FIREBRAND

Lean Six Sigma

Green Belt

Courseware

Version 2.6

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ORIENTATION

Lean Six Sigma

Green Belt

Welcome

Welcome to the

Lean Six Sigma

Green Belt

Training

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Introductions

Be prepared to share with the class your:

- Name
- Designation
- Organisation
- Location
- Expectations for the course
- Summary of your project

Programme Schedule

Day 1 - Define

- Define the scope of the problem to be tackled – in terms of the customer and/or business requirements and the process that delivers these

Day 2 - Measure

- Map the "as-is" process and measure the current performance

Day 3 - Analyse

- Analyse the gap between the current and desired performance, prioritise problems and identify root causes

Day 4 - Improve

- Generate the improvement solutions to fix the problems, implement them and prevent them from re-occurring, so that the required financial and other performance goals are met

Day 5 - Control

- Ensure that the improvement continues

FIREBRAND LEAN SIX SIGMA GREEN BELT Certification Exam

When
- Day 5, 2.30pm

Duration
- 1 hour (60 minutes)

Number of Questions & Format
- 30 questions, open book

Assessment
- Questions test candidates on LEAN & DMAIC principles, process & precepts

Passing Score
- 75%

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LEAN

Objectives of this module

At the end of this module, you will be able to

- Understand the history and principals of Lean and Six Sigma
- Explain the differences between Lean and Six Sigma
- Explain how Lean Six Sigma is deployed within a business
- Understand the role of a Green Belt project manager

Lean Thinking

- Lean emerged from post-WWII Japanese automobile industry as a fundamentally more efficient system than mass production

History of Lean

Ford Rouge Plant

Indianapolis 300

Supermarkets

Toyota Production System

Lean Thinking, *continued*

	CRAFT	MASS PRODUCTION	LEAN THINKING
Focus	Task	Product	Customer
Operation	Single items	Batch & queue	Synchronized flow & pull
Overall Aim	Mastery of craft	Reduce cost & increase efficiency.	Eliminate waster & add value
Quality	Integration (part of craft)	Inspection (a 2nd stage after production)	Inclusion (built in by design & methods)
Business Strategy	Customization	Economics of scale & automation	Flexibility & adaptability
Improvement	Master-driven continuous improvement	Expert-driven periodic improvement	Worker driven continuous improvement

Lean Thinking, *continued*

- Lean thinking is the *dynamic*, *knowledge-driven* & *customer-focused process* through which *all people* in a *defined enterprise continuously* eliminate waste & create value

8 Forms of Waste

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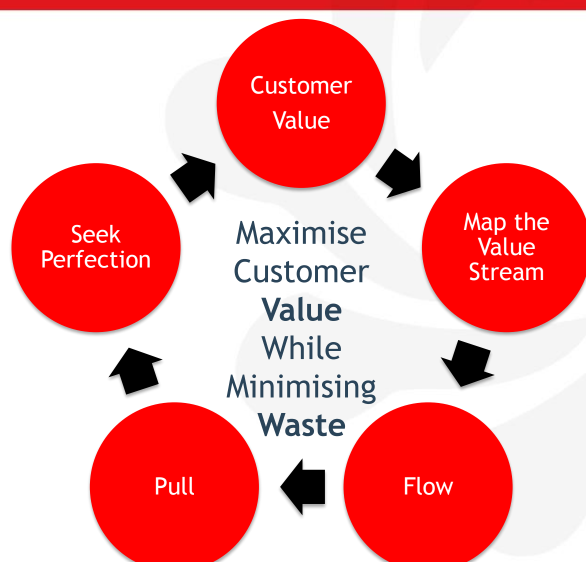
8 Forms of Waste - *Continued*

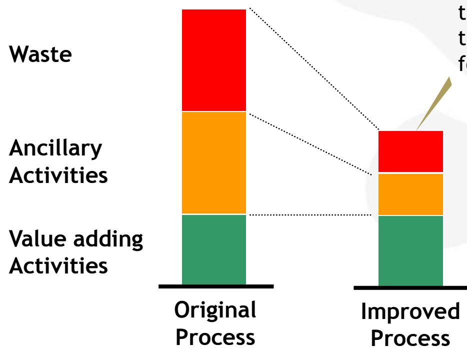
WASTE	Description
Transport	Moving people, materials and information around the organisation
Inventory	Any supply in excess of one piece flow
Motion	Any movement of ***people*** that does not add any value to the product or service
Waiting	For people, machines, materials, information, etc
Over-production	Doing things earlier / faster than the next process needs
Over-processing	Effort that adds no value to the service from the customer's viewpoint
Defects	Having to re-do work that wasn't done right the first time
Skills	Not utilising people's experience, skills, knowledge, creativity

LEAN



Reducing Waste & Ancillary Activities

In order to increase the percentage of value adding activities, the focus is to **minimise the time and effort spent on the waste and ancillary activities.**



Understand value from the point of view of the customer. It is essential not to spend time on activities which do not add value for the customer.

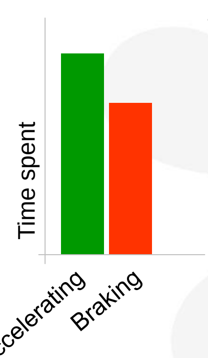
Objective

Maximise the proportion of time spent on value adding activities by removing wasteful and ancillary activities

In a traditional organisation, the value adding ratio= <10%

Lean in a nutshell

Jaguar Racing in the 1950's & 1960's



- Jaguar focussed on removal of the waste (braking)
- Increased the value (acceleration) proportion automatically

ORIENTATION

SIX SIGMA

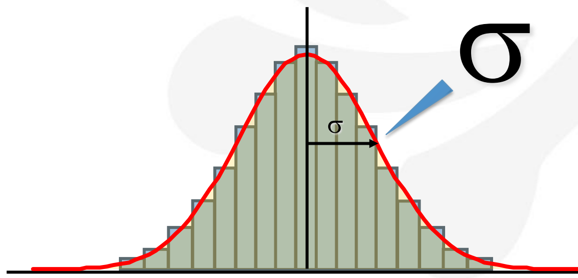
What is Six Sigma?

- Six Sigma is a 5-phase problem solving methodology that
  - Understands a business problem
  - Translates it into a statistical problem
  - Solves the statistical problem
  - Translates it back into a business solution
- Six Sigma is a data driven philosophy & process resulting in dramatic improvement in product/service quality & customer satisfaction
- Using Six Sigma reduces the amount of defective products manufactured or services provided, resulting in increased revenue and greater customer satisfaction.

Definition of Six Sigma

What is ~~Six~~ Sigma?

- Sigma is the symbol for Standard Deviation
- Standard Deviation is a measure of the data variation
- Standard Deviation is calculated from the data from the process – it's the Voice of the Process



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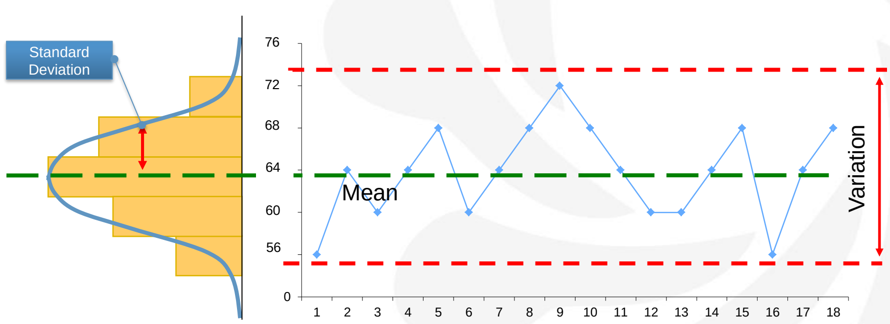
What is Six Sigma? … and what is a standard deviation?



Variation exists in all processes.

The principal aim of Six Sigma is to reduce variation to operate consistently within customer expectations

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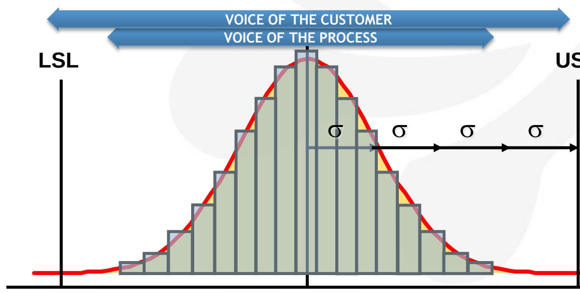
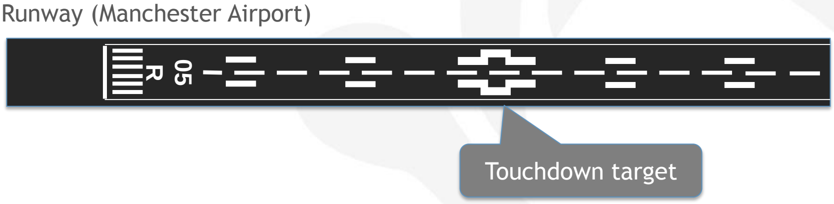
Definition of Sigma Level

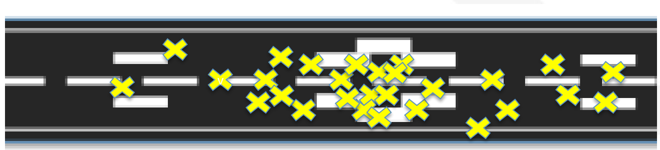
- Sigma Level is a measure of process capability
- Sigma Level requires **customer specifications** to calculate the capability of the process.
  - These are derived from the Voice of the Customer (VOC)
- Sigma Level states how many Standard Deviations lie between the average and the nearest customer specification limit



Target Performance

Runway (Manchester Airport)





How well can the pilot achieve the target performance?

We want to be able to measure the performance and use it to compare the quality of pilots.

If we were to select a pilot for a new route to SABA – how do we compare their performance?

Why Use Six Sigma?

Variation → Errors & Defects → Poor Quality → Dissatisfied Customers → Business Loss

Is 99% Good Enough?

3.8-Sigma Level 99% Good	*6-Sigma Level 99.99966% Good*
• 20,000 lost articles of mail per hour	• Seven articles lost per hour
• Unsafe drinking water for almost 15 minutes each day	• Unsafe drinking water one minute every seven months
• 5,000 incorrect surgical operations per week	• 1.7 incorrect operations per week
• 11.8 Million shares incorrectly traded on the NYSE every day	• 4,021 shares incorrectly traded on the NYSE every day
• 10,700 defects per million opportunities	• **3.4 defects per million opportunities**

Y = f(x)

$$Y = f\,(x_1; x_2; x_3; x_n)$$

Outcome = function of the factors of the process

So what are the **Factors** for a *Great* cup of coffee?

Cup of coffee = f (coffee beans; water)

- x_1 - coffee beans
- x_2 - Volume of water
- x_3 - Volume of coffee
- x_4 - hardness of water
- x_5 - pH levels of water
- x_n - etc.

Six Sigma Overview Summary

1. The objective of Six Sigma is to reduce process variation such that a process continues to meet customer expectations over time
2. To reduce variation it identifies then reduces the statistically validated root causes of variation
3. Six Sigma performance means a near defect free process (<3.4 defects per Million opportunities)
4. A Sigma level is a measure of capability for the process to meet the Customer Specifications
5. Freeing a process from producing defects means that capacity increases or throughput time decreases (faster)

ORIENTATION

LEAN SIX SIGMA

Six Sigma v Lean in a nutshell

Imagine a leaking pipe and consider how LEAN and Six Sigma work together to tackle the problem……

Six Sigma tackles defects/rework, one of the wastes Lean attacks

Lean Six Sigma Simulation

The coin simulation

Objective: To illustrate how to apply Lean Six Sigma principals

- Your instructor will read the instructions of the simulation

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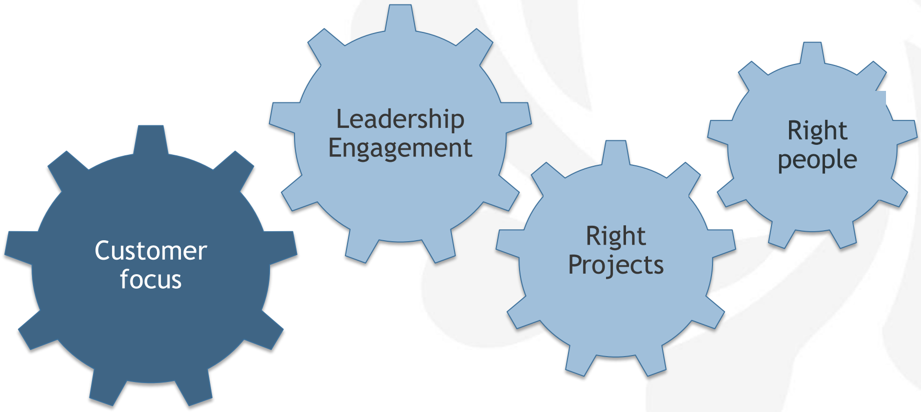
Deploying Lean Six Sigma in the business

Deploying Lean Six Sigma in the business

There are four key components critical for a successful Lean Six Sigma deployment



Let's take a closer look at each of these in turn starting with **Customer Focus**

Customer focus

- Lean Six Sigma is customer centric. It strives to delight customers by delivery of product/service to customer specification time after time
- Understanding requirements through techniques such as Voice of the Customer (VoC) is critical to measure success in this regard
- Requirements are translated to measurable characteristics called Critical to Quality (CTQ) which measure adherence to these requirements
- Delighting customers drives business profitability

Customer focus

- The satisfaction of customer needs (internal and external) drives quality, efficiency and ultimately profitability
- Cross-functional teams working together focussed on a clear definition of customer requirements will deliver increased customer value and reduced waste

Leadership Engagement

- Why should leaders lend their support to your LSS deployment?
  - Enabler of strategy
  - Improve customer experience
  - Develop the problem solving capability of the business
  - Tackle their most challenging problems
  - Return on investment

Leadership Engagement

- What should Lean Six Sigma leaders do?
- Use process improvement tools and methods in daily work
  - Create a team from different parts or the organisation and/or external organisations
  - Be responsive to support teams through tough patches
  - Get involved by participating in some events
  - Develop the capability of the teams
  - Hold the team and themselves accountable for the success of improvement opportunities
  - Communicate widely on the progress and success of the deployment

Right Projects

For a new lean six sigma deployment to gain momentum, project selection is critical

- Too many projects being worked (resources spread too thin), results in longer than needed cycle times
- Too many marginal-value projects being worked = Low ROI

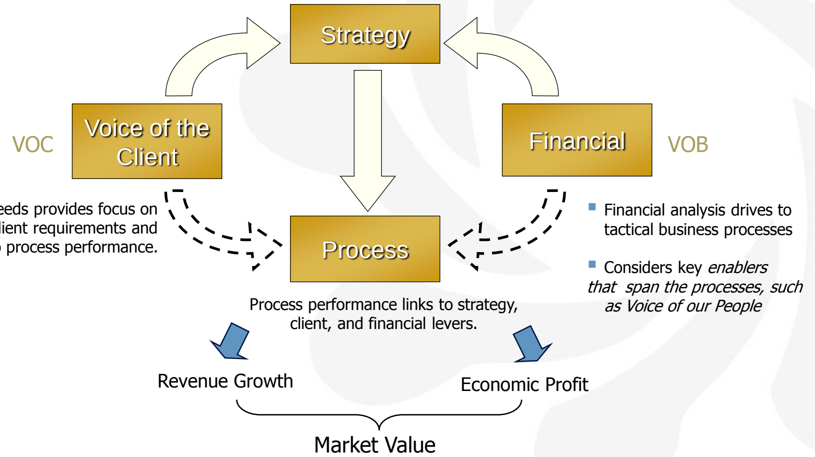
Right Projects

- Consistently use prioritisation and selection criteria
  - Related to driving Economic Profit and Revenue Growth
- Actively manage projects-in-process
  - Stop working marginal value projects
  - Launch projects based on skill not resource availability

Right Projects

1 Identify Value Levers	2 Identify Project Opportunities	3 Screen Initial List of Opportunities	4 Scope and Define Projects	5 Prioritise List of Defined Projects
▪ Identify value levers in the business • Strategic • Financial • Client • Operational (Process) ▪ Prioritise value levers	▪ Translate Value Levers into Opportunity Areas ▪ Translate Opportunity Areas into Project Ideas	▪ Score each project as High / Med / Low for Benefit and Effort ▪ Fill in Benefit / Effort Matrix ▪ Select highest priority opportunities for further analysis	▪ Assign opportunities to project sponsors for project definition ▪ Complete Draft Project Charters	▪ Evaluate projects using Evaluation Criteria ▪ Update Benefit / Effort Matrix ▪ Review plotted results ▪ Prioritise projects ▪ Schedule project launches based on resource availability

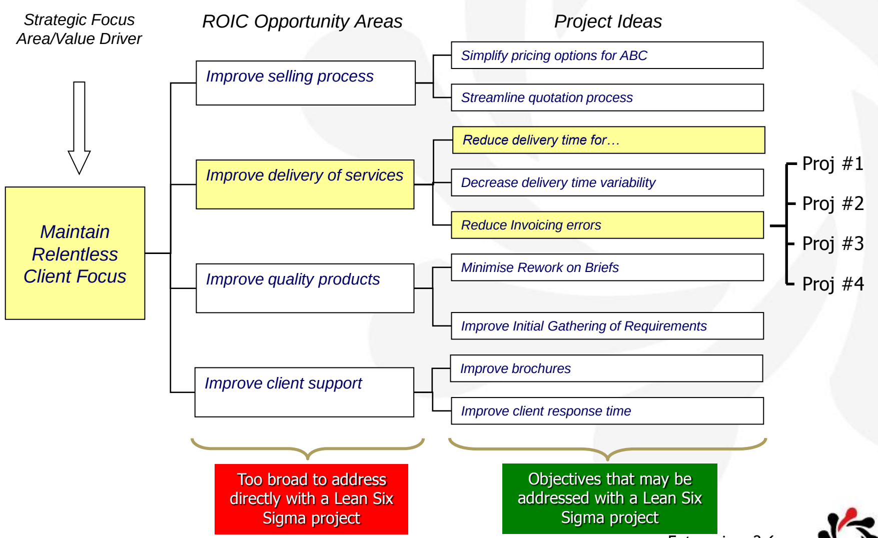
Right Projects – Identify Value Levers



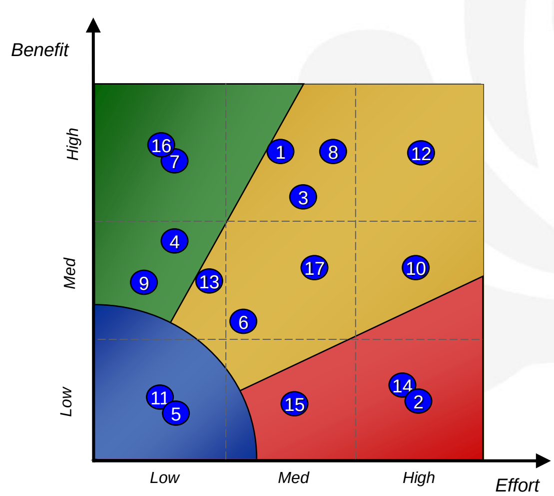
- Client Needs provides focus on critical client requirements and drives to process performance.
- Financial analysis drives to tactical business processes
- Considers key *enablers that span the processes, such as Voice of our People*

Insight: Tools such as Scorecards and Dashboards are used to translate Strategy into Key Process Metrics in order to sustain improvement results

Right Projects – Identify Project Opportunities



Right Projects – Screen Initial List of Opportunities



Highly Desirable Opportunities
Projects in upper left are the most desirable projects.

Potentially Desirable Opportunities
Projects in the upper right are potentially desirable, but usually require more analysis to ensure good decision making. "Tie breaking" variables such as strategic fit, resource availability and project type may also be employed.

"Potential Quick Hits"
While typically low in benefit, these can be executed with little effort .

Least Desirable Opportunities
Projects in the lower right are the least desirable.

Right Projects - Scope and Define Projects

- High priority project ideas are assigned to Process Owners for project definition
- Charters must be completed in enough detail to enable final prioritisation

We'll cover more on charters within the Define module

Right Projects - Scope and Define Projects
Problem Statement

- Problem Statement Purpose
  - Focuses the team on a process deficiency
  - Communicates the significance to others
- The problem statement does not include any guesswork as to the cause of the deficiency or what actions will be taken

A POOR Problem Statement

Process rework is too high due to process A and will be reduced by analysing first and second level pareto charts.

A GOOD Problem Statement

In 1999, sub process A had 480 sales returned, 58% of total returns, resulting in a profit impact of $2.9MM, and customer dissatisfaction.

Right Projects - Scope and Define Projects
Project objective

Example 1	Example 2
A Poor Objective	A Good Objective
Reduce returns by implementing individual performance measures and objectives	Reduce sub process A returns from 450 to 225 by year-end, resulting in a benefit of $1.5MM.

