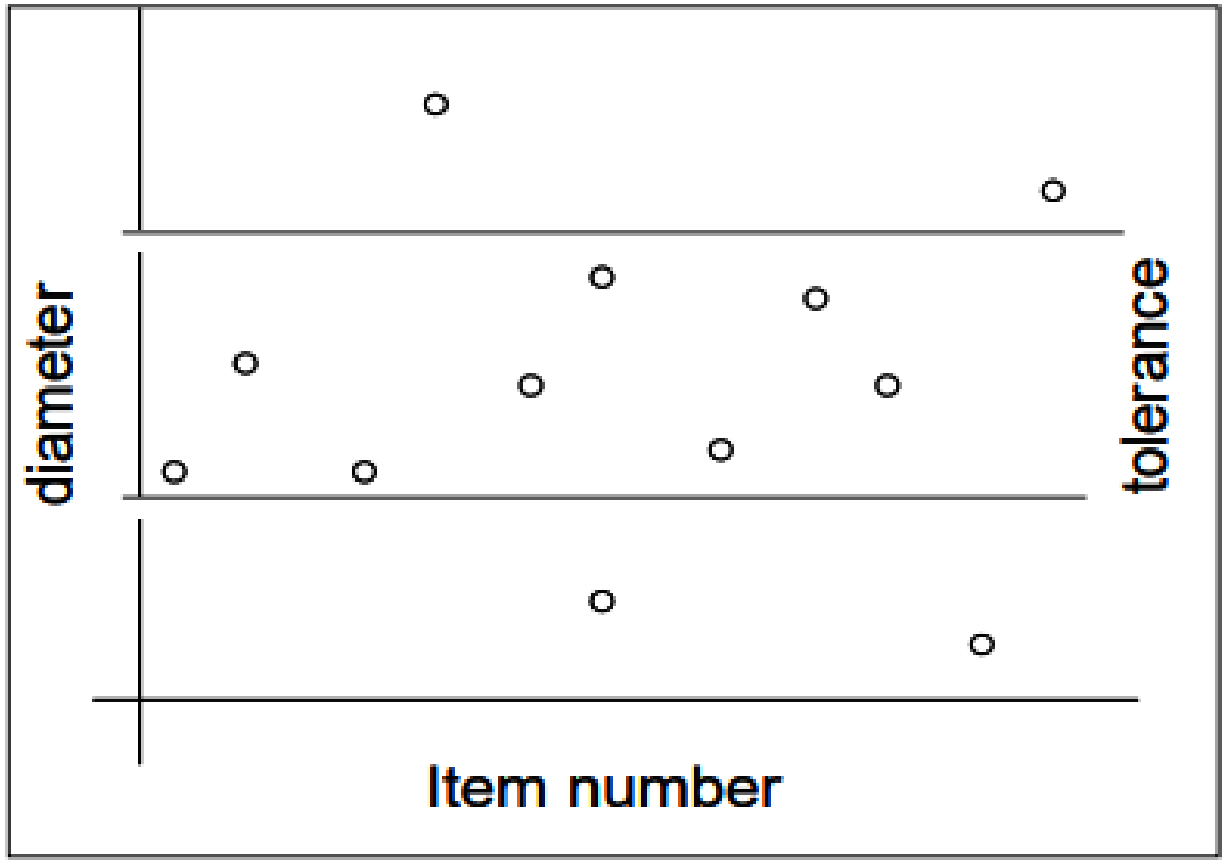
Early Days of Quality

- Quality was usually a simple “go / no-go” system
- As an example parts were measured and found to be either within tolerance or not .
- Little or no analysis of the statistics or trends in the process.

Statistical Process Control

Control Charts

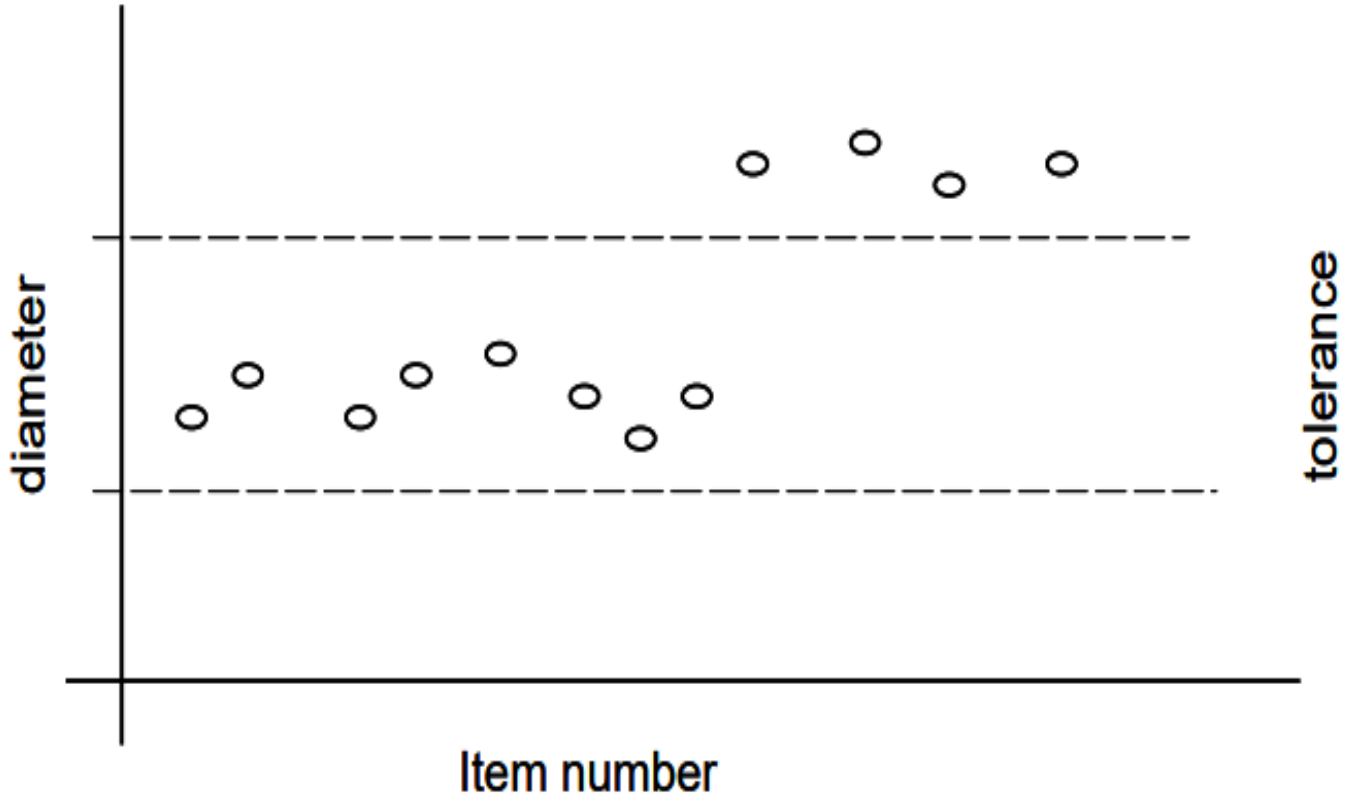
- The key parameters of a process are measured & monitored
- This allows the process to be evaluated in terms of both capability and trend
- Control Charts can help us answer quality questions



Is the process suitable for the job?
Should we grind rather than turn?

Statistical Process Control

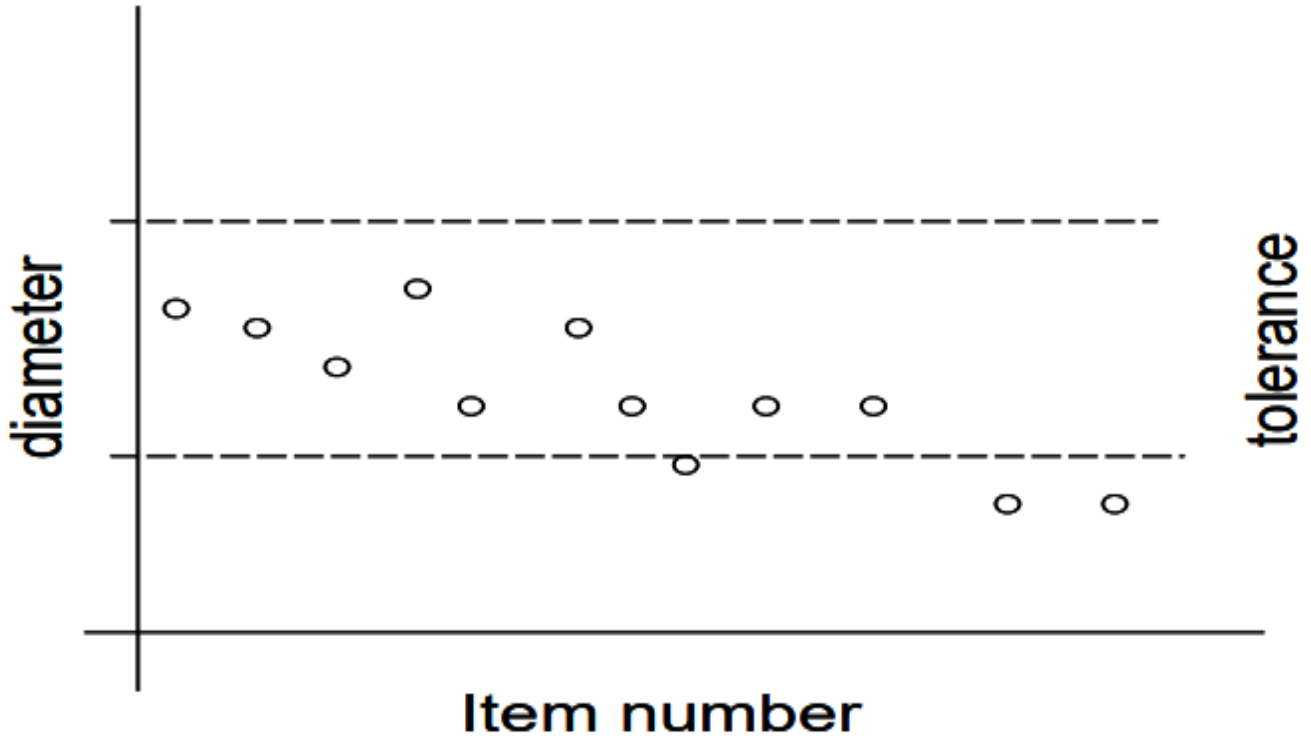
Control Charts



What does the control chart show us?

Statistical Process Control

Control Charts



What does the control chart show us?

What is Six-Sigma?