The Project objective does not state the cause of the deficiency or what actions will be taken.

As it is progressed, the Project team will determine what areas need to be improved.

Right Projects - Scope and Define Projects
Primary Metric

- The primary metric is the yardstick that will be used to measure the success of your Project
- It must be consistent with the *Problem Statement* and *Project Objective*.
- It is plotted on a time series graph, with the following content:
  - Actual Performance
  - Baseline Performance (average over time or number of projects)
  - Target Performance
- It should reflect 6-12 months of historical data and be updated during the project

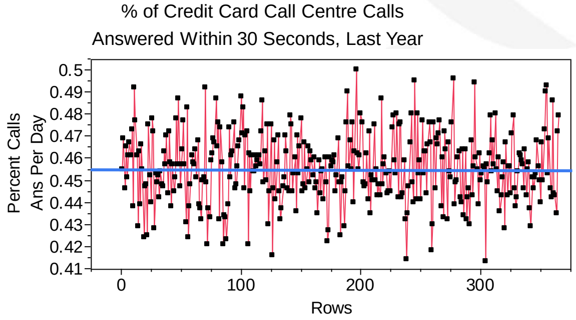
Right Projects - Scope and Define Projects
Secondary Metric

- The Secondary Metric is the conscience that will “keep you honest”
- Otherwise, you could improve or optimise one portion of the process at the expense of another
- The Secondary Metric has no target
- As with the primary metric, the data should reflect 6-12 months of historical data, and be updated during the project

Right Projects - Scope and Define Projects
Contact Centre case study

The call centre’s leadership team identified a major gap to achieve world class service level performance:

- *World Class Performance* – 90% of calls answered within 30 seconds
- *The Industry Average* – 70% of calls answered within 30 seconds
- *ABC’s Performance* – 45.5% of calls answered within 30 seconds



Right Projects - Scope and Define Projects
Contact Centre case study (continued)

Mr A Champion has asked you to support development of the project charter by drafting

- A problem statement
- A project objective
- Potential secondary metric(s)
- Any further questions and/or research you may need to complete the charter

Use the flipcharts to draft and present your work to the class

Right Projects – Prioritize List of Defined Projects

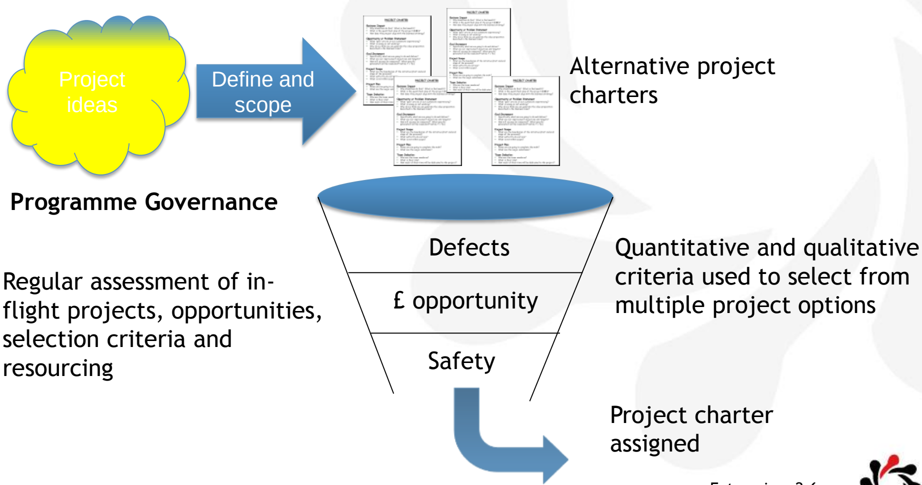
The project charter will drive the most appropriate project “vehicle”

	Quick win	Local project	Large project	Major change
Type	Well defined issue with known solution	Simple project with no obvious solution	Complex problem with no obvious solution	Large scale project/programme with high impact and complexity
Timescale	1 week - 1 month	1 - 6 months	6 - 12 months	12 - 24 months
Sponsorship	Local	Local	Head of function	Business unit executive
Improvement enablers	Stakeholders	Green Belts	Black Belts Potentially with Green Belt support	Master Black Belts Potentially with Black Belt support

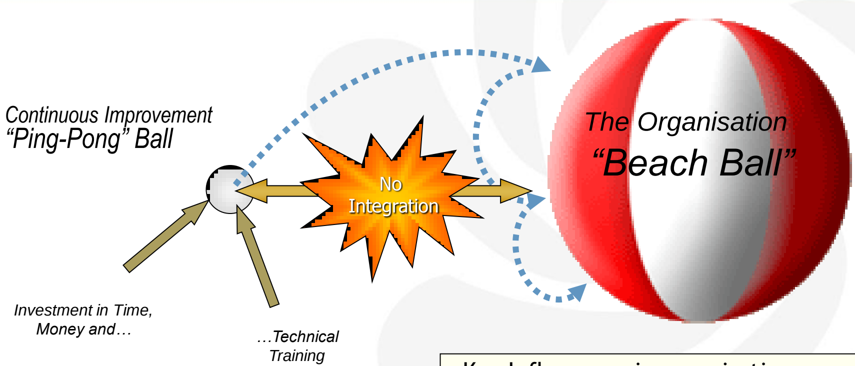
Ensuring that the correct projects are selected is critically important

Right Projects – Prioritize List of Defined Projects

Project selection can be thought of as part art, part science

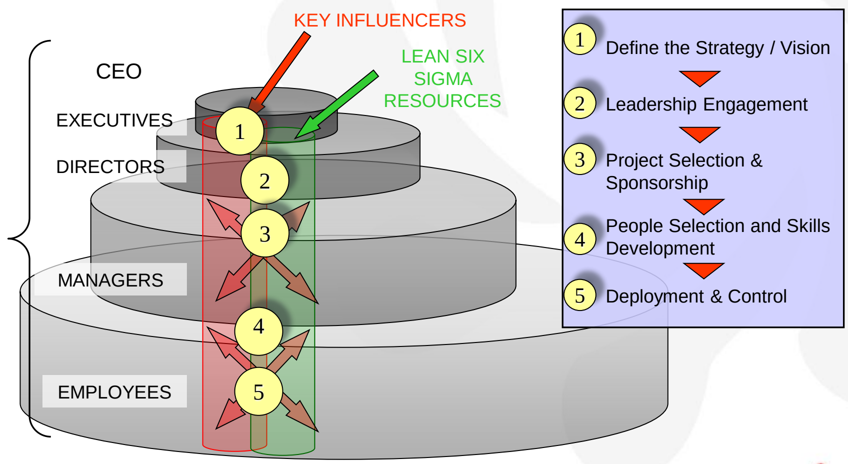


Right People -The Typical Flawed Approach



- Key Influencers in organisation are not involved – this creates a lack of understanding and encourages resistance

Right People -The organisational view



Right People - Being a Green Belt

The objectives of a strong Lean Six Sigma Green Belt are to:

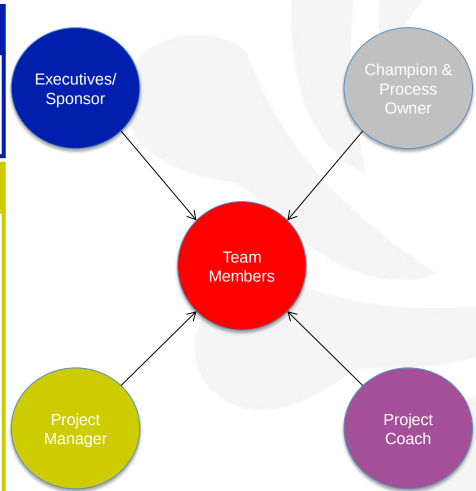
- Be able to describe the Lean Six Sigma methodology
- Deliver Lean Six Sigma projects utilising the right tools and techniques at the right time
- Support your business to build problem solving capability
- Support Black Belts and Master Black Belts in the execution of complex projects

To support you in this, there are a number of key support roles required.

Right People - Lean Six Sigma Roles & Responsibilities

Executives / Sponsor
- Owns vision, direction, business results
- Leads Change

LSS Project Manager
- Has been trained on Lean Six Sigma
- Has time dedicated to leading projects using Lean Six Sigma methods and tools
- Supports team in executing project plan
- Provides support in implementing continuous improvement elements



Champion & Process Owner
- Decides to launch project
- Provides resources / means
- Helps moving roadblocks
- Validates solutions to be implemented

Coaching
- From experienced Project People
- Supports project managers and project teams

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In Summary....

Key learning points

- The history of Lean and Six Sigma
- The differences and complimentary nature of Lean and Six Sigma
- How to establish a Lean Six Sigma deployment
- The key roles and responsibilities

Recommended coach support points

- When defining value from a customer perspective
- Developing your project charter
- Developing your plan baseline process performance
- Sizing potential opportunities
- Engaging key project/programme stakeholders for the first time

DEFINE

Lean Six Sigma

Green Belt

Objectives of this module

D

At the end of this module, you will be able to:

- Define the business problem
- Identify product families
- Develop customer focused metrics
- Establish your project team
- Create your *Define* project charter
- Understand some of the key change adoption considerations when delivering projects

Lean Six Sigma Project Structure

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Lean Six Sigma projects are typically delivered through a 5 tollgate DMAIC process:

- Define
- Measure
- Analyse
- Improve
- Control

The Define phase is the first of these phases and starts with defining the business problem

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DEFINE

Define the business problem

Perception of Problems

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A problem well defined is a problem half solved…

"If I had one hour to save the world, I would spend fifty five minutes defining the problem and only five minutes finding the solution."

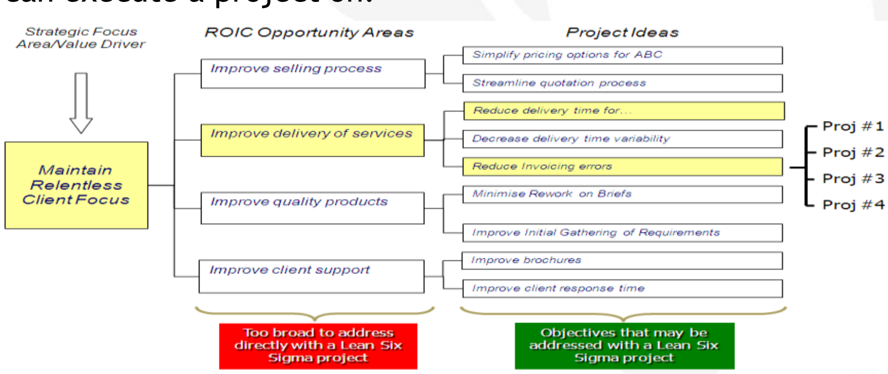
Einstein

The Define phase of a Lean Six Sigma project is often considered the most important

Scoping the problem

D

There can be multiple issues to be tackled to solve a problem as generic as "maintain relentless customer focus". We need to break this down to something that we can execute a project on.



Scoping the problem

D

To help us break the problem down we're going to illustrate the use of three simple tools:

- Brainstorming
- In/Out of frame
- N/3

Brainstorming

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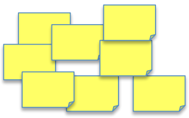
Ask Question → Capture initial ideas → Loosely Affinitise → Clarify ideas → In scope/ out of scope

Ask Question: For Brainstorming to be effective – a frame of reference is needed. This can often be a simple question;

Eg. How can we grow existing revenues? How can we reduce staff costs?

Capture initial ideas: Let people have time to generate some ideas on their own. When it looks like things have slowed down, gather the ideas on a flip chart



Loosely Affinitise: Read out the ideas and start to make some form of grouping. You could let the team do this. Let any additional ideas be forthcoming

Clarify ideas: When it looks like there are no more ideas, read through the ideas and clarify - practice "appreciative enquiry" – do not give your own opinion – ask how it relates to the initial question

In scope/ out of scope: Finally the ideas need to be sorted into those that are to be taken forward or those that may be eliminated

Brainstorming (cont'd) - Affinity Diagrams

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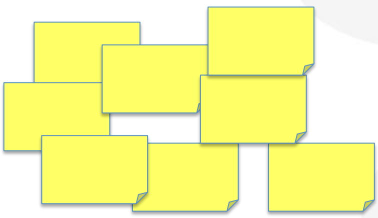
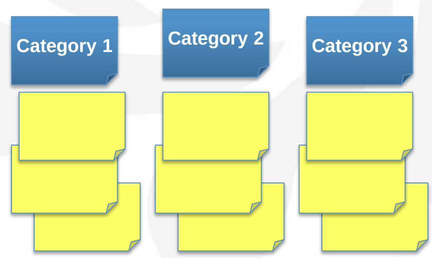
1) Gather ideas around the Subject



2) Group into relevant categories



In Frame / Out of Frame

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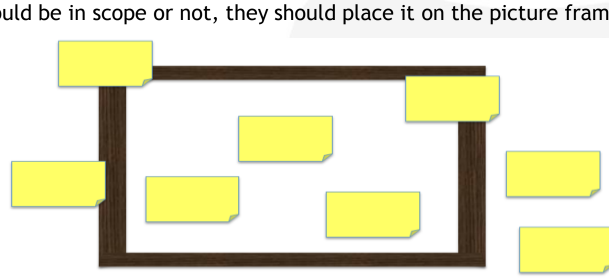
Use this tool to enable agreement to be reached on the scope of the change efforts

- Draw a large rectangle on flip chart paper to represent the "picture frame"
- Give each team member a packet of post-it notes and fine-tip paper
- Each team member writes one idea per post-it
- As a group discuss and stick in scope ideas "inside the frame", out of scope "outside the frame"
- If people have any questions on where their post-it should go or are unsure whether it should be in scope or not, they should place it on the picture frame



N/3 Technique

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Use this tool to prioritise ideas based on voting.

- This tool will reduce the number of alternatives to a small, manageable number.

Count the number of ideas → Divide by 3 → Each participant get N/3 votes → Vote → Review to ensure it make sense

- This tool should be used after generating as many alternatives as possible

The “N” is the total volume of ideas.

Scoping the project

D

Defining your project scope

Objective: To illustrate the use of narrowing tools

Using your own project or use the example of a mobile telephone company looking to improve customer service to try:

- Brainstorming
- In/Out of frame
- N/3 Technique

Time - 45 minutes

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DEFINE

Product families

What is a product family?

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A product family is a group of products or services that use the **same** or **similar** processing steps and equipment.

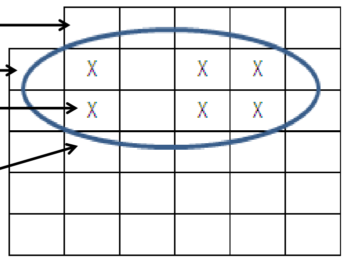
As a value stream represents the end to end flow of the product, a value stream map cannot map more than one product flow with any clarity.

Creating a product family matrix

D

Product families are identified using a product family matrix.

- List the process steps on the top
- List the products on the left
- Identify steps required for each product
- Group products that have similar processing requirements
- Identify families - groups that use the same process



Creating a product family matrix (cont'd)

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- **The listed process steps** should be in enough detail to show differences in products listed. To be in the same family, we're looking for approx 80% of the processing steps to match.

- **Products** should be listed in enough detail to show the differences in processes. In a manufacturing company this is fairly easy being the different products or services the organisation sells, it can be a little more challenging in a transactional environment.

Product family matrix example

The completed matrix below for an energy supplier shows the identification of five product families.

product/Service		ID&V	Raise Meter Reading job	Update Personal details	Take payments	Transfer contact	Update account narrative	Assigned product family
	Take customer payments	X			X		X	Payments
	Make a change to account personal details	X		X			X	Account maintenance
	Billing enquiry	X	X				X	Billing
	Open a new customer account	X	X	X		X	X	Hot-key
	Close account	X	X			X	X	Hot-key
	Buy second service	X	X			X	X	Hot-key
	Sales lead	X	X			X	X	Hot-key
	Complaints	X		X		X	X	Escalation
	Manager calls	X		X		X	X	Escalation

While not a perfect match for every process step, the Hot Key product family captures four “products”.

Selecting a product family

In the previous example of an energy supplier, five product families were identified.

In order to decide what to work on first, for each identified product family we need to asses criteria such as:

- Disparity with customer expectations
- Importance to company strategy
- Opportunity for improvement
- Ease or speed of implementation
- Volume of units of product

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DEFINE

Develop customer focused metrics

Four step approach

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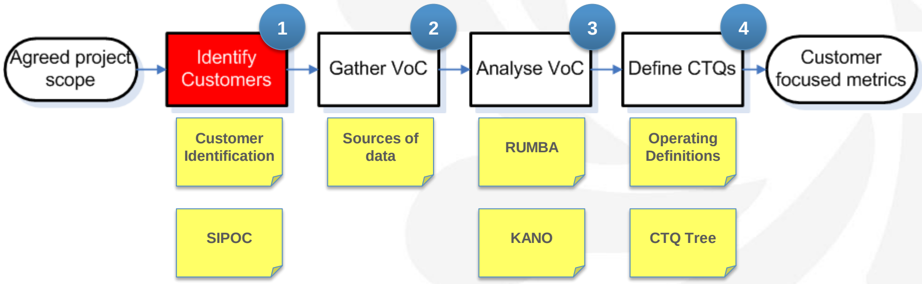
Step 1: Identify Customers



Customer Identification

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Customer (noun)

1 a person who buys goods or services from a shop or business: *Mr Harrison was a regular customer at the Golden Lion*.

2 [with adj.] a person of a specified kind with whom one has to deal: *he's a tough customer*.

- A Customer is a recipient of an output from a process
- They can be either internal or external
- They can be **both** a supplier and a customer
- External customers are typically the **end-user** of the product or service
- Internal customers are the recipient of the process output – **the next person in the process chain**

Identifying customers

D

	External	Internal
Direct	*Customers who directly receive our product or service*	
Secondary/ Tertiary	*Customers who receive our product or service through another party*	
Indirect	*Regulatory and policy setting agencies that speak on behalf of the customer, (eg. FCA)*	

SIPOC

D

Suppliers — Who supplies the information / product that moves through the process?

Inputs — What are the inputs to the process? List out all the "pieces" that are received for the process to perform.

Process — Process Name

Outputs — What are the outputs from the process? List out all the "pieces" that are delivered as a result of the process.

Customers — Who receives the outputs from the process?

High level process step 1 → High level process step 2 → High level process step 3 → High level process step 4 → High level process step 5

SIPOC Example

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Supplier(s)	Input	Process	Output	Customer(s)
Manufacturer (A)	Coffee Mug (A)	Sell a cup of coffee	Mug of coffee	Customer
Catering Supplier (B)	Coffee (B)		Change	
Milk Supplier (C)	Sugar (B)			
Customer (D)	Milk (C)			
Power Company (E)	Order (D)			
Society (F)	Money (D)			
	Electricity (E)			
	Staff (F)			

High Level Process Map (50K View)

Heat water → Take order → Pour coffee in mug → Add hot water → Add milk → Collect money → Give mug

Table exercise: using SIPOC

D

SIPOC

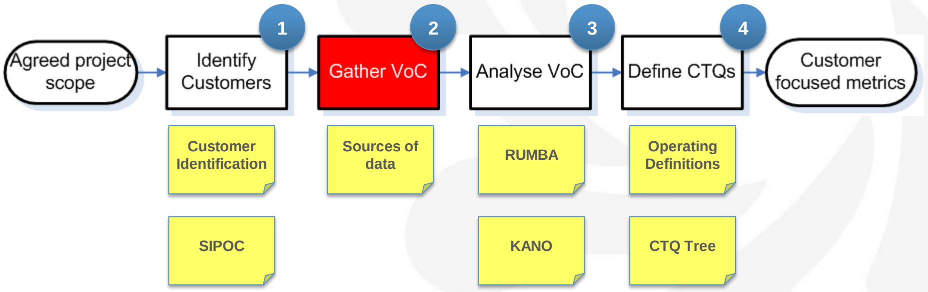
Objective: How to use SIPOC to identify customers and suppliers of a process

- Prepare a SIPOC for one of the projects within your table team

Time - 20 mins

D

Step 2: Gather VoC



What does a customer want?

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- Reliability
- Responsiveness
- Competence
- Access
- Courtesy
- Performance
- Timeliness
- Communication
- Credibility
- Security
- Understanding
- Tangibles
- Reputation
- Features
- ....