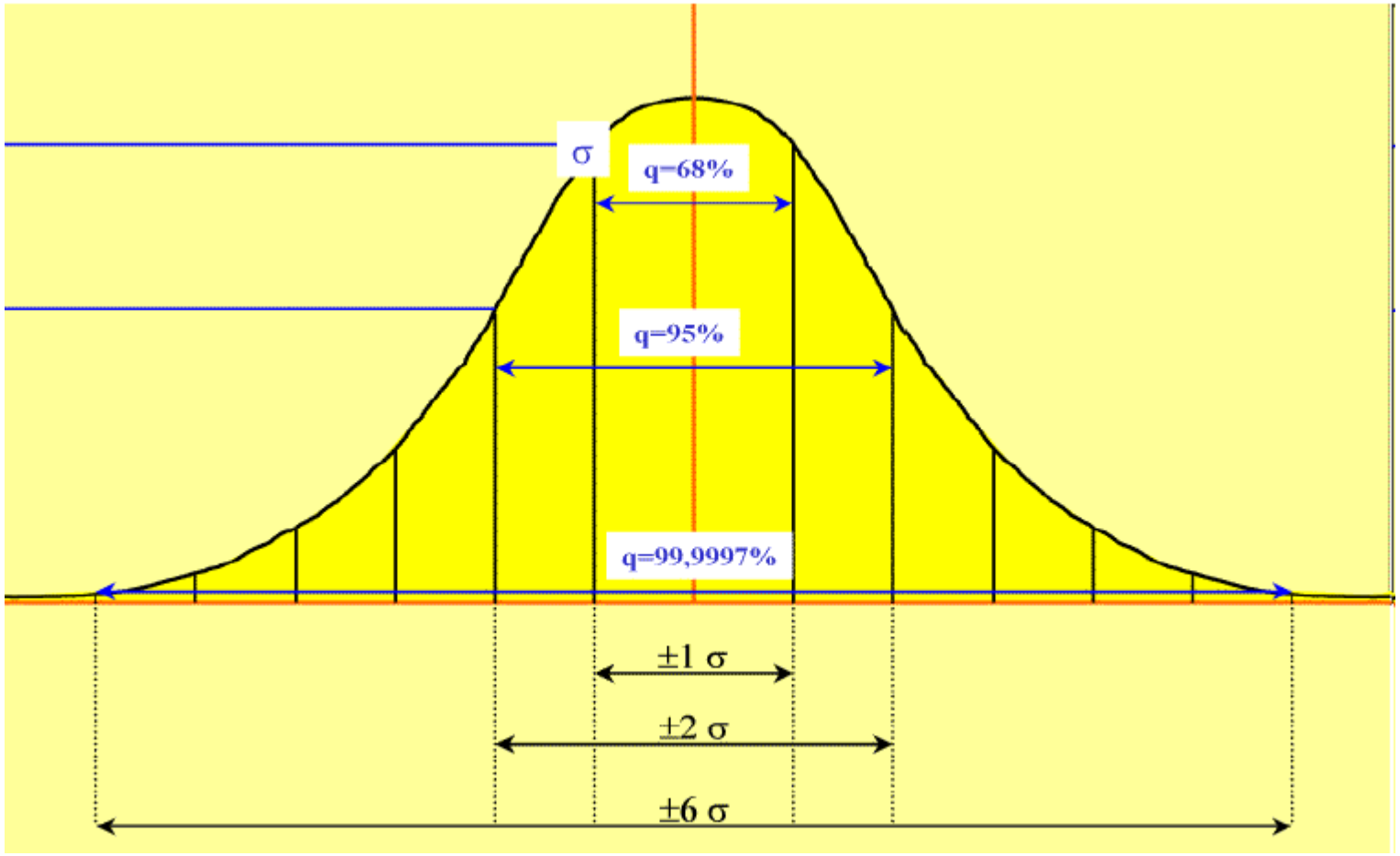
What is Six-Sigma?

A quality methodology that brings together:

- Statistical process control
- A focussed, customer oriented culture
- Organised staff training
- Leading management methods

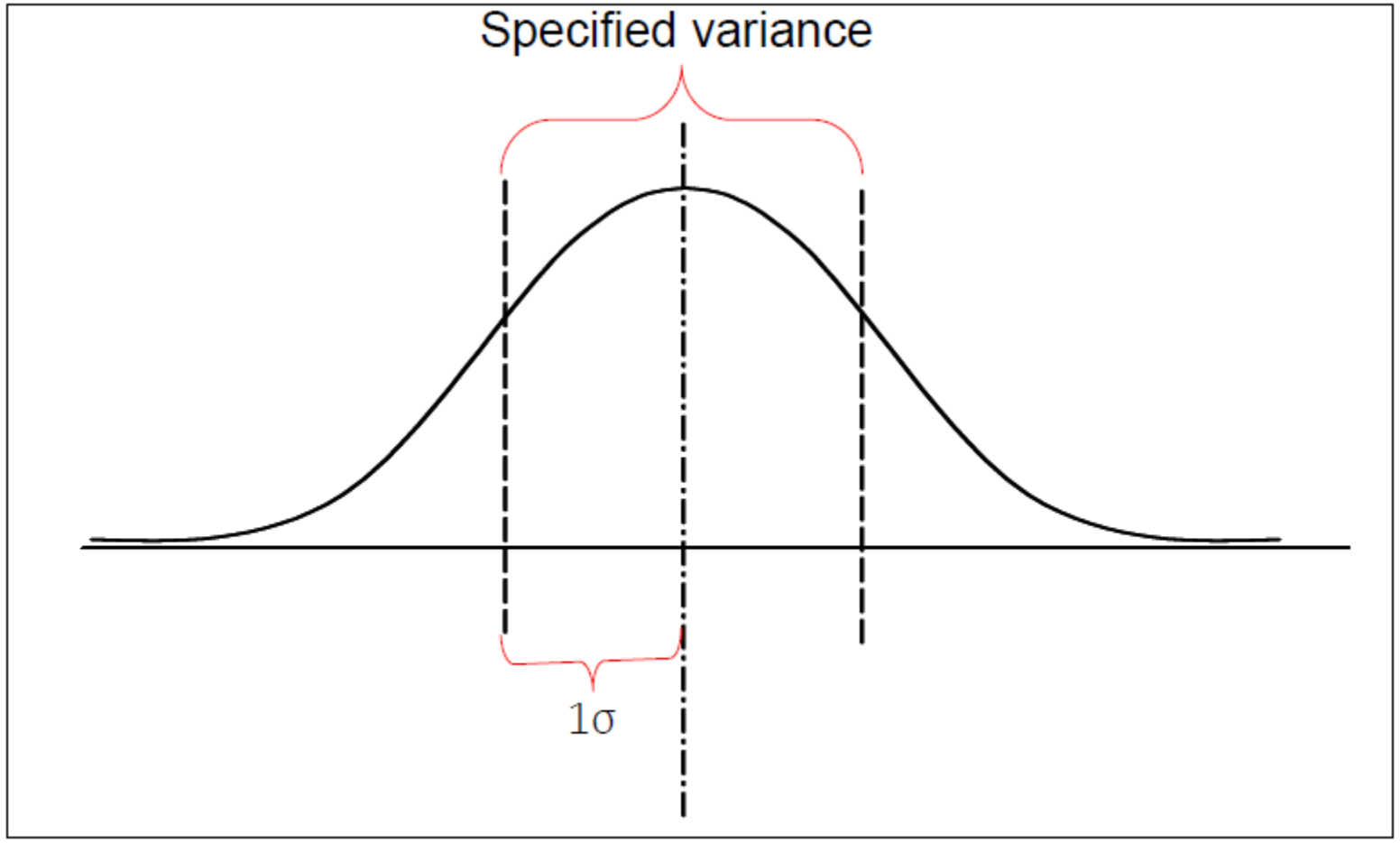
What is Six-Sigma?