Voice of the Customer

D

"If you don't take care of the Customer…….. someone else will"

This module introduces the tools that can be used to better understand customer requirements and needs;

- Determine what a customer values
- How to better understand a customer's requirements
- How to prioritise the requirements

Sources of VOC data

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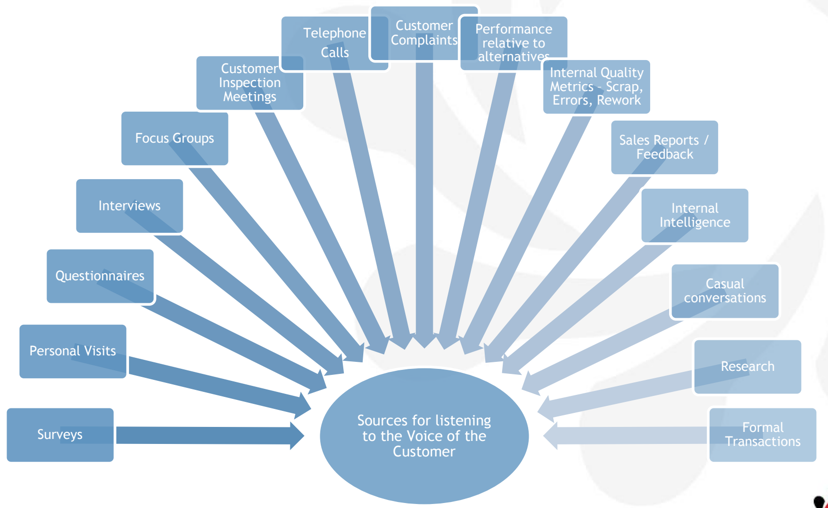

Think from the Customer's perspective

29

Quality of Customer Information

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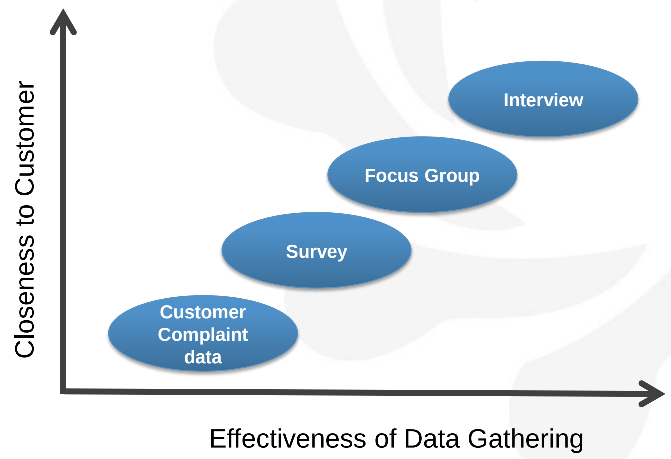

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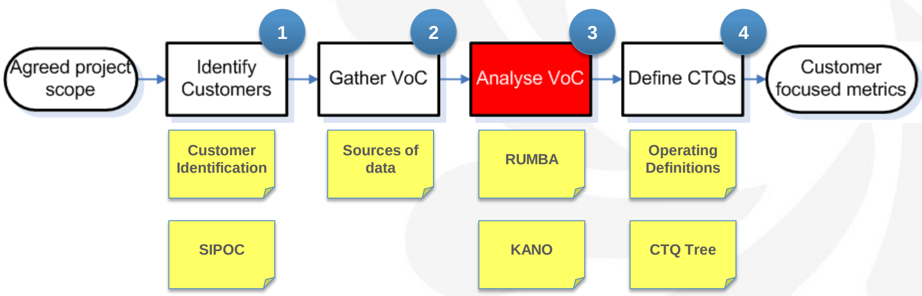
Step 3: Analyse VoC



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Analysing VOC data

- Many of the methods for gathering the VOC means that the data captured is often too abstract to be meaningful
- Often the information is presented as complaints or solutions – it needs to be analysed to ensure it is usable rather than just acting on it as a requirement
- We need to do a number of things to test out the requirement, to ensure it makes sense – and we must have a way to prioritise these requirements
- We need to ensure we know how the customer defines Value
  - The defined requirements are then known as the ***Output Characteristics***

Kano model

D

- Professor Noriaki Kano of Tokyo Rika University
- “Attractive Quality and Must-be Quality”, Journal of Japanese Society for Quality Control, Vol 14, no. 2 (1984).
- Kano Analysis does not prioritize customer needs
  - Instead it classifies needs
  - These classifications can then prioritize the design effort

Kano Analysis classifies needs, not features

Kano Model

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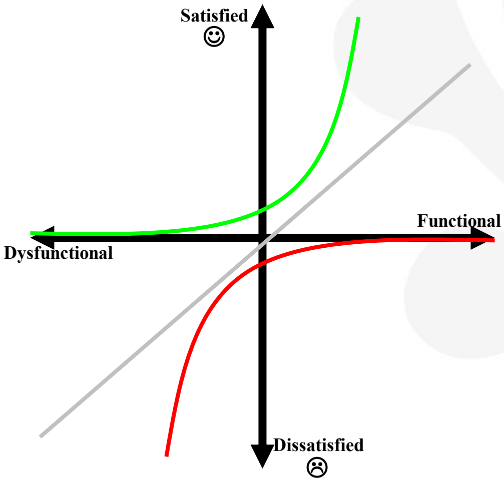

Attractive: unexpected criteria that if met will result in delight

One-dimensional: satisfaction is proportional to performance

Must-be: basic criteria that if not met will result in dissatisfaction

RUMBA - Test the customer requirements

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Reasonable	You or your department can meet the requirement (it does not violate company procedures, job accountabilities, etc.).
Understandable	The customers verify that you understand what they are requiring from you or your work group.
Measurable	The specification is measurable - in some way you can objectively determine the degree or frequency of meeting the requirement.
Believable	Your co-workers will be agreeable to strive for that level of achievement.
Achievable	You can meet the requirement. If not, you may need to renegotiate the specifications as facts and actual data may later dictate.

A want that meets all five RUMBA criteria is also a valid requirement.

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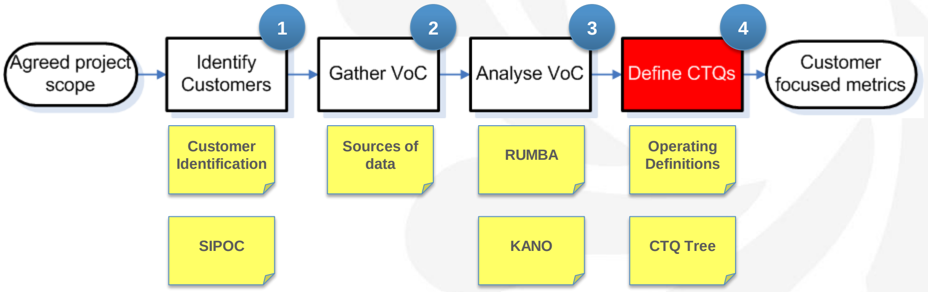
Step 4: Define CTQs



Operational definitions

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Consider the following scenario:

- Your project goal - reduce the average time to process new customer applications
- Your primary metric - average # of days to complete application
- Three fulfillment centres report the following data to your team:

Centre	Average # of Days to process applications
1	3.3
2	2.4
3	2.5

What does this information tell you? What actions would you take?

The importance of operational definitions

D

The operational definition for each location:

Location	Average # of Days to process applications	Day Request Is Received
1	3.3	**1**
2	2.4	**0**
3	2.5	**0**

Given this measurement information, would you still take the action you identified previously?

The importance of operational definitions

D

Key content

Intended to remove ambiguity and ensure consistent understanding of how data will be collected, measured and evaluated

- Specifies the exact criteria being measured
- Provides an exact description of how to calculate the metrics value
- Provides instructions as to how to collect and utilise the data

Be careful!!

D

The primary metric for most Green Belt projects are monitored through existing data collection systems:

Before collecting and analysing the data:

- Check for different operational definitions of the metric among locations/shifts/data collectors, and so on
- Check for consistent applications of the operational definition

CTQ Definition

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Critical to quality is an attribute of a part, assembly, sub-assembly, product, or process that is literally *critical to quality* or more precisely, has a direct and significant impact on its actual or perceived quality.

A measurable output of a product or a service that is important to the Customer. Remember, this is from a Customer's point of view.

CTQ's

D

Identify the VOC → Translate to the Key Issue → Create the Output Characteristic → Determine the Output Measure → Define the Target & tolerance

Voice of the Customer	Key Issue	CTQ / Characteristic	Metric	Target and Tolerance
I am always transferred to three or more different people.	Functionality: Want to talk to the right person the first time	Customer gets to the correct person the first time	Let's discuss	
I'm getting my bill at different times of the month.	Functionality: Consistent delivery of monthly bill	Customer bill received same day of month		

Structuring CTQ's

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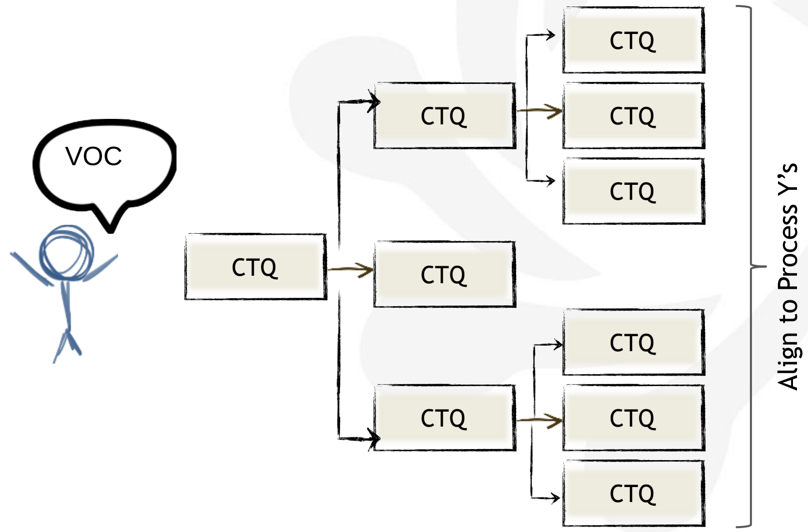

- It can be useful to structure the CTQ's to best visualise them

CTQ Tree

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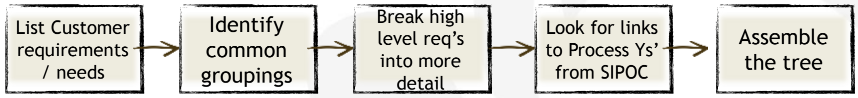

Why use it?

- Helps the team move from the broad and often vague high-level requirements and needs into detailed requirements
- Helps to ensure there is a direct relationship between the CTQ's and the Process Y's

Table exercise: Creating CTQs

D

Objective: To translate VOC to CTQ from

- Work in groups of 3-4 and review the following 'Voice of the Customer' statements (from a Sandwich shop):
- "It takes ages before I get my sandwich"
- "I really don't like your seats"

Complete VOC to CTQ template on next slide

Time - 5 mins

Exercise: Translate VOC to CTQ

D

Voice of the Customer	Key Issue	CTQ / Characteristic	Metric	Target and Tolerance
It takes ages before I get my sandwich				
I really don't like your seats				

VOC & CTQ Summary

D

- Understanding customer requirements is critical for all Lean Six Sigma projects
- There are numerous primary, secondary and tertiary sources of VoC
- Customer needs can be classified using Kano analysis and prioritised
- VoC should be translated to CTQs
- CTQs should be measurable following an agreed operational definition

Voice of the Business (VOB)

D

Derived from two primary drivers

What is the profit to be delivered from the process?

- What are the primary performance guidelines we want to achieve?
  - Unit costs
  - Transaction costs
  - Manpower levels
  - Asset utilisation
  - Material costs

What is the customer experience to be delivered?

- How does the customer expect to be treated when dealing with us?
  - How do we differentiate from our competitors?
  - Can we make negative interactions seem positive to the customer?
  - How do we make ourselves easy to work with?

Critical to the Business (CTB)

D

Stakeholders

Controllership
Regulatory
Work Council
Unions
Legal

Employee
Safety
Morale
Satisfaction

Critical to the Business CTB

Shareholder
Net Income
Return On Investment
EBIT

Community
Environmental
Local Relations

- Often these interests result in constraints or boundaries that are imposed on the process

VOC vs VOB

D

- **Lean Six Sigma is based on the belief that business benefit is derived from delivering customer requirements - it's customer focused**
- Many of the techniques for hearing and analysing **VOC** can and should be applied to **VOB**
- CTB's are **more often constraints than output targets:**
  - The business may not have defined targets for processes
  - The business may not have defined the customer experience it wants to deliver

Customer Requirements Summary

D

- Understanding & clarifying customer requirements is a 4-stage approach:
  1. Identify Customers (SIPOC)
  2. Gather their requirements (survey, interviews etc)
  3. Analyse the customer information (Affinity & Kano)
  4. Define the CTQ (target & tolerance)
- Translating **VOC into CTQ** provides a **method to measure** whether the customer requirements are being achieved

The CTQ makes the VOC measurable

FIREBRAND

DEFINE

Project Charter

The project charter

D

The project charter is the primary output document of the Define phase.

- It pulls together all the components of Define
  - The problem statement
  - Business case
  - Scope
  - Goal statement
  - Team roles, responsibilities and time commitment
  - High level timeline of tollgate delivery
- Could be thought of as a “contract” between the project team and the business

A basic project charter – Page 1 of 2

D

Project Leader	Project Name	Project Coach	Project Champion	Process	LOB	Project Type

Problem Statement

Business Case

Project Scope

Project Goal Statements

Project Team

Role	Name	Department	% Time Commitment
Project Leader			
Project Champion			
Project Coach			
Finance Certifier			
Process Owner			
Team Member			
Team Member			
Team Member			
Team Member			
Team Member			
Team Member			
Team Member			
Team Member			
Team Member			

A basic project charter – Page 2 of 2

D

Project Plan Summary

Phase	Start	Finish	2012 Jun	Jul	Aug	Sep	Oct	Nov	Dec	2013 Jan	Feb	Mar	Apr	May
Define	08/06/2012	31/06/2012												
Measure	12/07/2012	19/08/2012												
Analyse	20/08/2012	01/10/2012												
Improve	13/10/2012	14/12/2012												
Control	20/12/2012	12/02/2013												

CTQ's and Metrics

CTQ	Unit	Base level	Target

Benefits Forecast

Year	Benefit

Tollgate Status

Define	Measure	Analyse	Improve	Control

The problem statement

D

The problem statement should identify what problem this project is focused on solving. The problem statement should contain:

- Who - Who is being impacted? (What customer)
- What- What is the issue that is impacting the customer
- Where- Where do the customers encounter the problem with the process? (e.g.. on the phone with NE call centre or on line bill pay set up screen. etc...)
- When- When in the process does the customer experience the problem?
- Impact- What is the impact to the customer when the problem occurs? (e.g.. calls are being dropped, can't complete bill pay set up etc...)

Use SIPOC to identify the customer and the output that they receive

Business case

D

The business case should provide a compelling case to the Line of Business as to why this problem needs to be solved.

It should contain:

- From a business perspective, why should we do this?
- How does this project align with other business initiatives/strategic plan?
- What is the focus for the project team?
- What impacts will this project have on other business units and staff?
- What benefits will be derived from the project?
- How are the value of the benefits quantified? (e.g.. increased revenue, lower expense, cost per unit, cost avoidance, strategic value)

Ensure you enlist the support of Finance in quantifying and validating the potential financial benefits for your project!

Example of a Business Case

D

Business Case Profile

During ______________________________ , the ______________________ for
(Period of time for baseline performance) *(Primary business measure)*

________________ was ________________ . This gap of _________________________
(Output unit) *(Baseline performance)* *(Bus obj. target vs. baseline)*

from _____________ represents _____________ of cost savings. This
(Business objective) *(Cost impact of gap)*

project will ____.
(Project's expected impact on performance of primary busi ness measure)

Project scope

D

The scope should consider:

- What authority do we have?
- What processes are we addressing?
- What is not within scope?
- What are the starting and ending points of the process?
- What components of the business are included?
- What components of the business are not included?
- What, if anything, is outside of the project boundaries?
- What constraints must the team work under?

In/Out of frame, brainstorming and N/3 are important tools here!

Goal statement

D

The goal statement addresses the key project success metrics, the primary and secondary metrics (covered in the LSS Enterprise module).

- What are my measures of success that are aligned to the project objective?
- What are the goals for primary and secondary metrics?
- How much does the primary metric need to change for your project to be considered a success?

Other items to be included

- How long will it take you to complete this project? (A summary project timeline should be completed as shown on page 2 of the Charter)
- The goal of the tangible and intangible benefits of the business case?

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DEFINE

Team

The Lean Six Sigma project team

D

Revision:

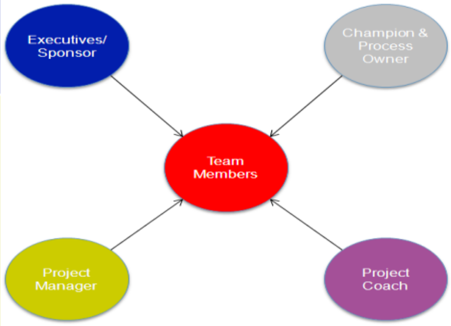
In the Enterprise module we covered the following core roles within the Lean Six Sigma project team

Executives / Sponsor

- Owns vision, direction, business results
- Leads Change

LSS Project Manager

- Has been trained on Lean Six Sigma
- Has time dedicated to leading projects using Lean Six Sigma methods and tools
- Supports team in executing project plan
- Provides support in implementing continuous improvement elements



Champion & Process Owner

- Decides to launch project
- Provides resources / means
- Helps moving roadblocks
- Validates solutions to be implemented

Coaching

- From experienced Project People
- Supports project managers and project teams

Other important roles include Project Finance Certifier and Operational Risk

Individual vs Systemic Efficiency

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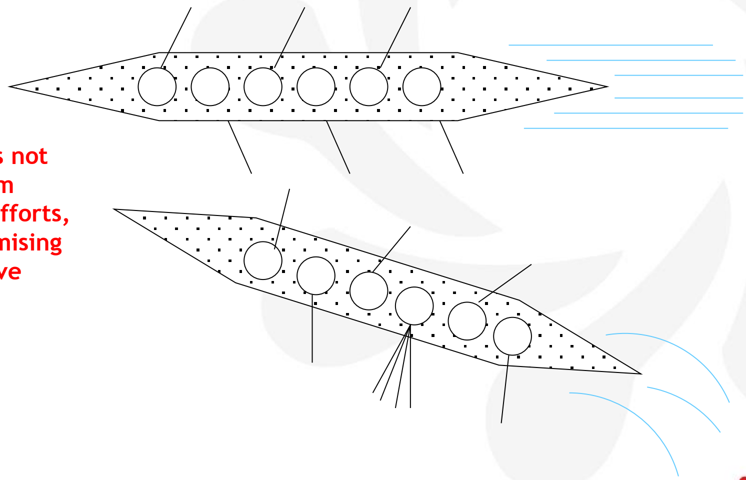


Efficiency is not derived from individual efforts, but by optimising the collective

The characteristics of a good core team member

D

A good core team member should:

- Have operational expertise in one or more sub-processes of the high-level process flow
- Be familiar with the problem
- Be motivated to fix the problem
- Commit to remain on the project until its completion
- Have the support of his or her manager

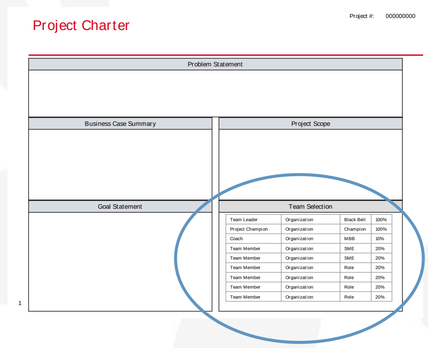
Document the agreed team roles within the Project Charter

D

The Project Charter should document these project roles within the "team selection":

Required information for each team member:

- Name
- Department
- Role on the project team
- Approximate percentage of time required on the project



Forming a team

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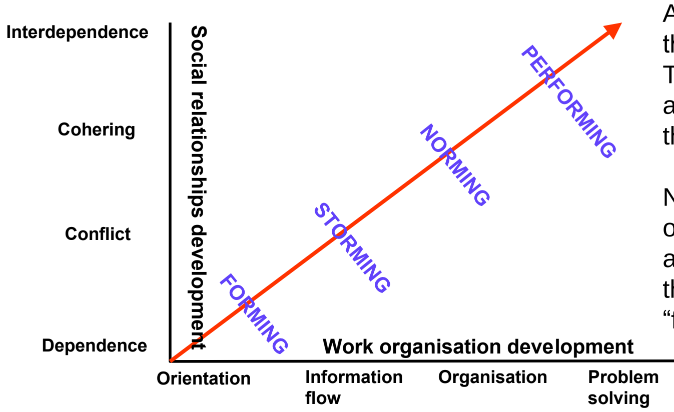
FORM TEAM

There is more to forming a team than gathering a group of people together



All teams will "go through" these stages. The Belts' role is to be aware of this and help the team through.

Note that the inclusion of a new team member at any stage will cause the team to return to "forming"

FIREBRAND

DEFINE

Change Adoption

Why is Change Adoption Important?