A Statistical Perspective



What is Six-Sigma?

A Statistical Perspective



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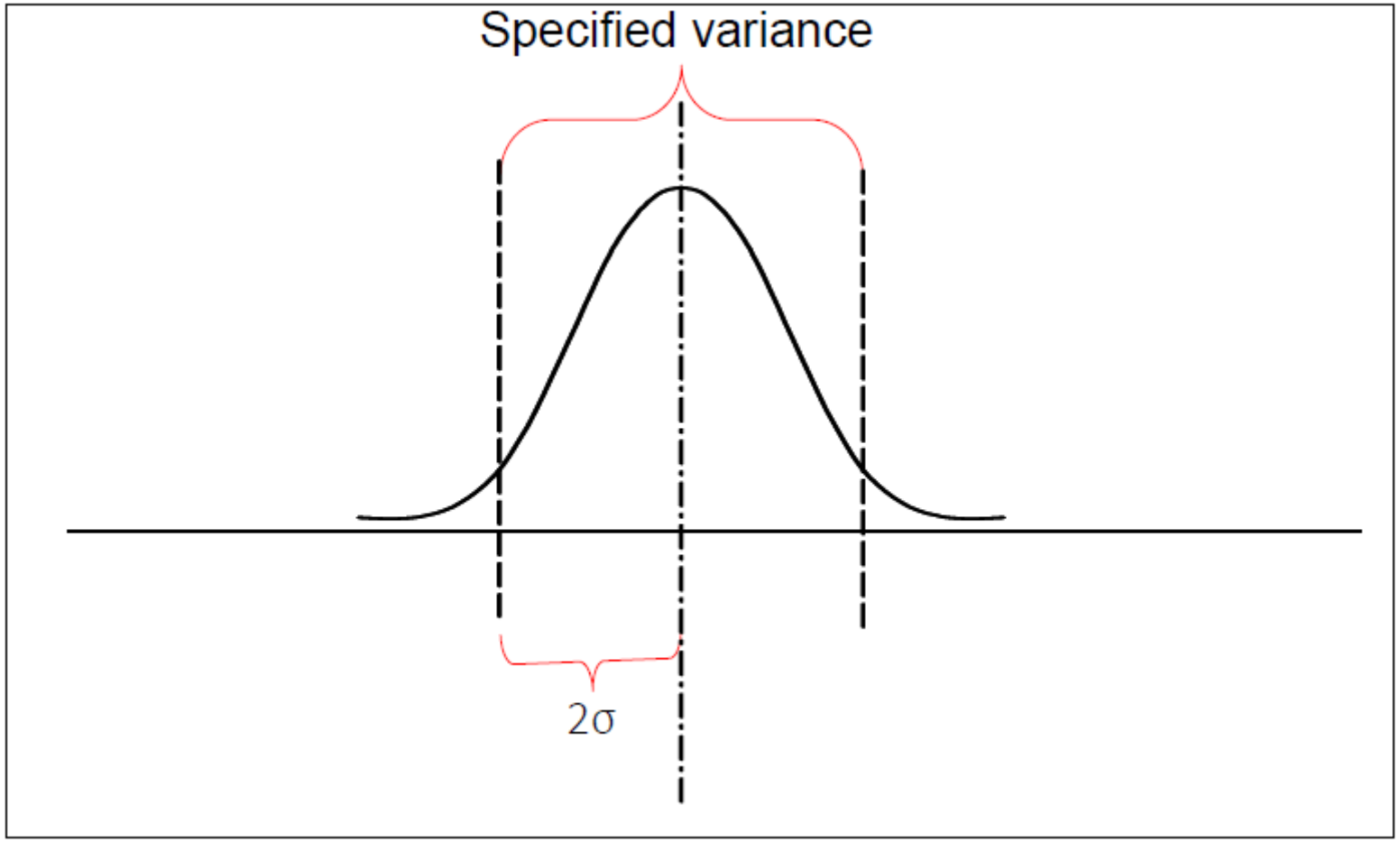
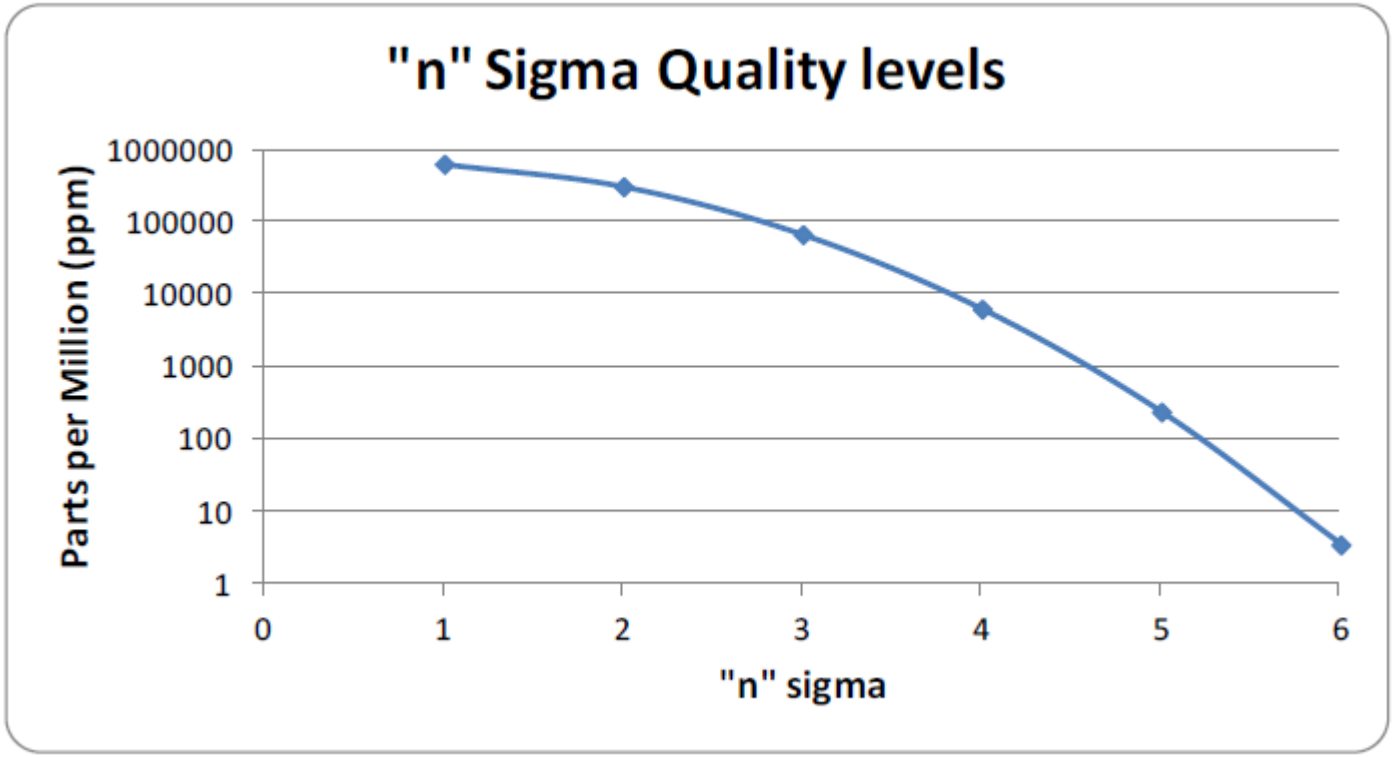