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$$E = Q \times A$$

E = Effectiveness of the solution

Q = Technical quality of the solution

A = Acceptance of the people

The change curve

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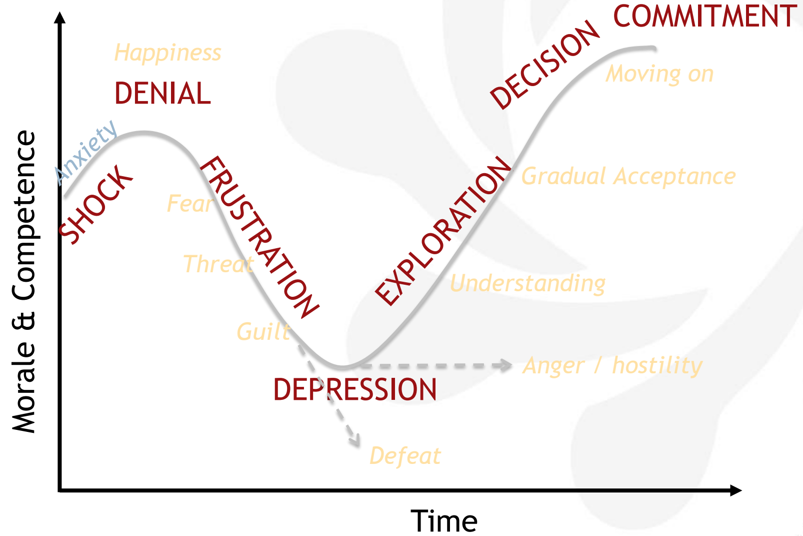

Original source Elizabeth Kubler-Ross (1969)

Change targets

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Impacted Populations	• People who are directly impacted by the change; way of working, organisation etc • Typically front-line, staff, middle management etc • Usually managed on a group basis
Key Stakeholders (individuals)	• Key individuals involved in the project or who have a vested interest in the project • Typically top-management • Usually managed on an individual basis
Work Councils, Unions & Authorities	• Organisations involved in the management of social & legal aspects of the change

DMAIC Change Management Strategy

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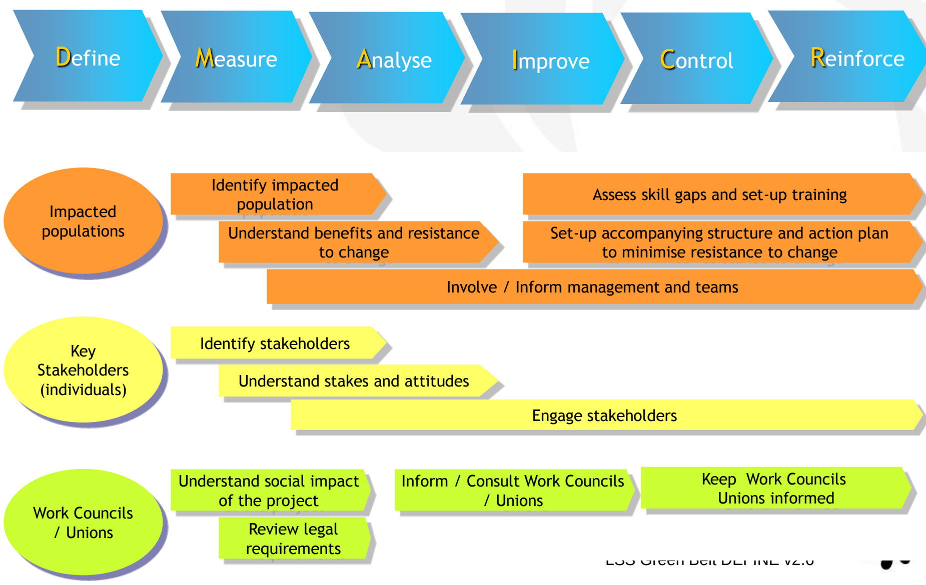

Change adoption

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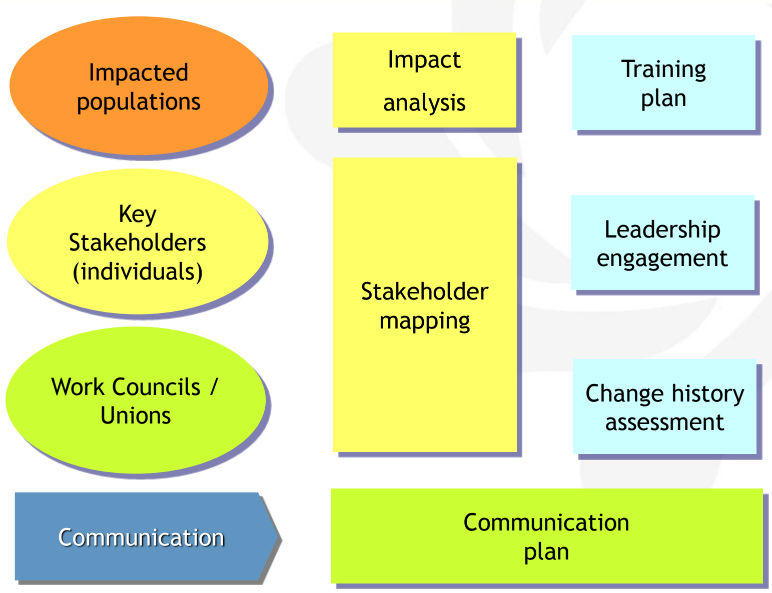

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Identify & Engage Key Stakeholders

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- Identify the key stakeholders associated with the project
- Evaluate their influence over the project
- Assess how much they support the project
- Prioritise communications actions in order to engage stakeholders and to maximise their positive impact on the project

Resistance distribution

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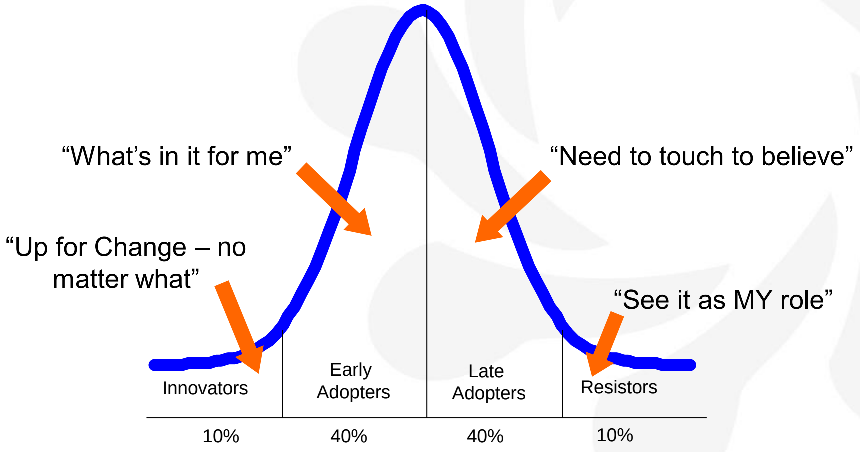
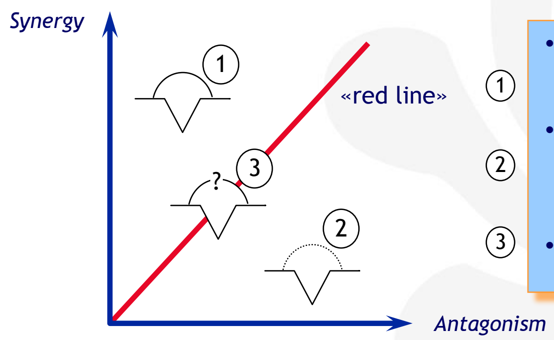
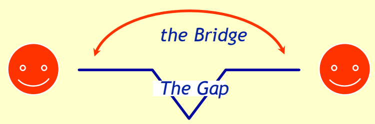


In relationships, Synergy and Antagonism co-exist…



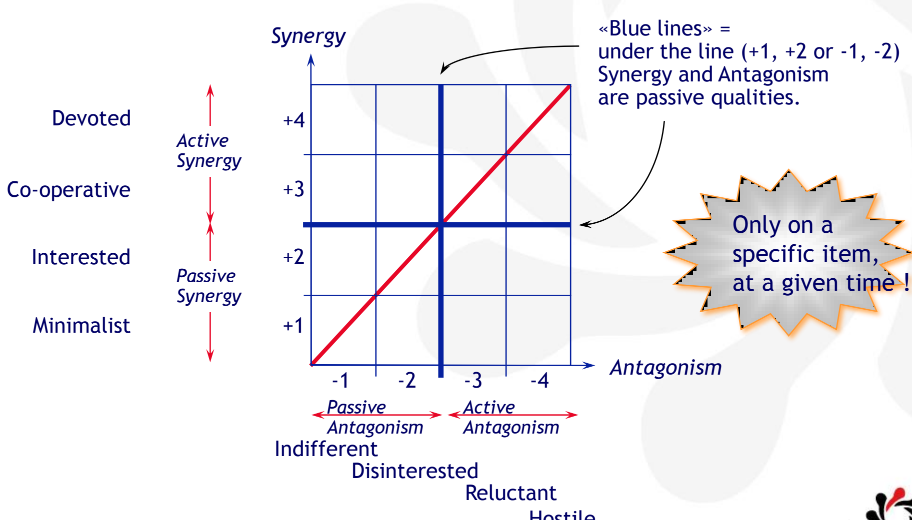
- Synergy > Antagonism :
  it's easy to work together !
- Synergy < Antagonism :
  easy to disagree with each other !
- Synergy = Antagonism :
  I am still *undecided*

We'd like to do something together (the Bridge), but …



… we have different priorities, interests and constraints (the Gap)…

4 levels of Synergy and Antagonism can be expressed at the same time



Stakeholders mapping – Principles

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Synergy

Intention credit / common game

+4

He/she identifies themselves with the project team in order to help reach a common objective, even if the team members are reticent

+3

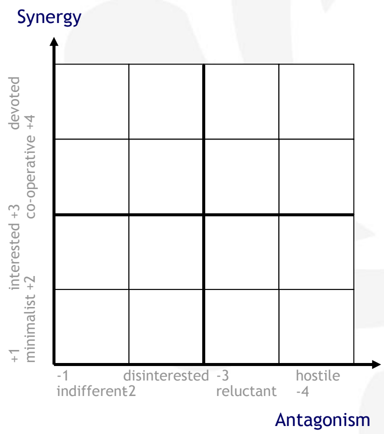
He/she takes the initiative to develop synergies, seeks consensus, offers suggestions, uses some of his own levers to support the project team. If they follow him/her, then synergy will increase in their relationship.

+2

He/she is interested in what the project team want, say or do. He consults, discusses and works but does not seek to go beyond what is strictly necessary…

+1

Rather favourable, he/she limits his/her relationship with the project team to the strict essentials…



Antagonism attitudes

Personal game

-4

He/she leverages absolutely everything to impose his/her own solution. If he/she does not succeed in doing so, he/she will break off the relationship !

-3

He/she uses more important levers to impose his own solution. If they do not succeed in doing so, he/she gives in and only to superior power and for a given period

-2

He/she uses certain levers and tries to obtain the best possible compromise for themselves via negotiation. He/she can give in at the end of the day…

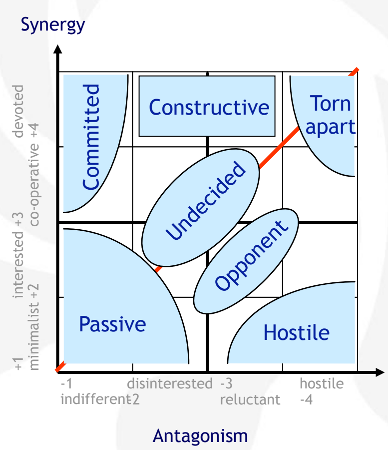
-1

He/she hesitates because they are fairly indecisive. He/she will rally to a contrary point of view in a passive manner, with someone who is more decisive than them

Stakeholder mapping : an essential tool to cope with Antagonism

D

- Passive : they do the minimum
- Undecided : they are ready to get involved if they get something in return
- Hostile : they will give in only when confronted by a stronger power ; they can decide to stop the confrontation
- Opponent : they are driven by the satisfaction of their own interest
- Committed : they support the cause
- Constructive : they support the project, and may offer positive criticism
- Torn apart : they have equal amounts of love and hate…



Stakeholder management – The Allies strategy

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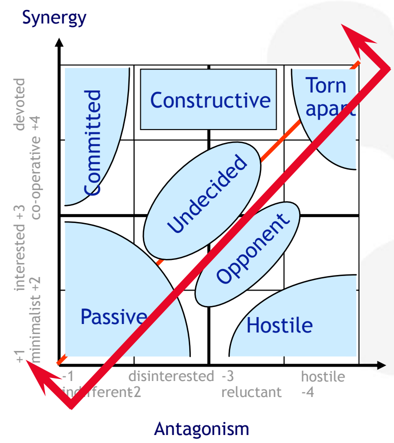
Once stakeholders are identified, then elaborate a strategy for each category



Any positioning is only meaningful :
- at a given date
- on a given subject / topic

Allies management Strategy

- Spend 2/3 of your time with your "Allies" :
  - Praise their efforts, accept them for what they are, support them, spend time with them… and in return, be demanding !
  - Surround the Passives and the Undecided, motivate them by offering them a joint stream to work on, compromise on issues of lesser importance…
  - Propose / suggest (at any moment) to the Passives to rally to a project, thus increasing their synergy
- Use your Allies to convince, ignore or exclude your opponents :
  - With 1/3 of your time (maximum), contain the attempts of the Opponents and Hostiles to rally the Undecided and the Passives to their side, by making counter-offers.
  - If necessary, neutralise the Hostiles, maybe by changing the scope of your project…

Example of Stakeholders management strategy

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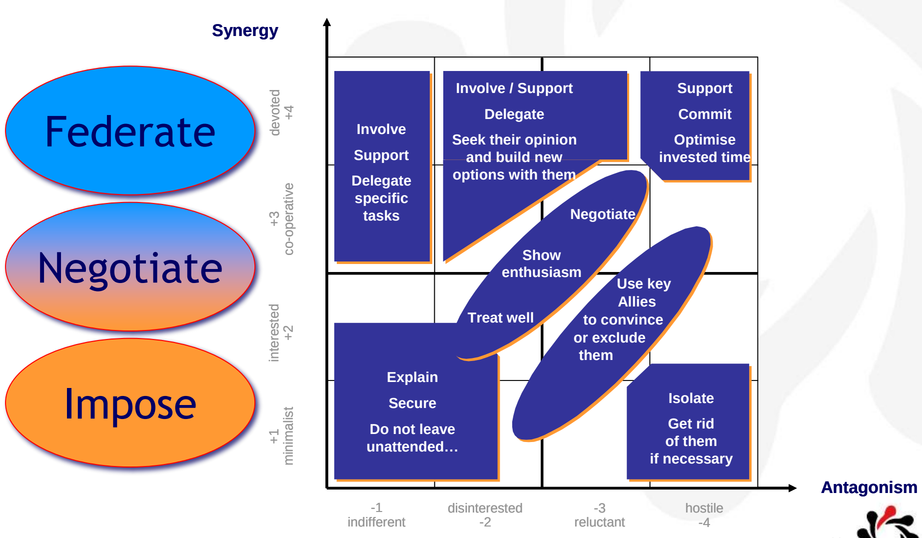

Where should we map our stakeholders?

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Where people are located on the stakeholder map depends on the specific project/point of application and the precise moment in time

As you us the tool..

- Don't try to guess, ignore or analyse the reasons why....
- ...rather measure the facts, focus on behavioural observation,
- Many positions seem irrational but...
  … there is always a rationale in the individual interests of different partners !
- Build your perceptions through cross information, exchange points of view with team members
- Define key actions with project management

Don't think people will stay where you saw them the last time !

Things, actions and positions move… all the time !...
Because that's what Change Adoption is all about..

Communications Plan

D

Use a communication plan to ensure stakeholders are kept properly informed and engaged throughout the change process. Ensure you adjust your communication strategy based on the issue under discussion and where the stakeholder is on the stakeholder map

Process Name	Project Name	Project #	Line of Business	Date Completed
Project Leader Name	Project Champion	Project Coach	Project Type	
Purpose of Communication Plan				

		Timeline	Channel	Recipient Response				
Audience	Key Message			Know	Feel	Do	Responsible	Responsible

Table exercise: Stakeholder mapping

D

Objective: To produce a stakeholder map

- Working in groups of 3-4, read the briefing document on the next slides.
- You are a project manager about to kick-off a cross-functional project on the bid process
  1. Map the stakeholders positions
  2. Think and plan the top 5 actions to get a better picture of the stakeholder positions
  3. Are there any immediate communication needs?
  4. Use the communication plan template to plan any communication needs

Time
45 mins + 15 mins discussion

D

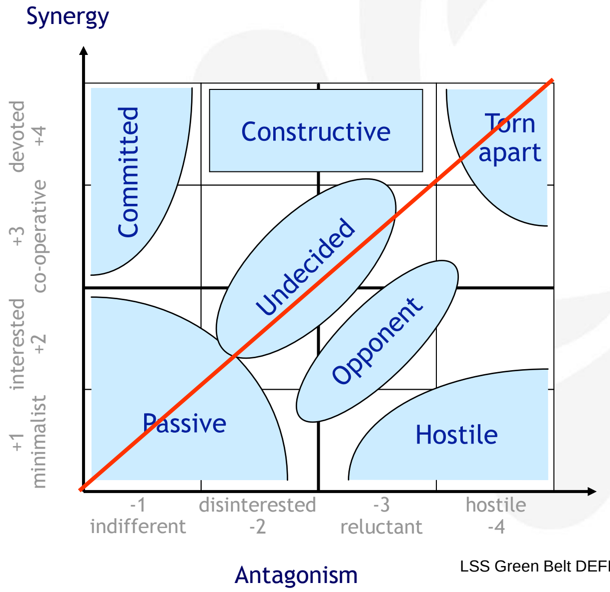

Table exercise: Stakeholder mapping - briefing

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- **NOTE this is an invented set of characters; there is no similarity to any of the people involved in the real project**

Name	Role/Organisation
Leonard	Sponsor
Cameron	Business Line leader
Giles	Head of Credit
Scott	Credit Approval Analyst
Ray	Bid Manager
Julie	Sales Lead

Leonard Sponsor

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- Leonard has worked at BFB for 15 years. His wife also used to work for BFB where she was a successful Lean Six Sigma Project Manager and was recently recruited by another Financial Services company to head their Lean Six Sigma programme.
- Leonard has become increasingly interested in Lean Six Sigma as he has seen it succeed. He has been with BFB long enough to have seen many other improvement initiatives start and fail.
- Before Relationship Management he used to be Head of HR at BFB. His preferred business style is to reach consensus smoothly and always put the client first.
- He is not a detailed person; always talks about the big picture; tends to delegate rather than direct.

Cameron Business line leader

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- Cameron has 25 years experience in the Financial Services industry and has successfully identified and built a new broker/dealer client segment at BFB. Whilst initially profitable, in the last year the smaller clients have struggled in the post-crash environment and in turn some have become loss-making for BFB.
- Cameron is commercially and politically astute. He knows there needs to be radical change to the bid process to ensure new clients brought in are profitable for BFB. He believes great client service and a cross-functional bid approach are key to this.
- He reports locally to the CEO and to the Global Business Head. Both are close to retirement age and he knows that if he can successfully turn-around the segment he could be in line for an Executive position.
- Cameron exudes old-school charm which the clients love and he is a gentleman to work with at BFB.

Giles Head of Credit

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- Giles has a Masters in Economics from the Sorbonne.
- He has taken great intellectual interest in the recent crash in Financial Services and has written several papers on the topic which have been published in The Economist.
- Giles' economic expertise is acknowledged and respected within BFB and he is based in the Head Office so he is on hand to advise the Global Business Head.
- At the weekend he goes sailing with the Head of the BFB Group. This relationship has helped secure him several senior credit positions within the group despite his lack of leadership & communication skills.
- His direction to the Credit Approval team is to be risk-averse and follow the procedures but he also personally looks into some Credit applications which his team have advised against for his old colleague Julie (Sales Lead).

Scott Credit Approval Analyst

D

- Scott has worked in Financial Services for 18 years, 10 at BFB.
- His previous role was as a Sales Lead where his fingers were burnt in the crash when his client went bust and cost the organisation £2.5million when they defaulted on a loan that he had secured credit approval for.
- Scott took a career change to the Credit Approval team where he is passionate about protecting the bank from Credit Risk.
- His experience in Sales and Credit make him ideal at working with the client and Sales leads to come to a Credit agreement that works for both parties. But with some of the smaller broker dealers, Scott knows that their risk is too high for BFB's credit policy and clearly explains this from the start.
- Scott works hard and gets frustrated when Julie contacts Giles after her client application has been declined. Not following the procedure wastes everyone's time and frustrates the client.

Ray Bid Manager

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- Ray has worked for BFB for 5 years. He keeps a low profile but is well respected by his team and works hard and diligently.
- He used to be a Police Officer where he enjoyed working in an environment of strict rules which were followed and great team spirit.
- His role is to compile the bid based on the information provided to him by Sales and the Business Line. Conditions of the bid are provided by Credit, Legal and Compliance.
- The Request for Proposal (RfP) process works to strict market deadlines so Ray depends on the information being provided to him in a timely manner. In reality his team spend a lot of time chasing and end-up working long hours and weekends before the deadline.
- As a result, quality of the bid suffers and Ray feels disenchanted by the organisation, struggling to maintain morale in his team.

Julie Sales Lead

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- Julie is the rising star of the sales team. She started her career in Head Office and made it her business to become and stay well connected with the senior players.
- Julie has had some early success with winning broker/dealer business. Following implementation some of these deals have not turned out to be as profitable as forecast which has not gone unnoticed by the Business Line or Credit department.
- Julie is the consummate sales person and focuses on the win. Individualist by nature she does not follow procedures but makes calls to her network of senior players to make things happen. This causes friction with her colleagues that make up the deal team but the behaviour seems to be tolerated and even encouraged by senior management.
- Julie's ambition is to be the Sales Lead on high profile deals and eventually transfer back to Head Office to take on the role of Global Business Head when the incumbent retires.

Change adoption - Summary

D

- E = Q X A
- Change adoption techniques should be used at every stage of the change journey
- Use mapping tools to adjust your communication approach with different stakeholders
- Remember that stakeholders perception of change moves over time be prepared to adapt your approach

Lean Six Sigma simulation: Round 2

D

The coin simulation

Objective: Use the tools covered in this module to prepare

- A project charter for the process. Your instructor has some information but will only give it to you if you ask the correct questions!
- Re-run the simulation implementing 1 quick win.

60 mins

Recommended coach support points

D

- When agreeing the scope of your project
- Defining your problem statement
- Gathering VoC data and translating it to CTQs
- Drafting your Define tollgate project charter

Key points of the module

D

- Defining the business problem is of critical importance to the success of any Lean Six Sigma project
- The Project Charter pulls together the key components of the Define phase
- Change adoption efforts should start as early as possible and continue through to completion of your project

FIREBRAND

MEASURE

Lean Six Sigma
Green Belt

Objectives of this module

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At the end of this module, you will be able to:

- Use various mapping techniques
- Identify potential root causes
- Understand the basics of data
- Conduct an attribute MSA
- Baseline process performance relative to customer requirements
- Create and execute a data collection plan

Six step approach

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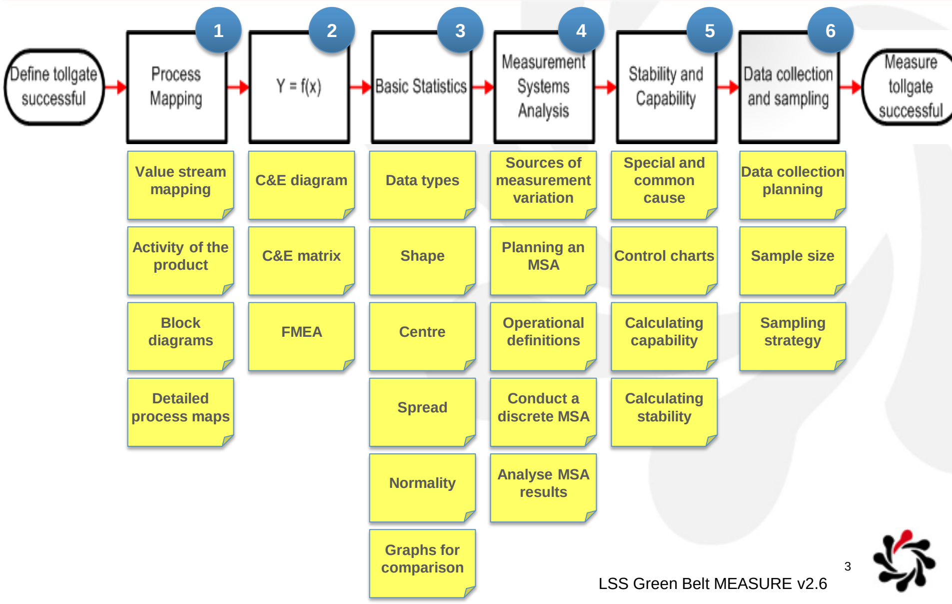

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MEASURE

Map the process

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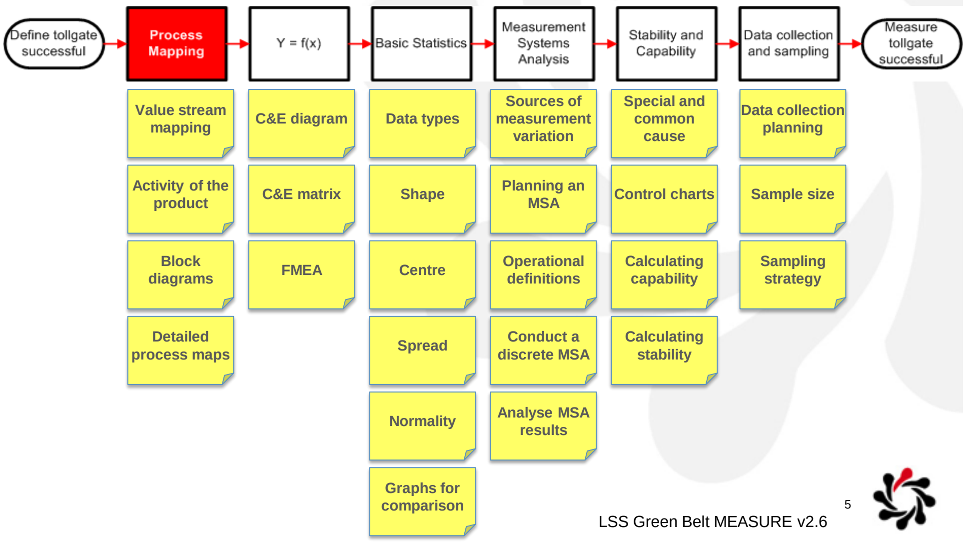
Step 1: Map the process



LSS Green Belt MEASURE v2.6 5

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Preview of the lesson

In this module we'll discuss the need to document the existing process as a first step to improve it. We'll review:

- Different mapping techniques
- How to create them

LSS Green Belt MEASURE v2.6 6

Types of visual maps

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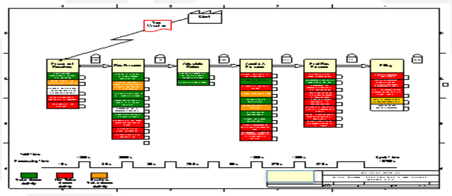
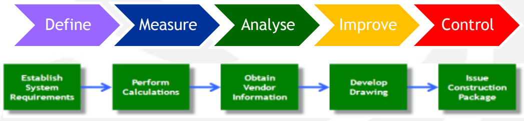
- **Value Stream Map**

  See the whole process, from beginning to end. Focuses on the journey of a "product" from order to delivery



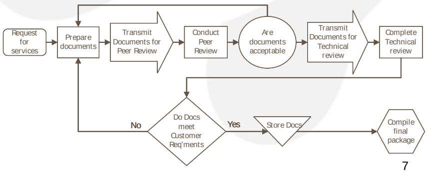
- **Block / Chevron Diagrams**

  High Level, low detail, typically showing phases



- **Process Map**

  Detailed, with different symbols representing different types of activities



Styles of maps

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<u>Value stream map (VSM)</u>

- A value stream map is all of the actions, both value-creating and non value-creating required to bring an order to delivery
- A VSM is therefore a "picture" of the process from a products point of view

Consistent use of icons are needed to create a clear picture of the value stream.

The company view of itself

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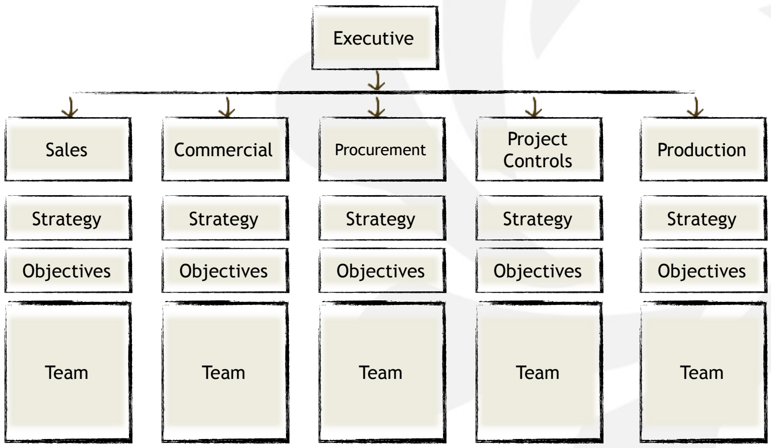

Companies are usually organised vertically – for a transaction to be completed, it flows up and down each department before being passed onto the next department.

The customers' view of the company

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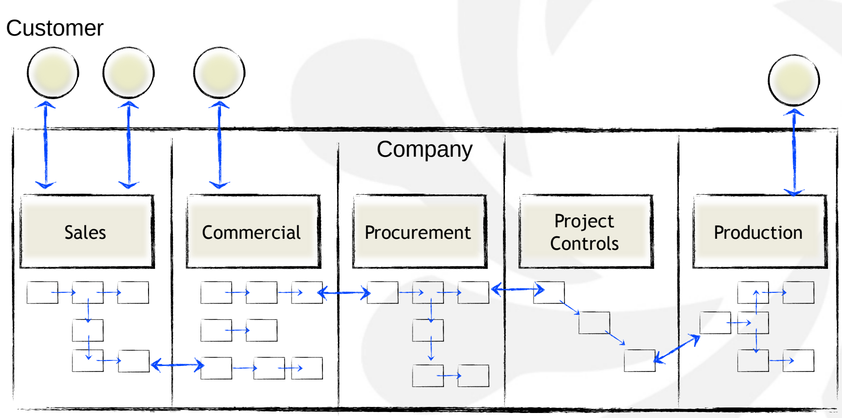
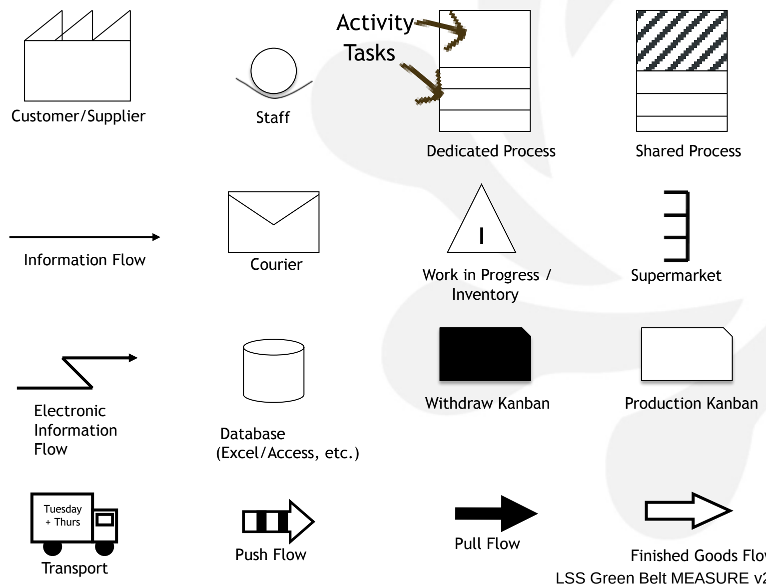


The customer views and experiences only a proportion of the interactions required in the production of a product / processing a transaction / provision of a service.

Customers are not concerned with the handoff between teams or their individual performance. They are concerned by the end result and their experiences along the way.

Typical VSM icons



Creating a value stream map

A “current state” value stream map is prepared to help build a picture of how the existing process delivers value to the end customer

To create a current state value stream map:

- Define a unit of product
- The team should follow a “product” through the entire value stream (physically if possible)
- Post-it notes and pencil should be used to sketch out the first drafts allowing you to refine as you learn more
- Use the standard icons as shown on the previous slide
- Collect “real” data, don’t rely only on process documentation or existing reporting

Typical sequence to building a VSM

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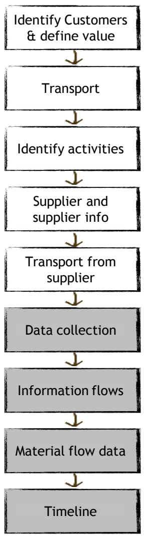


Identify customers and define value

- Include a clear definition of value from the customer perspective
- Demand on the process incl quantities, mix, batch size and working hours

Transport

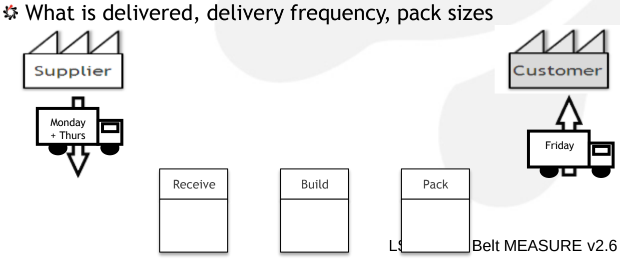
- Delivery frequency, mode of transport

Identify activities

- The activities/processes through which the process is flowing
- A picture of the flow including parallel processes and branches

Supplier and supplier information

- What is delivered, delivery frequency, pack sizes



Key measures and definitions

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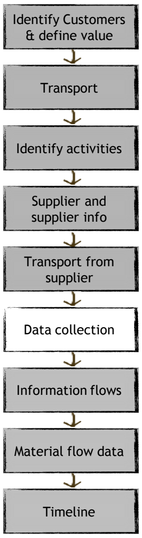


Cycle Time	CT	The rate at which product is produced at any point in the value stream
Value Adding Time	V/A	The time during which value is added for the customer
Waiting Time	WT	The time work in progress is waiting for the next operation to become available
Lead Time	LT	The elapsed time between a piece of work entering the value stream and the time it is released (to an internal or external customer) or is completed.
Processing Time	PT	The elapsed time from when the product enters a process until it leaves that process
Uptime	UT	% of planned operating time the process operates assuming product is available to work

Key measures and definitions

M

- Identify Customers & define value
- Transport
- Identify activities
- Supplier and supplier info
- Transport from supplier
- Data collection
- Information flows
- Material flow data
- Timeline

Work in Progress (Process)	WIP	Number of items in process or waiting at each activity
Pack size / Pack-out quantity		Volume of product required by the customer for movement or shipment
Scrap rate		% of total product that does not meet customer requirements and must be discarded
Rework rate		% of total product that does not meet customer requirements and must be worked on again
Defect rate		% of total product that does not meet customer requirements and includes both scrap and rework rates
Number of people		Number of people per process on an FTE (full time equivalent) basis
Available time		Time that the VSM can run continuously
TAKT time	TAKT	Available time / Customer demand

Typical sequence to building a VSM

M

- Identify Customers & value
- Transport
- Identify activities
- Supplier and supplier info
- Transport from supplier
- Data collection
- Information flows
- Material flow data
- Timeline

Information flows

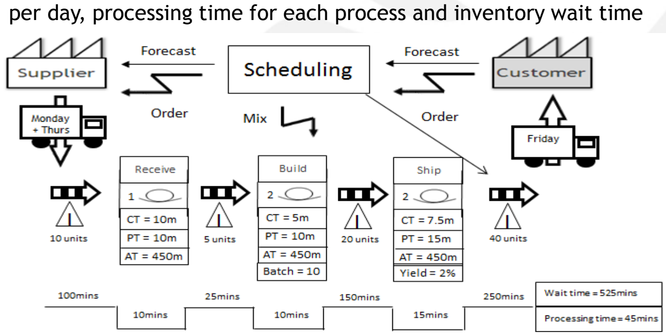
- Information flows inform each process what to do next. Examples include schedules, priorities and forecasts

Material flow data

- Information on whether the product whether in raw material, finished goods or part-completed is pushed or pulled through the value stream.

Timeline

- How long the product has taken to journey through the value stream. Information to be added to the VSM includes available time, production rate per day, processing time for each process and inventory wait time



Shingo model

The key principal of the Shingo model is:

Analyse Separately, Design as One

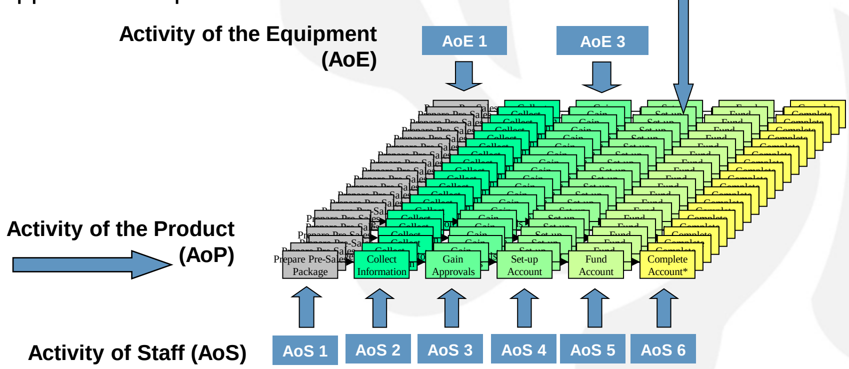
Separately analyse the activity of the <u>product</u>, <u>staff</u> and <u>equipment</u> to locate the waste in a process

Design a process solution that integrates the elements

Activity of the product (AoP)

We start with AoP as up to 80% of the improvement opportunity lies with what happens to the product:

50 – 80% of the improvement opportunity exists here



The product flow (AoP) reveals the overall level of waste in the process. Its journey is impacted by both the people and equipment.

The four possible activities of a product

M

There are four activities that can happen to a product at as it moves from one end of the process to the other. A product can be:

The Product

- **Stored** (Non-Value-Adding)
- **Transported** (Non-Value-Adding)
- **Inspected** (Non-Value-Adding)
- **Processed** (Value-Adding or Non-Value-Adding)

How did we define value-adding activity?

The structure of AoP template

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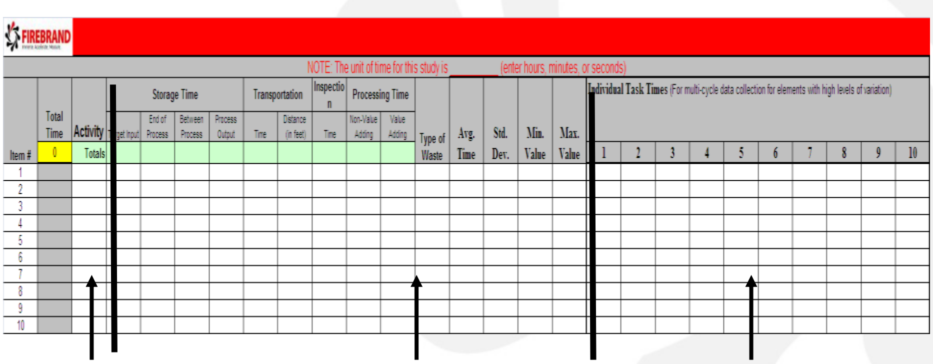
The AoP analysis worksheet consists of three sections:



Section 1

Describes what happens to the product

Section 3

Lists and categorises the average cycle time for each activity of the product (stored, transported, inspected or processed)

Section 2

Lists the cycle times for the activity, and displays descriptive statistics

The Structure of AoP Template, *Continued*

M

The second tab of the template summarises the AoP data in tabular and graphical formats and will provide you with a baseline of the value add time in the process

The tabular format lists the total processing time for each activity category and its percentage of contribution to the total lead time for the product.

FIREBRAND Activity of the Product Summary

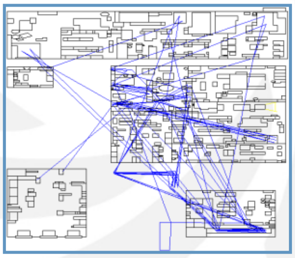
			TIME	PERCENT
Storage			71	80%
	time	percent		
Target Input (X)	50	70.42%		
End of Process	5	7.04%		
Between Process	13	18.31%		
Process Output (Y)	3	4.23%		
Total	71	100.00%		
Transportation			4	4%
Inspection			5	6%
NVA Processing			6	7%
VA Processing			3	3%
Total Time			89	100%

Why and when spaghetti diagrams are used in the step

M

Spaghetti diagrams depict the physical travel or movement of a product, helping you identify waste across the production environment whether that be an office or manufacturing facility

- The AoP study "quantifies" the travel or movement of the product.
- A Spaghetti Diagram shows a product's travel distance and pattern as it flows through a single cycle of the process.
- Use a Spaghetti Diagram when the product moves physically through the process.



Spaghetti Diagrams can also track staff movement.

Quantify the current inventory levels throughout the process

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Inventory is:

The raw materials, work in progress and finished goods in a process that are not yet delivered to the customer

- Inventory can exist in a physical or virtual state

What problems might occur my holding too much inventory?
How much inventory is just enough?