What is Six-Sigma?

A Statistical Perspective



At 6σ (6 Standard Deviations from the mean) there are only 3.4 rejects per million samples.

What is Six-Sigma?

A statistical perspective

- If you wash one hundred coffee mugs, but break one, the operation is statistically at the 3 8 Sigma level.
- If the efficiency improves and washing coffee mugs is at 6 Sigma level, another coffee mug would not be broken until 294 117 more had been washed.

The Six-Sigma Framework

The Six-Sigma Framework

Six-Sigma Training

A large and varied range of available tools and methods

- Requires trained and experienced staff or specialists to implement
- ‘Black Belts’ will have the experience to know which methods to use and how to apply them.
- For difficult issues some organisations have ‘Master Black Belts’
- Other lesser trained staff will have different belts such as
  - Green
  - Yellow – basic training

  but a common language to talk about quality issues.
- Implemented using a prescribed framework

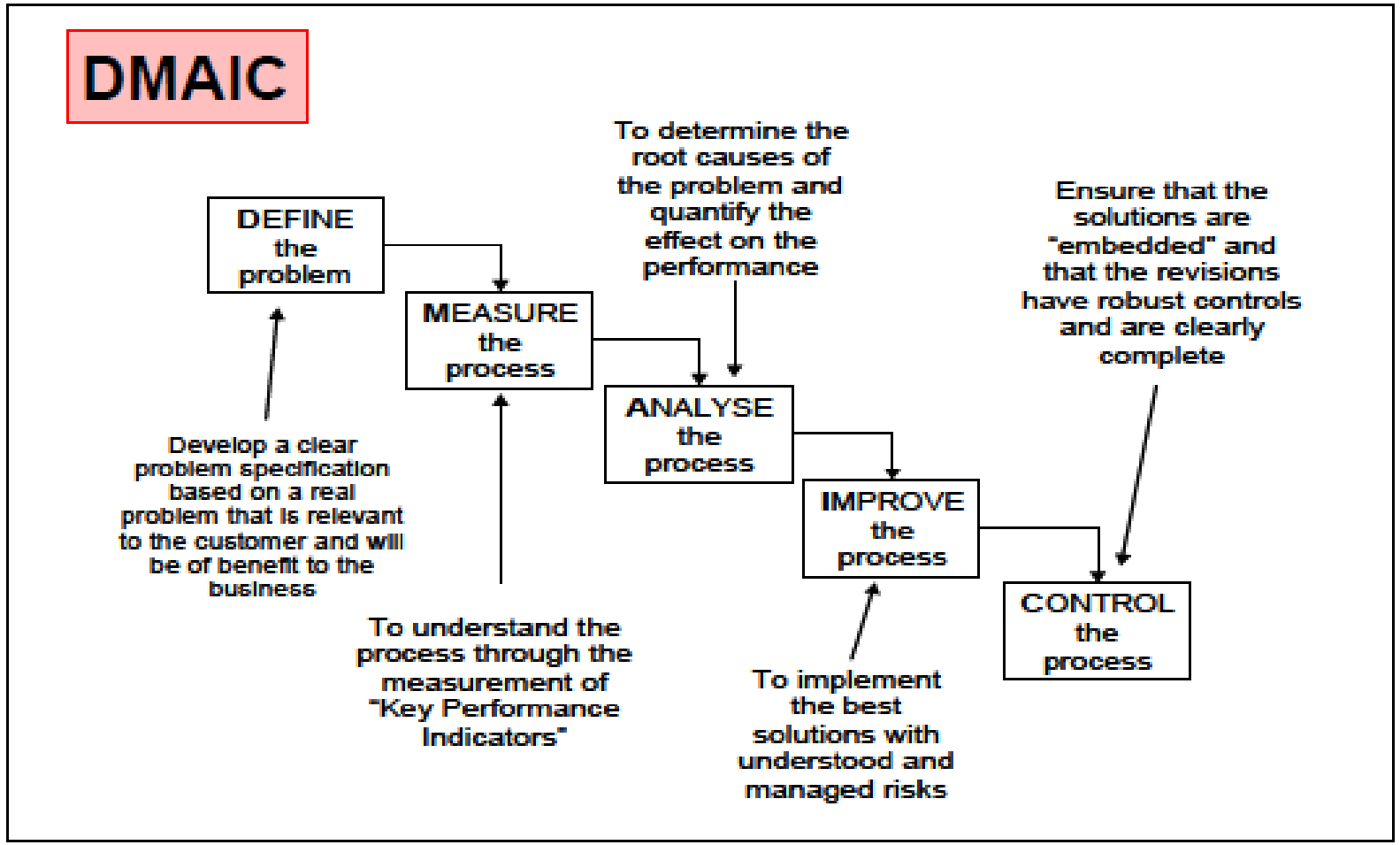
The Six-Sigma Framework

Lean Six Sigma

- There is considerable commonality and overlap between Quality, Lean and also Risk.
- All have a common toolkit of methods that can require experience (the ‘Black-Belt’) to apply appropriately.

The Six-Sigma Framework

The DMAIC process



The Six-Sigma Framework

The Define Stage

What is the problem?
What do we want to do about it?

Problem statements must be SMART

- **Specific**–is it clear what the problem is?
- **Measurable**–can we measure & analyse the process?
- **Achievable**–can we solve the problem?
- **Relevant**–will the solution improve customer satisfaction?
- **Timely**–what is the timeframe for implementing change?

The Six-Sigma Framework

The Define Stage

For example

- ‘We must make better parts’, is **not SMART**!
- ‘We must reduce the parts that are out of tolerance from 500 ppm (parts per million) to 100 which will save the business £2m per year’ is **SMART**–we can define it and measure the progress.

The Six-Sigma Framework

The Define Stage

The essentials of a Six Sigma team are:

- A **Six Sigma Champion** who will have a view of the overall 6σ strategy.
- The **Project Sponsor** –who has responsibility for the project. This person is likely to be a senior manager who has responsibility for the process (and / or people) involved
- The **Project Leader**–usually a full time 6σ "Black Belt"
- **Team Members**–often trained to "Green Belt" level or process specialists, possibly involved part time. There will be as few members as possible

The Six-Sigma Framework

The Measure Stage

- What do we need from our measurements?
- Develop process metrics –how do we measure the problem?
- Collect process data –where does the data come from?
- Check the data quality –does it represent what we think?

The Six-Sigma Framework

The Measure Stage

Key Performance Indicators (KPIs)

The Quality Team will define specific KPIs

These are the essential parameters that define the process

KPIs will cover:

- Customer perspective
- Supplier perspective
- Effectiveness (e.g. speed of service)
- Efficiency (e.g. cost of each delivery)

The Six-Sigma Framework

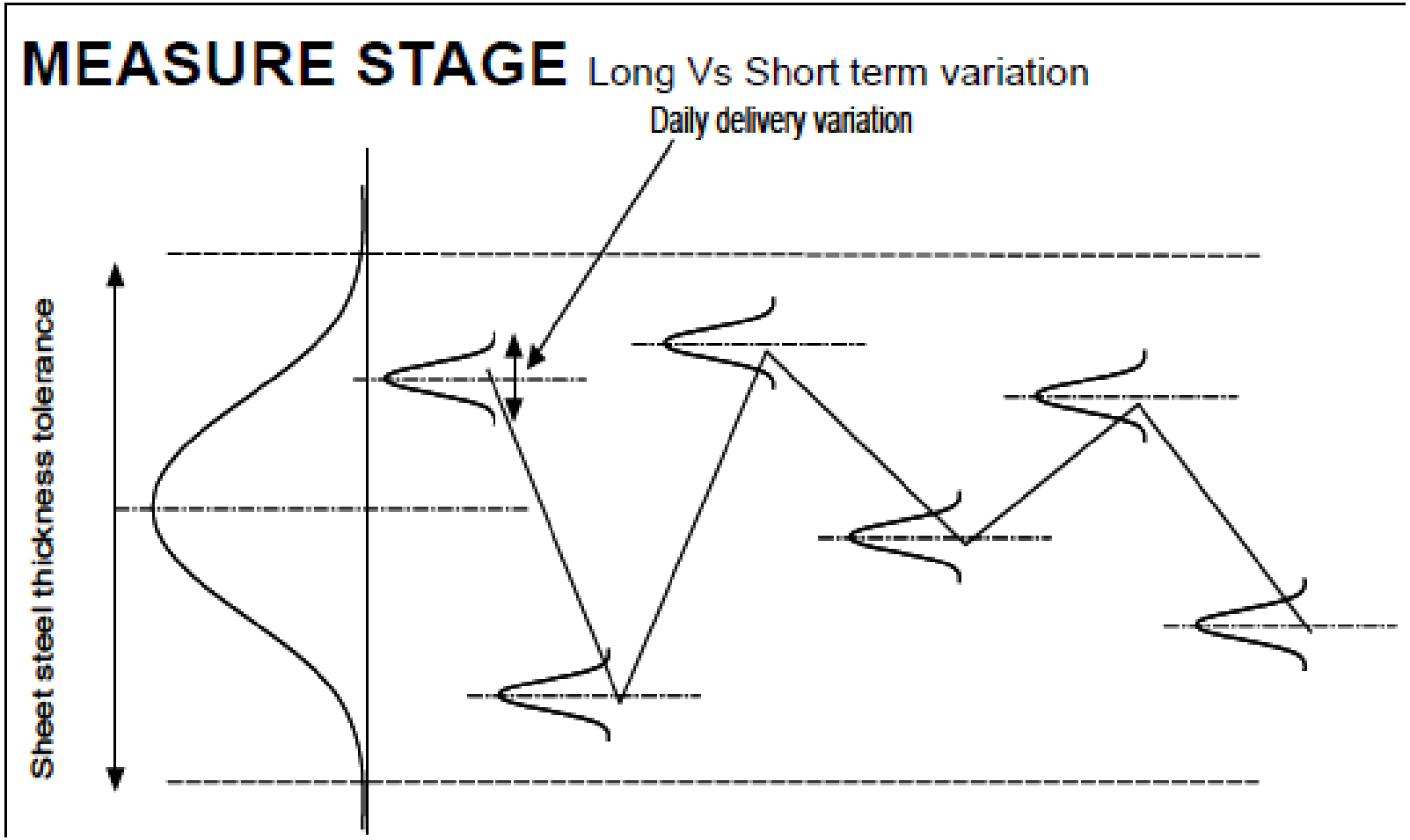
The Measure Stage

The KPIs for a courier service might be:

- The speed of delivery
- Cost of delivery
- Reliability (How many parcels get lost or damaged?)
- Customer service
- Location of collection centre
- Number of parcels
- Staffing levels
- Number of delivery vehicles
- Number of collection centres
- Average delivery cost target

The Six-Sigma Framework

The Measure Stage



The Six-Sigma Framework

The Measure Stage

6σ analysts like to talk in terms of ppm. Caution should be applied:

There is no virtue in “forcing” ppm results from inadequate data.

Could you apply ppm to:

- Memory chips?
- Hand made Swiss watches?
- A ‘one –off’ cruise ship?
- Quality teams must chose suitable statistics to suit their process

The Six-Sigma Framework

The Analyse Stage

- Analyse the process –understand how the process is working
- Develop theories and ideas –understand the root causes of quality issues
- Analyse the data –Understand what the data actually says
- Verify root cause and understand cause and effect –how does the root cause affect the process

The Six-Sigma Framework

The Analyse Stage

Analysis tools:

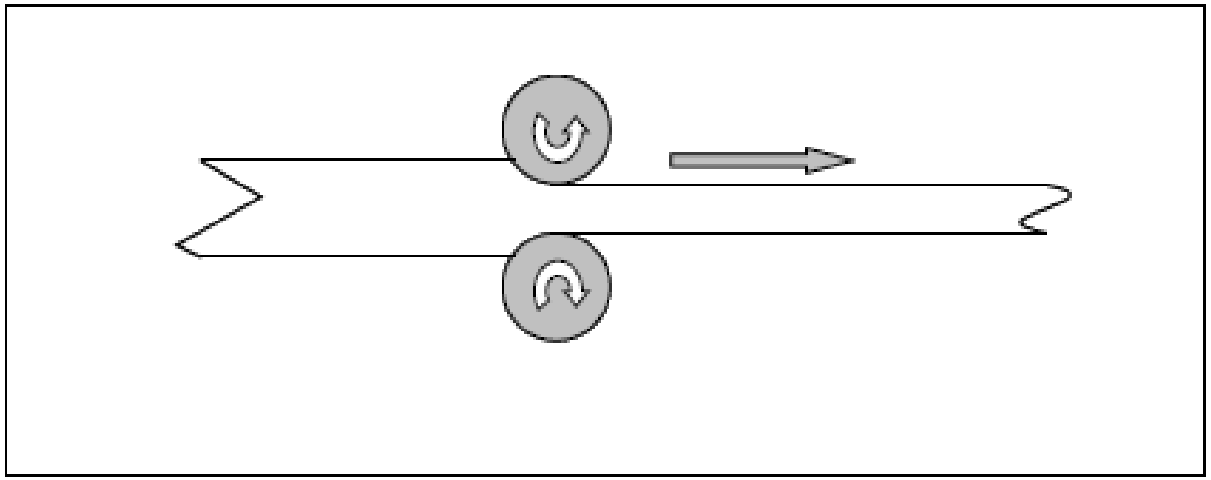
- Value Stream Mapping
- Root Cause Analysis
- FMEA
- Brainstorming
- Fishbone diagrams
- Fault Trees
- Pareto Analysis

The Six-Sigma Framework

The Analyse Stage

Example –metal rolling process

The Quality Team will come up with ideas and theories as to how the process may be improved.
These must be tested somehow to see why we have unacceptable variation in final thickness.



The Six-Sigma Framework

The Analyse Stage

Example –metal rolling process

Some potential variables:

Velocity
Initial thickness