How inventory is identified and quantified

M

Identifying and quantifying inventory is straightforward.

- As you follow the product through the process, locate and count each inventory type:
  - Raw materials inventory (before and after each process step)
  - Work-in-progress (the number of products at each process step not fully transformed into the end product or service)
  - Finished goods inventory (any completed products that are being stored or held)

The count of each inventory type is recorded on a **Inventory Map.**

How inventory is identified and quantified, *Continued*

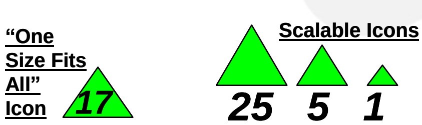
Virtual inventory is more difficult to identify and quantify.

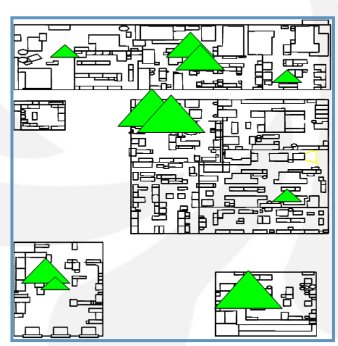
- Virtual inventory exists in the form of electronic files.
  - For example, a list of pending applications stored on a computer server
  - Another example are IT change requests which are work in progress virtual inventory.
- Review the information systems used at each process step for virtual inventory

Inventory maps

An Inventory Map graphically depicts the volume of inventory in the process at a given point in time.

- The inventory is shown on a physical layout of the workplace.
- Icons indicate where and how much inventory exists at the given point in time.





Baseline Rolled Throughput Yield (RTY)

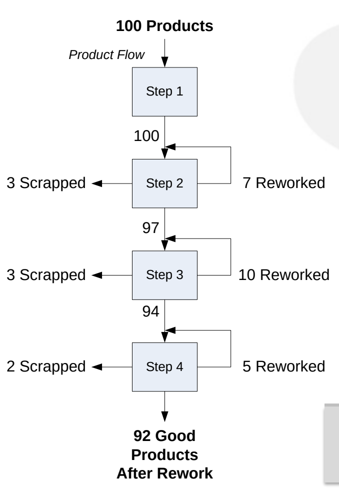
Yield is the percentage of products that are judged as "good" from the total number of products processed.

- The "product" is the reference product from the Value Stream Map.

$$\textbf{Yield} = \frac{\text{Number of "Good Products"}}{\text{Number of Products Processed}} \times 100$$

- The yield of a process is the yield of the process steps multiplied together

How Yield is calculated



$$\textbf{Yield} = \frac{\text{Number of "Good Products"}}{\text{Number of Products Processed}}$$

$Yield_1 = 100 / 100 = 1$

$Yield_2 = 97 / 100 = 0.97$

$Yield_3 = 94 / 97 = 0.97$

$Yield_4 = 92 / 94 = 0.98$

Process Yield = 1(0.97)(0.97)(0.98)=0.92
Or 92%

The traditional yield calculation does not account for defects fixed through rework!

The effort to fix defects in a process is often called the "hidden factory".

RTY is the preferred measure of product quality

M

The Rolled Throughput Yield (RTY) reveals the rework that occurs in a process (the hidden factory).

- RTY is the probability that a single unit can pass through a series of process steps free of scrap or rework

$$\textbf{RTY} = \frac{\text{Number of Products Processed} - (\text{Number of Products Scrapped and Reworked})}{\text{Number of Products Processed}}$$

- It is the product of the yields of the individual steps of a process in sequential order.

How RTY is calculated

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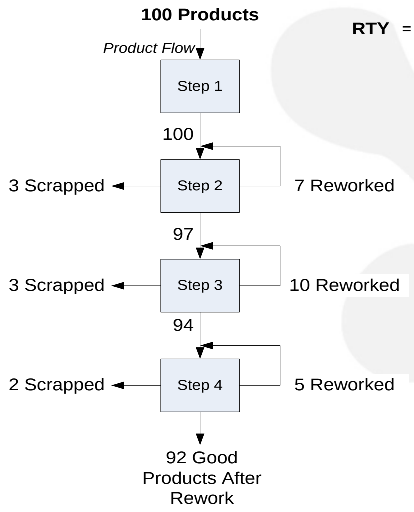

$$\textbf{RTY} = \frac{\text{Number of Products Processed} - (\text{Number of Products Scrapped and Reworked})}{\text{Number of Products Processed}}$$

$RTY_1 = (100 - 0) / 100 = 1$

$RTY_2 = (100 - (7+3)) / 100 = 90/100 = 0.90$

$RTY_3 = (97 - (3+10)) / 97 = 84/97 = 0.87$

$RTY_4 = (94 - (2+5)) / 94 = 87/94 = 0.93$

RTY = 1(0.90)(0.87)(0.93)= 0.73 or 73%

Definition of a process

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Dictionary

- A series of activities, changes or functions bringing about a result

Practical

- A manner or order in which a task is carried out repeatedly
- A systematic way of reaching an objective

A Process is not the same as a procedure

- A procedure is usually a written set of steps / instructions which when repeatedly followed targets consistency of the performance of a specific function.
- SOP – can refer to either Standard (or Standing) Operating Procedures

Block Diagrams

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- A block diagram is the simplest type of map. It provides a quick and uncomplicated view of the high level process
- Only rectangles connected by lines are used in this type of map. The rectangles represent major activities and the arrows indicate direction of flow
- Block diagrams can be used to simplify large and complex processes

Example block diagram

Block Diagrams

- Normally contain only rectangles
- Help show process scope
- Identify major steps and flow
- Contain 5-7 Blocks; fit on one page

Block Diagrams are typically used for presentations or management overviews

They do not provide the detail needed for diagnostics or problem solving

The block diagram scopes the detailed process map

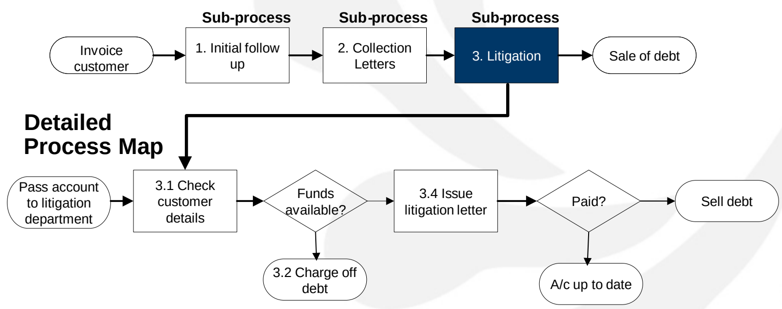
The block diagram can provide context:

While the detailed process map can be used to break these steps down further

The levels of process detail

The detailed process map breaks down the sub-processes in the block diagram:

Block Diagram



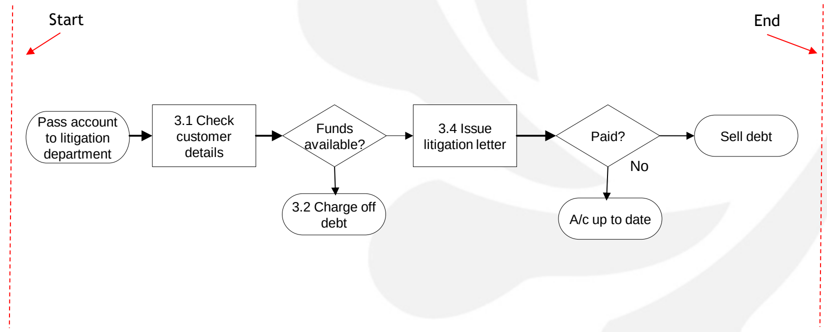
Symbols used in detailed process maps

All Process Maps use symbols to depict the flow.

Symbol	Description
	Start and End Symbol
	Action
	Decision Point
	Direction of Flow

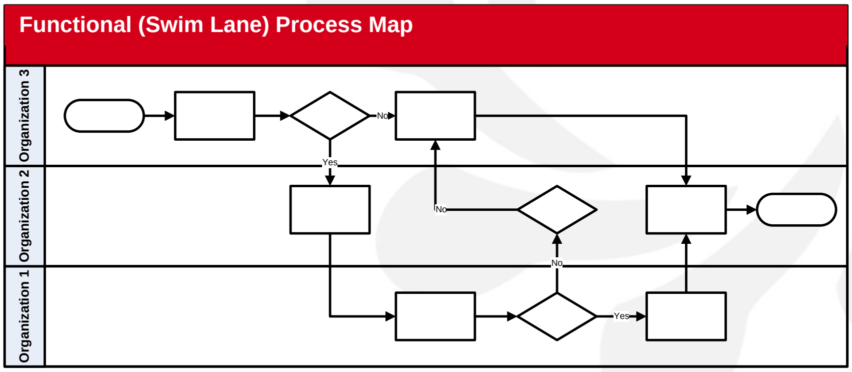
Identifying boundaries for your process

Boundaries define the start and end points of the process:



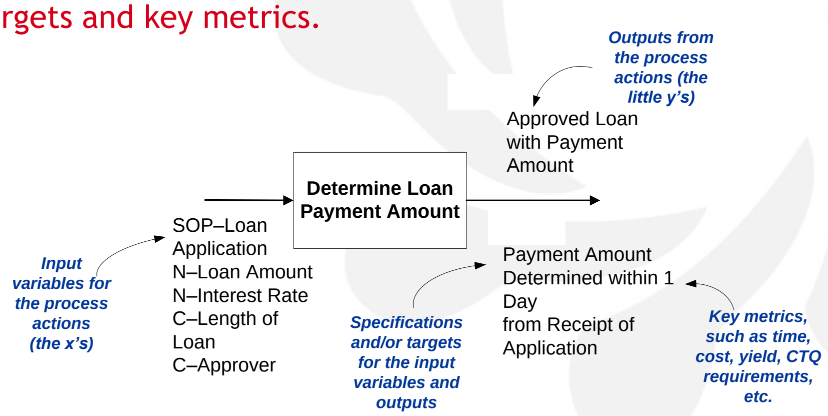
Functional process maps

Process maps can be built in a functional (swim lane) format:



Components of a detailed process map

Detailed Process Maps build on the process flow by depicting input variables, outputs, specifications and/or targets and key metrics.



Steps to develop a detailed process map

1. Determine the format for the Detailed Process Map eg vertical or horizontal
2. Identify the flow of steps and decisions within each sub-process.
3. List the outputs for each step.
4. List the inputs for each step.
5. Classify the input variables as Noise, Controllable or Standard Operating Procedure.
6. List the current specifications and targets for the process inputs and outputs.
7. Evaluate the Detailed Process Map to ensure that all criteria have been met.

Your detailed process map will be complete when you can answer the following two questions adequately:

- Who is responsible for doing the work to complete each process step and what activities do they perform to complete that work?
- How does the product or service go from initial input to final output?

Example of a detailed process map

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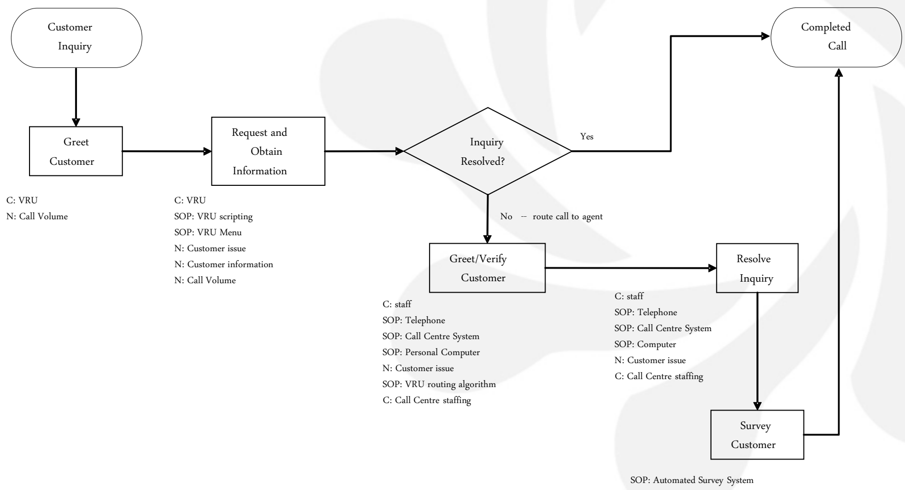

Class Activity: Mapping Exercise

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Objective: to practise mapping

Team A: draft a value stream map for a process you know well highlighting what information you'd collect to complete it

Team B: create a Block diagram and swim lane detailed process map for one of the following;

- Your project
- The process to book on this course

Time - 45 minutes
(incl 10 min de-brief)

Summary of key learning points

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- VSM's are the key maps to understand the whole of the process. They include how the materials, information or product flows through the process. ["Cradle to Grave" or "Soup to Nuts"]
- Capture key metrics such using Activity of the Product, Spaghetti Diagrams and Inventory Maps as you go
- Block diagrams are used to summarise a large process.
- Process Mapping (flowcharting) is used to drill down into a process, allowing it to be analysed for interactions etc. This takes time and therefore can be costly so care should be taken to ensure that the scope is carefully defined

FIREBRAND

MEASURE

Y = f(x)

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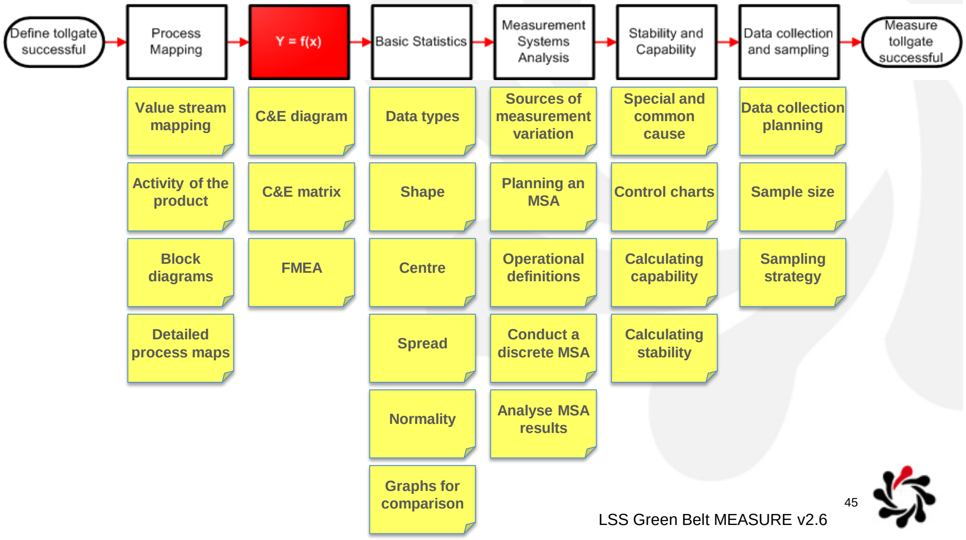
Step 2: Identify potential root causes



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Preview of the lesson

In this module we’ll discuss how to identify potential root causes using the following techniques:

- Cause & Effect diagram
- Cause & Effect matrix
- FMEA

What is Y = f(x)?

The "Y" in this simple formula relates to the output of a process:

- At a point in time
- Over a period of time
- At a point in the process
- Overall for a set of process steps

- Examples include:
  - Total time required to complete all process steps (lead time)
  - Percentage of deliveries achieved according to customer demand
  - Percentage of pizzas delivered within 15 minutes of order

What is Y = f(x)?

The "x" is the input upstream process indicator

- In-process measures
- Upstream from the customer of the process
- Taken at key points in a process to assess performance and intervene before customers are impacted

Knowing how these inputs (Xs) drive the process output (Y), allows us to predict and control process performance.

For this reason, the process output (Y) is sometimes referred to as the ***dependent variable*** while the input (X) is referred to as the ***independent variable***

Developing outcome indicators

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Customer Requirement = Outcome Indicator

Helpful guidelines:

- Measure data at intervals
- Describe how to measure
- Measure defects/non-conformance
- Avoid using averages alone
- Understand customer specifications

Developing outcome indicators

M

Avoid using averages alone as outcome (Y) indicators

Pipe Spool Deliveries
(What is the average delivery time of each supplier?)

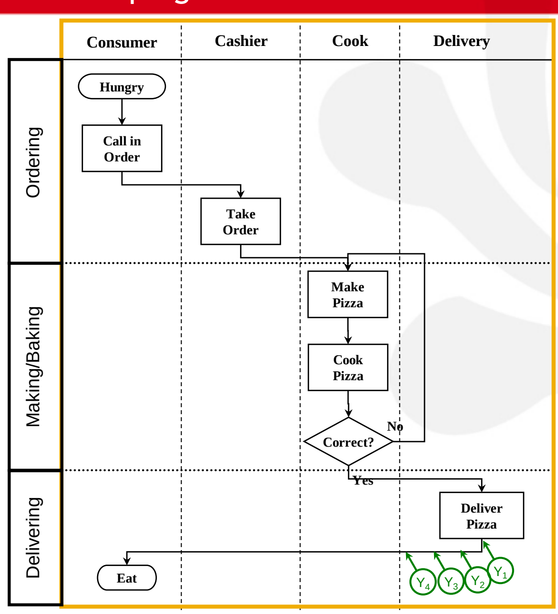
	Shipment 1	Shipment 2	Shipment 3
Fabricator 1	8 weeks	8 weeks	8 weeks
Fabricator 2	4 weeks	6 weeks	14 weeks

Developing outcome indicators

Understand Customer Specifications

Customer Valid Requirements	Customer Specification(s)	Outcome (Y) Indicators
Fast Delivery	30 minutes or less from order placement to delivery	Y1 = % pizzas delivered >30 min.
		Y2 = Actual pizza delivery time
Hot Pizza	At least 140° F	Y3 = % pizzas delivered >10 min. from "out-of-oven"
		Y4 = Actual time from "out-of-oven" to delivery

Developing outcome indicators



Y_1 = % Pizzas delivered >30 minutes

Y_2 = Actual delivery time

Y_3 = % pizzas delivered >10 minutes from "out of the oven."

Y_4 = Actual time from "out-of-oven" to customer.

Identifying the vital few inputs (x's)

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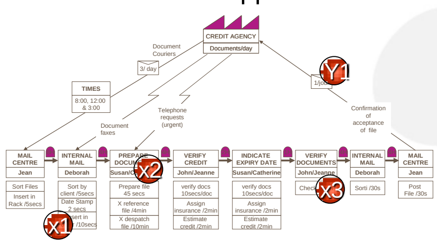
Cup of coffee = f (coffee beans; water)

- Identify on the map where the measures will be applied



- What are the factors?
  - X1 – coffee beans
  - X2 – qty of coffee
  - X3 – hardness of water
  - X4 – pH levels of water
  - X5 – Chlorine content of water
  - Etc, etc, etc

Identifying the vital few inputs

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Our process mapping will have identified a number of input variables but not all of these will have an impact on the process output

We use one of the following narrowing tools to answer the question, "Which are the **potential** vital few inputs (x's)?"

- Cause-Effect Diagram (Fishbone Diagram)
- Cause-Effect Matrix (C&E Matrix)
- Failure Mode Effects Analysis (FMEA)

The potential vital few inputs (x's):

- Are the short list of x's that the team identified is believed to have a critical influence or effect on the Y
- Will be statistically confirmed in the Analyse phase

Overview of the C&E Diagram

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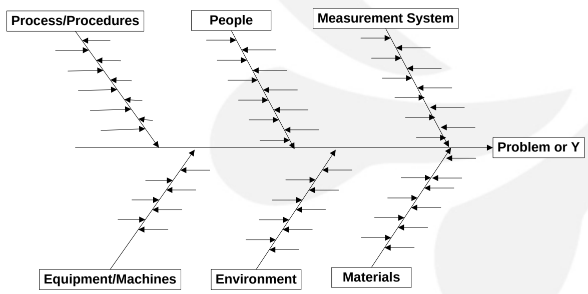
The C&E Diagram:

- Is a visual brainstorming tool to identify potential causes for your problem
- Also known as a fishbone or ishikawa diagram



Prioritising the causes

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Methods for prioritising causes:

Categorise as:

- High or low control to make or influence change for the identified cause

Causes → OR

High Control

The cause is within scope of the project.

The team can affect change to address the cause within the timeline established within the project charter.

Low Control

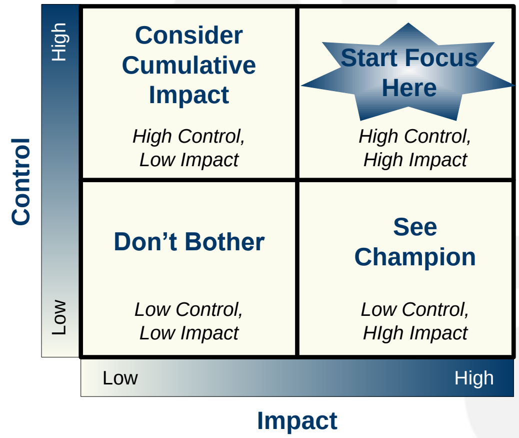
Maybe outside of scope of the project. The team should consider meeting with the Champion.

The team cannot affect change to address the cause within the timeline established within the project charter.

- High or low impact upon the stated effect

Prioritise causes based upon impact to the project

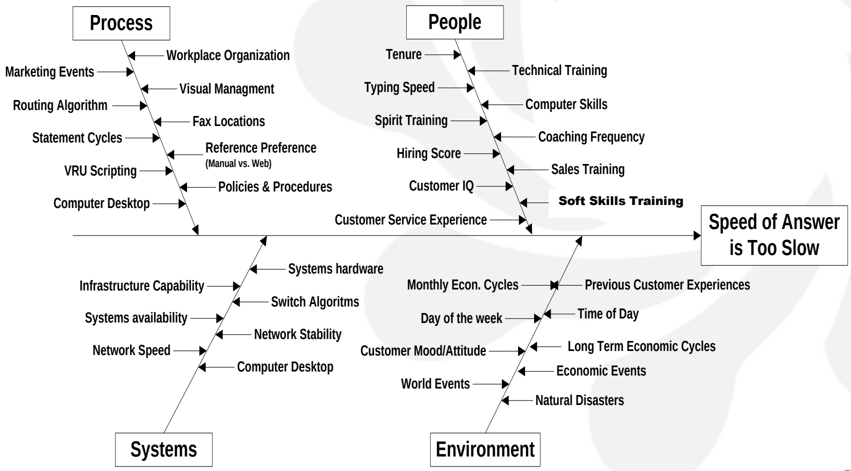
Priority Matrix



Steps to identify the potential vital few inputs (x's) with a C&E diagram

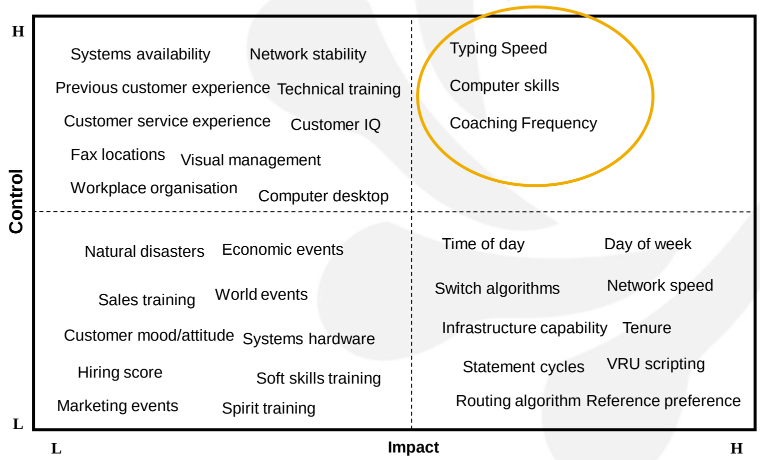
1. Record the Y for the project in the head of the diagram, stated as a problem or effect.
2. Determine the categories for the causes on the spines of the diagram (e.g., consider People, Materials, Measurement Systems, Equipment/Machines, Process/Procedures, Environment)
3. List the causes and attach them to the appropriate spines.
4. Identify the potential vital few causes by using a Priority Matrix.
5. Align the potential vital few causes with the inputs from the Process Map.

Example of a Cause-Effect diagram



Example of a C&E diagram, *Continued*

Priority Matrix



Overview of the C&E matrix

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The C&E Matrix

- The C&E Matrix generates an individual score for each of the identified inputs (x's) on the Process Map.
- The score defines the collective impact of the identified inputs (x's) upon all key customer CTQ requirements for the project.
- The potential vital few inputs (x's) are the inputs on the matrix with the highest scores.

	Output Variables (Y's)	Metric 1	Metric 2			
Input Variables (X's)	Output Ranking	10	8		Score	% Rank
Input 1		3	3		54	7.89%
Input 2		9			90	13.16%
Input 3		3	9		102	14.91%
Input 4		3	1		38	5.56%
Input 5		3			30	4.39%
Input 6		1	3		34	4.97%
Input 7					0	0.00%
Input 8		3			30	4.39%

Steps to identify the potential vital few inputs (x's) with a C&E matrix

M

1. List the project metrics.
2. Prioritise each metric.
3. List the inputs (x's) in the rows of the matrix.
4. Assign a correlation rating for each x and metric pairing.
5. Cross-multiply the priority and correlation ratings to obtain the score for each x.
6. Identify the potential vital few inputs based on the score

Example of a C&E Matrix

M

Name of Project: **_Call Center Service Level_**
Date: 1-May-06
Green/Black Belt: **_Jake Calc_**

Input Variables (X's)	Output Variables (Y's) / Output Ranking	Call answered within 30 seconds	Average Handle Time	First call resolution	Issue handled correctly	Cost per call		Score	% Rank
		10	7	7	7	8			
VRU		9	9	3	3	3		219	9.30%
Call Volume		9	9	3	3			195	8.28%
VRU Scripting		9	9	9	9	3		303	12.87%
VRU Menu		3	9	9				156	6.63%
Customer issue			9	9	9			189	8.03%
Customer information			9	9	9			189	8.03%
Associate		3	9	9	9	3		243	10.32%
Telephone		3	3			1		59	2.51%
Call Center System		9	9	9	9	3		303	12.87%
Personal computer		3	3	3		3		96	4.08%
VRU routing algorithm		9	9			3		177	7.52%
Call Center staffing		9	9			9		225	9.56%

Identifying potential vital few inputs

M

Identifying the potential vital few

Objective: To use narrowing tools

Based on the process of arriving to class on day 1:

- Choose to utilise either the C&E Diagram and Priority Matrix; or the C&E Matrix to identify the potential vital few inputs
- Discover the potential vital few inputs (x's) for the following problem:

Why do we arrive to class late?

Time - 30 minutes

Overview of FMEA

M

Failure Mode Effects Analysis (FMEA)

- An FMEA is a systematic way to evaluate and prioritise the *potential* failures of a process to prevent them from occurring.

Failure Modes	The things that go wrong (or fail) at a process step
Effects	The impact of the failure mode upon the customer
Causes	The sources of variation with the inputs that result in the failure mode
Analysis	FMEA prioritises the x's results based on three factors: • Severity of the effect on the customer • Occurrence of the cause • Detection or prevention of the cause or failure

The FMEA template

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FAILURE MODE AND EFFECTS ANALYSIS

Project Leader	Project Name		Date	Project Type	Project Coach

Comment boxes are embedded in each column heading to provide direction on how to complete this form

Process Step/ Function Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential / Cause(s) / Mechanism(s) of Failure	Occurrence	Current Process Controls Inspection Prevention Detection	Detection	RPN	What is the Recommended Action(s) to mitigate the risk and target resolution date(s)?	Who is Responsible for Action (s)	Action Results				
											Actions Taken	Date Action Taken	Sev	Occ	Det	RPN

Steps to identify potential vital few inputs (x's) with FMEA

1. List the process steps in the Process Function column of the FMEA template.
2. Enter the potential failures for each process step in the Potential Failure Modes column.
   How can this process step fail?
3. Enter the effects on the customer of a failure in the Potential Failure Effects column.
4. Enter the possible causes for the failure in the Potential Causes of Failure column.
5. Enter the methods and systems used to currently detect the failure in the Current Process Controls column.
   What do we have in place to either detect or prevent the cause or failure mode so that the effect does not occur?
6. Assign a rating to each effect by using a scale from 1–5 in the Severity (SEV) column.
   The higher the severity rating, the greater negative impact to the customer.

Steps to identify potential vital few inputs (x's) with FMEA, *Continued*

7. Assign a rating to each potential x by using a scale from 1–5 in the Frequency of Occurrence (OCC) Column.
   The higher the occurrence rating, the more frequently the cause occurs and will result in a failure mode.
8. Assign a rating to each potential x by using a scale from 1–5 in the Likelihood of Detection (DET) Column.
   The higher the detection rating, the more likely the customer will experience the effect.
9. Calculate the Risk Priority Number (RPN) for each potential x.
   RPN = SEV x OCC x DET
10. Identify the vital few inputs (x's) for validation in the Analyse phase.
    Prioritise by:
    - High RPN Value
    - High Severity Ratings
    - High-occurrence and low-detection ratings

Example of an FMEA

M

Process Step/ Function Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Potential / Cause(s) / Mechanism(s) of Failure	Occurrence	Current Process Controls	Detection	RPN
Resolve Inquiry	Call Center associate does not understand customer issue	Customer's issue not resolved	5	Customer does not provide sufficient information	2	VRU script	1	10
						Call Center System	2	20
						Card Call Center Procedure	3	30
				Call Center System is down	1	Call Center System maintenance	1	5
				Associate inexperience	3	Staffing	4	60
						Associate training	3	45
	Takes too long to resolve inquiry	Handle Time increases	4	Slow typing skills	3	None	5	60
				Associate does not understand Call center System	2	Associate training	4	32
				Call Center System is "slow"	2	Call Center System maintenance	2	16
				Associate inexperience	3	Staffing	4	48
						Associate training	3	36
	Call Center associate misclassifies customer issue	Customer's issue not resolved	5	Customer does not provide sufficient information	2	VRU script	1	10
						Call Center System	2	20
						Card Call Center Procedure	3	30
				Associate inexperience	3	Staffing	4	60
						Associate training	3	45
	Call is dropped	Customer's issue not resolved	5	Associate's telephone malfunctions	1	Maintenance	2	10
				Switch overloaded	1	VRU routing	1	5
				Associate inexperience with system	2	Staffing	4	40
						Associate training	3	30

Analysing the FMEA

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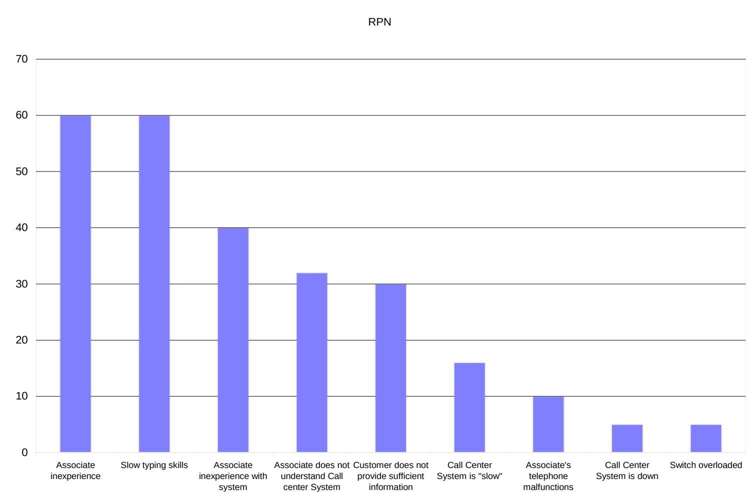

Building an FMEA

Failure Mode Effects Analysis

Objective: To prepare an FMEA

Based on the process of arriving to class on day 1:

- Create an FMEA and be prepared to present back to your classmates.

Time - 15 minutes

Guidelines on when to use the narrowing tools

The C&E Diagram

Advantages	Limitation
• It is quick and relatively simple to complete. • It organises the causes into categories.	• Only one CTQ can be evaluated with one fishbone.

Advantages and limitations of narrowing tools, *Continued*

M

The C&E Matrix

Advantages	Limitation
• It quantifies the influence of each x on the project metrics. • It uses the inputs from the Process Map. • It can evaluate multiple CTQs.	• Does not consider level of control

Advantages and limitations of narrowing tools, *Continued*

M

The FMEA

Advantages	Limitations
• There is more rigour in identifying and analysing inputs in a FMEA when compared to a C&E Matrix and a C&E Diagram • It is process focused. The flow of the tool follows the flow of the process. • It can evaluate multiple CTQs.	• It is time consuming to complete.

Summary of key learning points

After mapping out the processes

Step 1: Identify the key output metrics (Y's)

Step 2: Use the appropriate tool to identify the <u>potential</u> few inputs (x's)

- C&E Diagram
- C&E Matrix
- FMEA

Recommended coach support points

- The identification and measurement of your process outputs
- The type of narrowing tools used and the rationale for their selection
- The potential vital few inputs for your project Y

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MEASURE

Basic Statistics

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Step 3: Basic statistics

Define tollgate successful → Process Mapping → Y = f(x) → **Basic Statistics** → Measurement Systems Analysis → Stability and Capability → Data collection and sampling → Measure tollgate successful

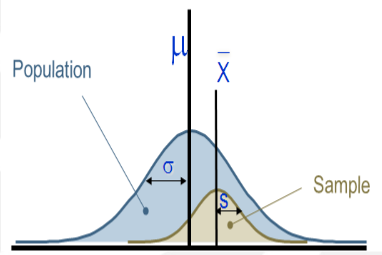
Process Mapping	Y = f(x)	Basic Statistics	Measurement Systems Analysis	Stability and Capability	Data collection and sampling
Value stream mapping	C&E diagram	Data types	Sources of measurement variation	Special and common cause	Data collection planning
Activity of the product	C&E matrix	Shape	Planning an MSA	Control charts	Sample size
Block diagrams	FMEA	Centre	Operational definitions	Calculating capability	Sampling strategy
Detailed process maps		Spread	Conduct a discrete MSA	Calculating stability	
		Normality	Analyse MSA results		
		Graphs for comparison			

Preview of the lesson

M

During this lesson we will cover the following basic concepts of:

- Determining the type of data
- Assessing the shape of the data
- Measures of central location
- Measure the spread
- Assess the normality of data
- Creating graphs for comparison



Types of Data

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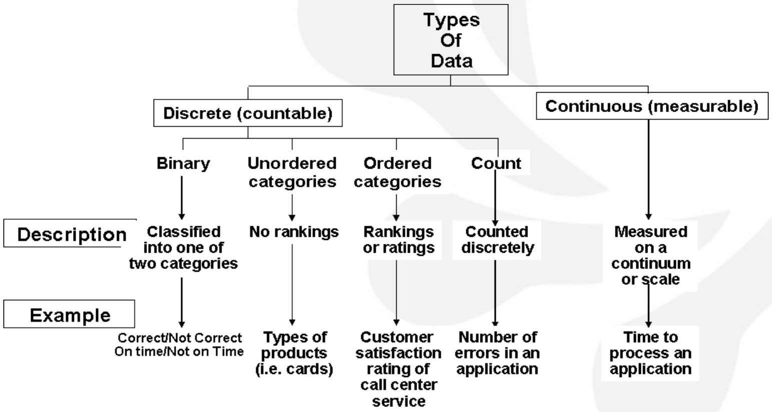

Continuous Data

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- It is measurable data.
- It is data that can theoretically be subdivided and measured in smaller and smaller units.
- Based on required precision, we decide the number of decimal places.
- Small amount of data is required to draw valid conclusions

Examples:

- The length of a cable
- Thickness of a wire
- Downtime of a LAN server
- The average repair time of a machine

Discrete data

M

- It is countable, indivisible data
- Whole numbers only—no decimal places
- Usually related to defects or proportions - after the error has had an effect
- Illustrates the trends only over a longer time period
- Large samples sizes are required in order to draw valid conclusions

Examples:

- The number of times a schedule date is missed
- The number of people absent
- The number of customers in various market units
- Percent of products defective

Data Classification

Continuous or discrete?

1. The frequency of failure of a machine (number of times)
2. The number of hours an installed circuit board lasts
3. The number of damaged telephone circuits in a business
4. The number of undelivered bills per month
5. The daily fuel consumption of repair trucks
6. The dollar differences from work order budgets and work order actuals
7. The percentage (%) of phone calls greater than 30 seconds
8. Shoe size?

Time - 5 minutes

Continuum of data possibilities

It is most desirable to be able to measure your Y on a continuous variable scale.

Other types of data can certainly be analysed. As you move from the ideal, more samples will be required to show and detect improvement.

The data at your disposal can be in many forms:

- Binary – classified into one of two categories
- Unordered categories - no rankings
- Ordered categories – rankings/ratings
- Count – counted discretely
- Continuous – on a continuous scale

Descriptive statistics

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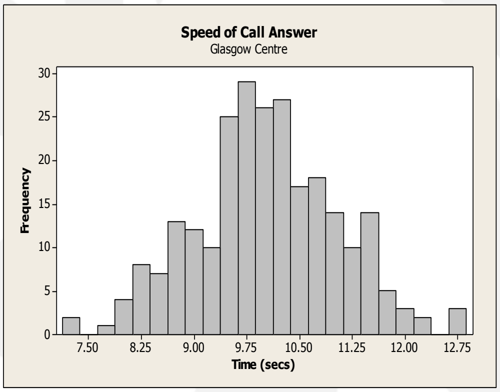
Shape of the data (Bell-Shaped or skewed)

Centre of the data (mean, median or mode)

Spread of the data (range, standard deviation or variance)



Assessing shape - Histogram

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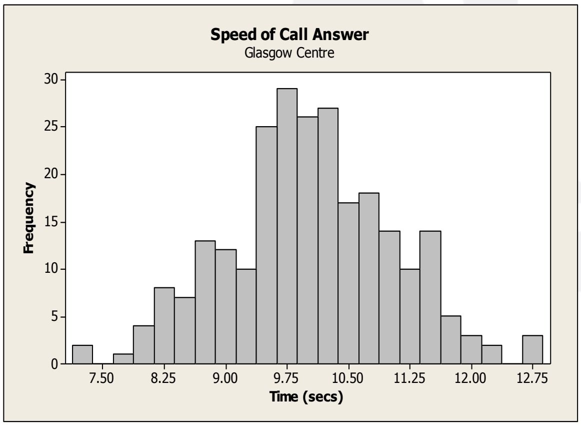
What does the shape of this Histogram suggest?



Parts of a Histogram

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A histogram is made up of three components:

Vertical or Y-Axis:

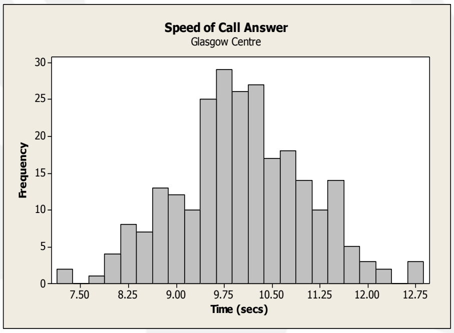
- Indicates the scale for the frequency of the bars

Horizontal or X-Axis:

- The scale of values into which the data values fit
- Data values grouped into intervals

Bars:

- Denote frequency of the data within the grouped intervals
- Provide indication of the shape



Advantages and limitations of using a histogram

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Advantages	Limitations
• A Histogram displays data in an easy to interpret graph. • It shows the general shape of data. • You can place specification limits on a Histogram to show what portion of the data that is within requirements.	• A Histogram cannot distinguish exact values; it creates intervals or “buckets” from the data points. • It is not meaningful for small data sets; at least 30 measurements are needed. • It will obscure any time differences within your data sets.

Use Histograms to answer the following questions:

What is the shape of my continuous data?

Does my process perform to specifications?

Measures of the central location

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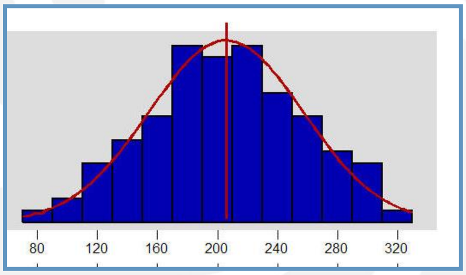
The three measures of centre:

- **Mean** - the average of the data
- **Median** - the middle point in the data
- **Mode** - the most frequently occurring value in the data



Formula for calculating mean

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Calculating mean:

$$Mean = \frac{Sum\ of\ All\ Data}{Number\ of\ Data\ Points}$$

Steps for calculating mean:

1. Calculate the sum of all the data.
2. Divide by the number of data points to calculate the mean.

$\bar{x}$	Sample mean also known as x-bar
μ	Population mean

Calculating the median

M

What is the median?

- Is the middle value of the ordered observations
- Half of the measurements are greater than the median and half are smaller than the median

$\tilde{x}$ Sample median

η Population median

Steps to calculate median:

1. Order the numbers from smallest to largest.
2. If the data set includes an odd number of data points, choose the point that is exactly in the middle.
3. If the data set contains an even number of data points, choose the two numbers that are in the middle and average them.

The impact of shape upon centre

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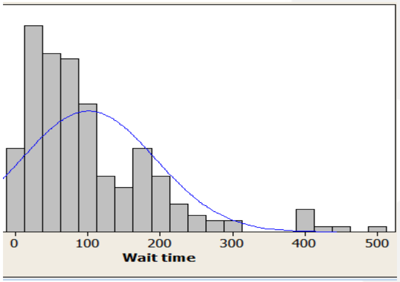
- The Histogram below plots the wait time, in seconds, at a hotel reception desk.