Alloy properties
Roller pressure
Heating rate
Cooling rate

How do we test the significance of each variable?

- Change one variable at a time?
- Design of Experiments (DoE) which is a statistically base method for designing experiments

The Six-Sigma Framework

The Improve Stage

- Generate potential solutions –what are the possible solutions?
- Select the best solutions –some solutions will be easier to apply or be more effective than others
- Assess the risks –any changes to the process involve risk, as it is always possible to unsettle an essentially stable situation
- Pilot and Implement –finally the team must carry out trials to assess the improvements

The Six-Sigma Framework

The Improve Stage

Solution Screening

The Quality Team will evaluate their solution using criteria such as:

- Will the solutions eliminate the root cause of the problem?
- Are the solutions likely to be effective?
- Will the customer accept the solutions?
- Will business accept the solutions?
- Can the solutions be standardised?

The process is similar to Risk Assessment

The Six-Sigma Framework

The Improve Stage

The Quality Team will compare the performance of their process with ‘World’s Best Practice’ (if known).

This comparison could be with another process

- Within their own organisation.
- Other organisations in a similar sector.
- Organisations in unrelated sectors, but who share the basic problem.

The Six-Sigma Framework

The Control Stage

Why do we need control?

From a scientific perspective, ordered systems left to their own devices will become disordered. Entropy or the second law of thermodynamics

The Six-Sigma Framework

The Control Stage

- Establish control.
- Establish a monitoring system.
- Establish continuous improvement system.

The Six-Sigma Framework

The Control Stage

Have the project goals been met ?

- How do we control our processes?
- Policy or procedure changes
- New Standards
- Change engineering drawings
- Change manufacturing planning
- Revising accounting systems
- Change information systems

Robust Design (in the Quality Management Context)

Robust Design

Quality in Design and Development

Quality starts in the design phase. This is where many of the features that are likely to cause failure originate.

- Risk Management and FMEA can be used to help address quality issues.
- This specifically considers at what stage a quality problem might arise.

Robust Design

Quality in Design and Development

- A recent example of this was the 2008-2011 failure of accelerator pedals in Toyota cars.
- In this case a simple fault in the design caused Toyota to recall millions of cars, of all models, throughout the world.
- In addition to the cost to the company, their reputation, particularly as an organisation that lead quality, was severely damaged.

Robust Design

System Design

System design refers to the functional level – what makes it work?

This is the product and process technologies and approaches that will be exploited in the design.

This might include;

- Sub systems
- Components
- Materials
- Production and process technologies Maintainability

Robust Design

System Design

A company manufacturing golf clubs might decide to use a composite rather than a steel shaft. This decision would be taken at a high level, possibly based on market research.

However, the strategy will impact

- the material
- the process
- methods necessary to maintain quality of a composite shaft.

Robust Design

Parameter Design

This considers the parameters and values which must be incorporated in the design.

- The product must be robust and reliable
- HOWEVER it should not be over-engineered to the point that
  - the cost will be excessive
  - the quality will be difficult to manage.

Robust Design

Parameter Design

Returning to the golf club example

- It would not be necessary to make the golf club out of a composite capable of withstanding 350 degrees C.
- This would make it expensive and difficult to manage
- The manufacturing processes is more complex The new materials are expensive

Robust Design

Tolerance Design

- The engineering design of any part will involve dimensional tolerances.
- It is important that tolerances should not be either over or under specified.
- The cost of a feature rises exponentially as the tolerance reduces.

Robust Design

Tolerance Design

Simple hole example

- With a tolerance of 0.1mm a hole can reasonably be drilled.
- If the tolerance is reduced to 0.05mm then the hole will have to be drilled undersize and reamed.

The additional step means

- The process takes longer
- A non-standard drill and reamer are necessary
- More sophisticated equipment is necessary to measure and inspect the hole.
- The designer must always be sure that tight tolerances are necessary for the satisfactory operation of the part.

Robust Design

Supplier involvement

In earlier days it was common for a company developing a new product to design and specify its own specialist parts, These were then sent out to potential suppliers for quotation. The suppliers, who might have valid specialist knowledge, would not be involved in the design process.

Current Lean thinking acknowledges the abilities of the best suppliers

It integrates them fully into the design and development stage.
If for example, a company requires a complex gearbox, it may send the supplier a Statement of Requirements and the supplier will complete the design, manufacture and validation process.

Robust Design

Supplier involvement

There must be a new relationship between the company and the supplier.

- Clearly the company has to trust the supplier both technically and financially.
- The company will not be able to go out and use the traditional “three quotes” approach.
- In exchange the supplier will expect security in their contract.
- Having developed the gearbox, the supplier will expect to provide a large number of them over a long period to recover their costs.
- In some cases the relationship between the company and supplier becomes quite close and complicated.
- The supplier is frequently expected to finance the design and development of the new gearbox and to recover the cost from their sales revenue.

Robust Design

Poka-Yoke ポカヨケ ‘to avoid a blunder’

- One method of reducing quality errors is to eliminate the possibility of errors as far as is possible.
- This technique was developed by from the Toyota Production System, or Lean Manufacture.
- The objective of poka-yoke is to eliminate human error, as far as is possible, by design.

Shigeo Shingo

Robust Design

Poka-Yoke ポカヨケ ‘to avoid a blunder’

- Parts that can only fit in one place
- A square peg will not fit in a round hole! Assemblies in which components can only fit in one orientation
- Parts delivered in sectored trays so that any parts not used in the assembly are easily seen
- Kitting

Zero Defects

Zero Defects

- Zero Defects (ZD) a concept originated by the Martin Marietta company in the 1960s
- It was a response to the requirements of the early space industry.
- They faced the problem of turning a relatively unreliable ballistic missile into a launcher capable of taking astronauts into space with a required reliability of 100%.

Zero Defects

- SPC methods from Toyota and Motorola required some failures to fix the statistics.
- The Space programme required only a few tens of launches, but could not accept any failures of crew-carrying flights.
- This lead to the Zero Defects concept

Zero Defects

There are Four Principles of the Zero Defects approach:

1. The definition of quality is conformance to requirements (Philip Crosby). Do your products meet the requirements or expectation of your client or customer?
2. Defect Prevention is preferable to Quality Inspection and Correction.
3. The Quality Standard is Zero Defects.
4. Money is the unit of quality.

Zero Defects

Principle 1

The definition of quality is conformance to requirements (Philip Crosby). Do your products meet the requirements or expectation of your client or customer

Fundamental concept in Systems Engineering

Zero Defects

Principle 2

Defect Prevention is preferable to Quality Inspection and Correction

Consider the Toyota throttle defect discussed earlier

Zero Defects

Principle 3

The Quality Standard is Zero Defects

This is different from six-sigma which needs some failure statistics.

Zero Defects

Principle 4

All failures represent a cost to the organisation. These costs can include

- Inspection time
- Labour
- Rework
- Scrap
- Lost sales revenue
- Cost of loss of customer confidence

Cash is the unit that allows these to be quantified

Zero Defects

Counter point and context

Zero defects popularised1961-64

Crew rated spacecraft losses

Apollo 1 (3 fatality)1967
Soyuz 1 (1 fatality)1967
Soyuz 11 (3 fatalities)1971
Challenger (7fatalities)1986
Columbia (7 fatalities)2003