The mean wait time is 100 seconds. The median wait time is 74 seconds.

Which one should we use?

Based on the shape of the data, what might we conclude about these wait times?

The impact of shape upon centre, *Continued*

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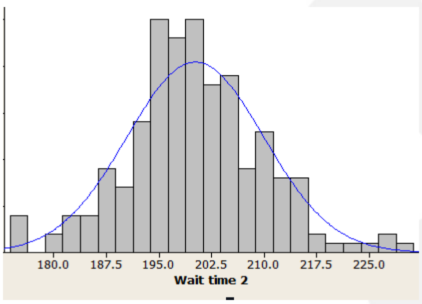
- Another wait time example:



This Histogram represents the wait times for another hotel. The mean wait time is 200.1 seconds and the median is 200.1 seconds.

There is no/little difference between the two statistics for centre of the data.

Why is this?

Guidelines for use of mean and median

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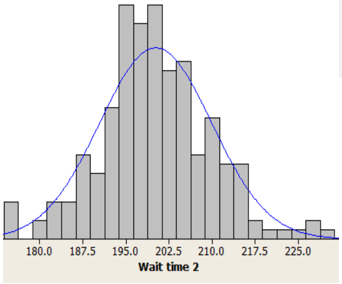
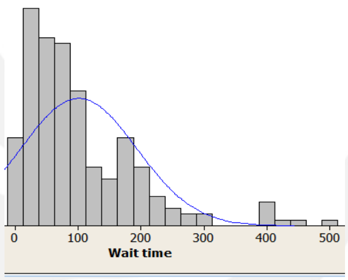
- Mean or Median?





If the data is bell-shaped, use the mean to describe the centre of the data.

If the data is skewed, use the median to describe the centre of the data.

Mode

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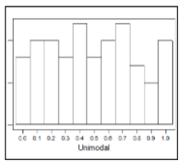
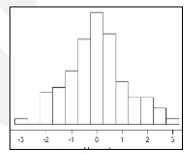
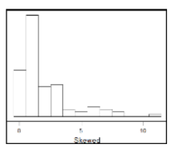
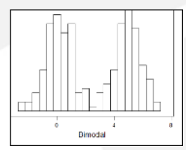
- Mode is the value in the data that occurs with the greatest frequency.


Uniform


Normal


Skewed


Bimodal

Spread of data - variation

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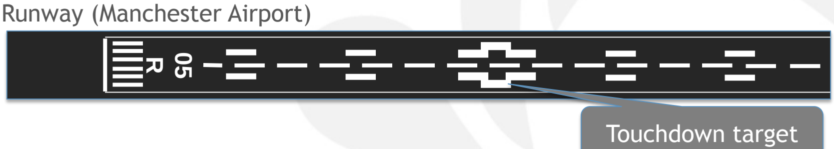
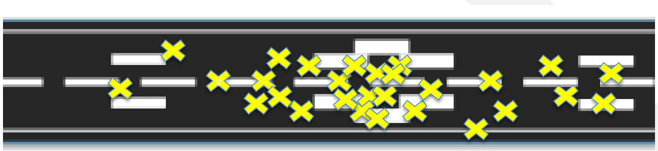
Runway (Manchester Airport)



How consistently do the pilots perform?



We want to be able to measure the performance and use it to compare the quality of pilots.

If we were to select a pilot for a new route to SABA – how do we compare their performance?

Measures of spread

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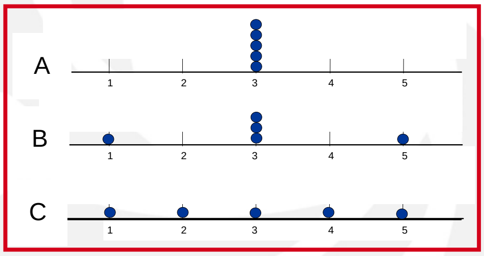
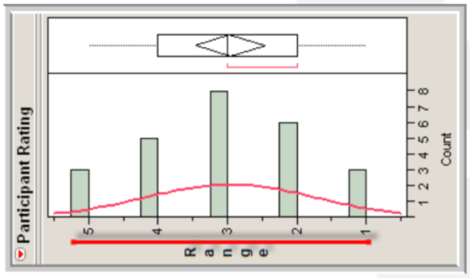
- **Range** - difference between the largest and smallest values in the data
- **Variance** - how far each data point is from the mean
- **Standard deviation** - square root of the variance



Range

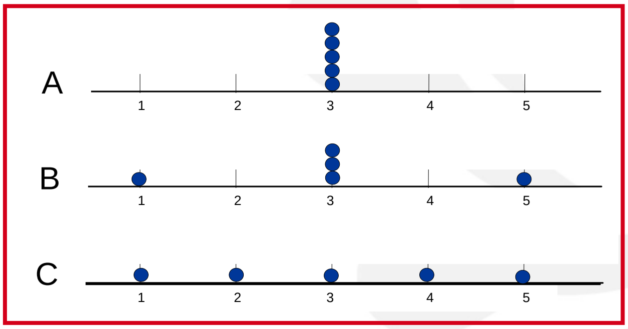
M



- Range = x $_{Largest}$ - x $_{smallest}$

Limitations of Range as a measure of spread

- What are the ranges for data sets A, B and C?



Range doesn't account for each point in the data; it only evaluates the extremes.

Variance and Standard Deviation

Variance does account for every point in the data.

Variance evaluates the squared difference of every point in the data from the mean.

Variance is not practical since it would be in squared units.

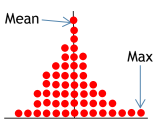
- To remove a squared term, take the square root.
- The square root of the variance is the standard deviation.
- We can use improvement software such as Minitab to calculate variance or we can calculate it manually!

Variation - *Variance*

M

Variance is a way of describing how much the data is dispersed around the mean.
As the values have been Squared – the units stay in the same units, but now a “Squared” unit.

$$S^2 = \frac{\sum (x_i - \bar{x})^2}{n - 1}$$



So VARIANCE is the average of the squared differences from the mean

$\mathcal{S}^2$ for Population Variance

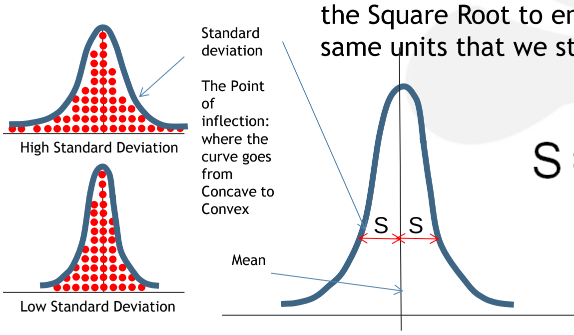
S^2 for Sample Variance

Standard Deviation

M

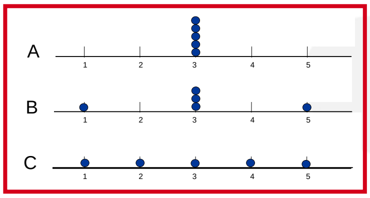
The trouble with the VARIANCE – is that the units don’t really make sense. If we are working with time (seconds) – what exactly does *seconds²* mean?

Our final step is to calculate the STANDARD DEVIATION. This is a way of describing how much of the data is dispersed around the mean. As we squared the values to get the VARIANCE – we apply the Square Root to ensure the answer is in the same units that we started with.



$$S = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{(n-1)}}$$

Lets work through an example….



	A	B	C
Mean	3	3	3
Median	3	3	3
Range	0	4	4
Variance	0	2	2.5
Standard Deviation	0	1.414	1.581

Variance

$$S^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{(n-1)}$$

Standard Deviation

$$S = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{(n-1)}}$$

Have a go!!!

For the data sets shown calculate:

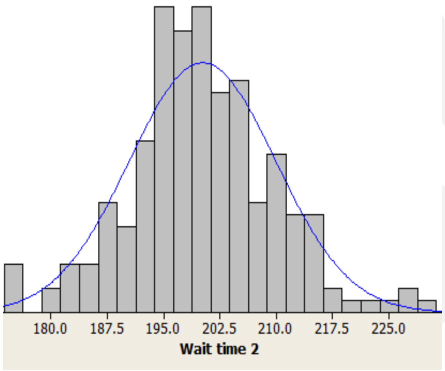
1. Mean
2. Median
3. Mode
4. Range
5. Variance
6. Standard deviation

Point	Data Set 1	Data Set 2	Data Set 3
A	3	4	10
B	3	3	1
C	6	5	7
D	7	4	1
E	4	16	10
F	7	4	6
G	5	3	1
H	5	4	8
I	4	3	1
J	6	6	1
K	5	3	9

Statistic	Data Set 1	Data Set 2	Data Set 3
Mean			
Median			
Mode			
Range			
Variance			
Standard Deviation			

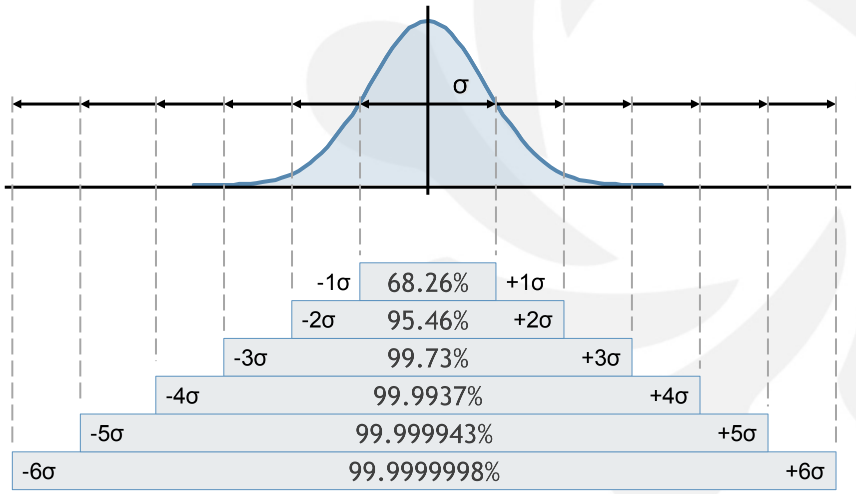
Normal Distribution Curve

Characteristics of the Normal Curve:



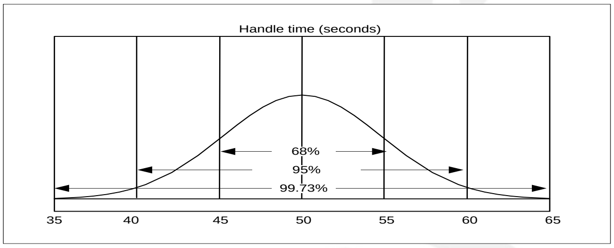
- It is symmetrical.
- The mean, median and mode have the same value.
- There is an equal number of values on either side of the mean.

Normal Curve properties



% of the data that falls within +/- x standard deviations from the mean

Normal Distribution example



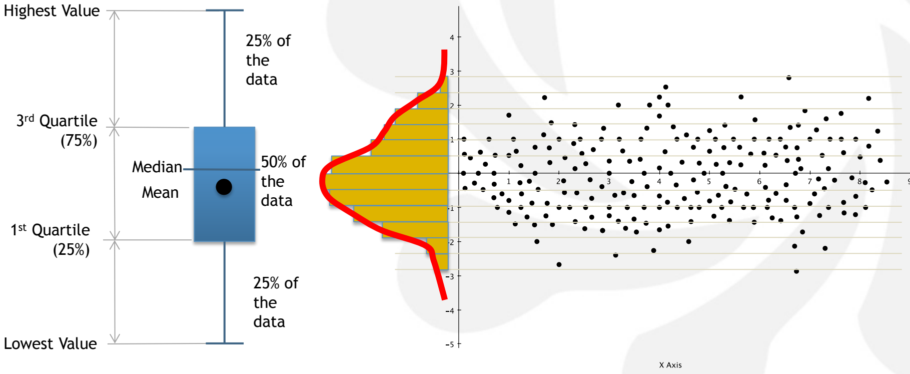
We have an average handle time of 50 seconds and a standard deviation of 5. If the distribution of the handle times is normally distributed, then we should expect to see:

- 68% of our calls between 45 and 55 seconds
- 95% of our calls between 40 and 60
- 99.73% of our calls between 35 and 65 seconds

If you were the call centre manager, how could you use this information?

Graphs for comparison - Boxplots

Components of the Boxplot



- The Boxplot shows the range values and gives a simple picture of the variation
- Note the distribution in not symmetrical

Boxplots for comparison

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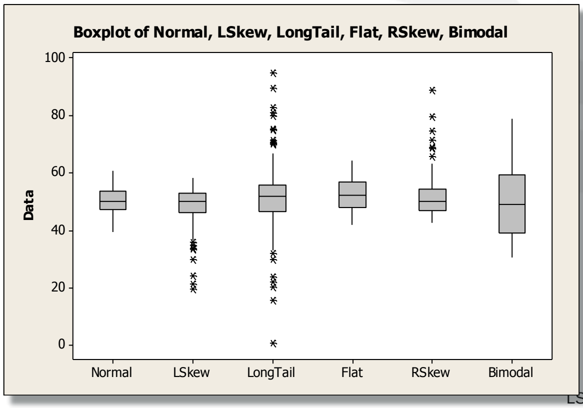
Boxplots are frequently used to compare one distribution to another.

They are especially useful for identifying differences in median, and spread as well as for highlighting the presence of outliers



What can we say about the following boxplots of airport queue time?

Using Boxplots

M

Advantages	Limitations
• Provide a general indication of centre and spread • Identify potential outliers that are present • Ideal for comparing different groups of data	• Can be misleading for data sets with less than 10 values

Use Boxplots to:

- Compare certain characteristics of the data
- Plot continuous data or to compare a continuous Y for discrete x's

Scatter Plot

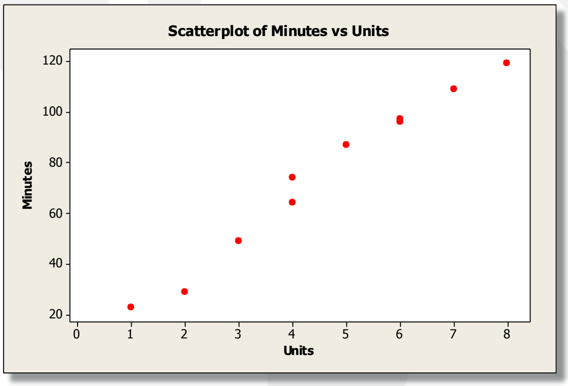
A Scatter Plot illustrates the relationship between two continuous variables.

Components

1. Vertical or Y-Axis
2. Horizontal or X-Axis:
3. Data Points

Tests the relationship between a continuous Y and a continuous x

Displays the direction (as x increases, does Y increase or decrease?), shape (linear or nonlinear) and strength of the relationship



Using a Scatter Plot

Advantages	Limitations
• Show a relationship between two variables • Can be used for continuous data or discrete count data • Display the direction and strength of the relationship between two factors	• Do not show the time order in which data was collected

Use Scatter Plots to:

- Examine how two continuous variables are related (indicate strength, shape and direction).

Summary of key learning points

Understanding data basics:

- Determine the data type.
- Assess the shape, centre and spread of the data.
- Assess normality
- Create graphs for comparison.

Recommended coach support points

- When your data is not normally distributed
- Comparing sets of data with small sample sizes
- Drawing conclusions from your graphical analysis

FIREBRAND

MEASURE

Measurement Systems Analysis

M

Step 4: Assess measurement systems

Define tollgate successful	Process Mapping	Y = f(x)	Basic Statistics	Measurement Systems Analysis	Stability and Capability	Data collection and sampling	Measure tollgate successful
	Value stream mapping	C&E diagram	Data types	Sources of measurement variation	Special and common cause	Data collection planning	
	Activity of the product	C&E matrix	Shape	Planning an MSA	Control charts	Sample size	
	Block diagrams	FMEA	Centre	Operational definitions	Calculating capability	Sampling strategy	
	Detailed process maps		Spread	Conduct a discrete MSA	Calculating stability		
			Normality	Analyse MSA results			
			Graphs for comparison				

Preview of the lesson

M

During this lesson we will cover the following basic concepts of:

- Why analysis of measurement systems is important
- Types of measurement system variation
- How to create an attribute study
- How to analyse the results

The additive nature of process and measurement variation

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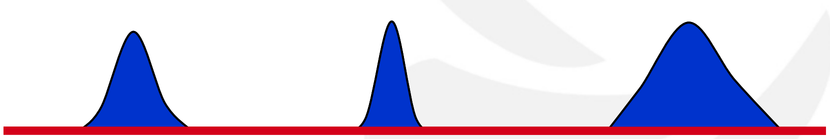
True Process Variation (σ^2 True Process) **+** **Measurement Variation** (σ^2 Measurement) **=** **Total Variation (Observed)** (σ^2 Total)



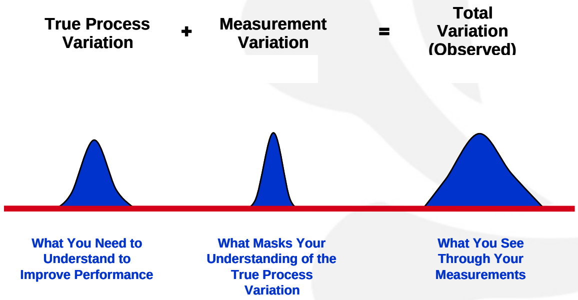
What You Need to Understand to Improve Performance

What Masks Your Understanding of the True Process Variation

What You See Through Your Measurements

Measure measurement variation first

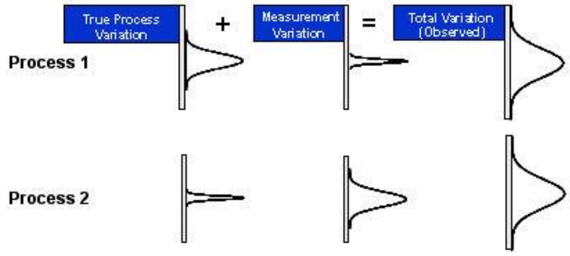
Why quantify measurement variation first?



- Difficult to determine the real problem and its cause.
- Faulty measurement system produces data leading to bad decisions.
- Bad decisions waste time and money.

Total observed variation

Observed variation is made up of two components.



Which process:

1. Has the largest total observed variation?
2. Has the largest measurement variation?
3. Has the largest process variation?
4. If you were to choose which process was in better shape statistically, which one would you choose? Why?

There are four sources of measurement system variation

Sources of measurement variation

M

Measurement Variation

- Accuracy
- Precision
  - Repeatability
  - Reproducibility
- Stability
- Linearity

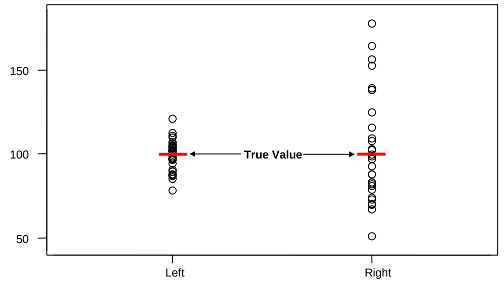
Definitions: Sources of measurement variation

M

Accuracy

Centering of measurement data around a known standard

- Accuracy
- Precision
  - Repeatability
  - Reproducibility
- Stability
- Linearity



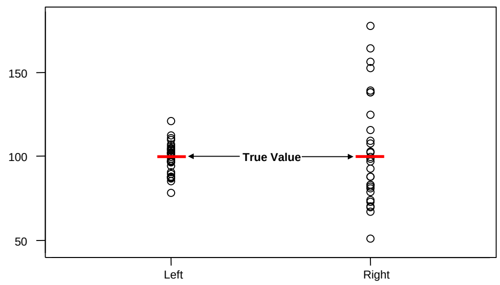
It is a measurement of how close the average of multiple measurements of an event is equal to the true value.

Definitions: Sources of measurement variation, *Continued*

M

Precision

Distribution of measurements around the average



- Accuracy
- **Precision**
  - Repeatability
  - Reproducibility
- Stability
- Linearity

Precision tells how clustered the individual measurements are around the target value.

Definitions: Sources of measurement variation, *Continued*

M

Repeatability

…measures the extent to which the same person gets the same measurement results using the same measurement system.

- Accuracy
- Precision
  - **Repeatability**
  - Reproducibility
- Stability
- Linearity

To determine if someone can get the same measurements by using the same measurement system repeatedly, we collect data repeatedly.

Since the event does not change, any change in the measurements must be due to changes in the measurement system.

Definitions: Sources of measurement variation, *Continued*

M

Repeatability

- …measures the extent to which the same person gets the same measurement results using the same measurement system.

Reproducibility

- …measures how several people or systems repeatedly measure the same event and we look for differences in the results among the people or systems.

- … quantifies the differences in results between the appraisers

- Accuracy
- Precision
  - Repeatability
  - Reproducibility
- Stability
- Linearity

Definitions: Sources of measurement variation, *Continued*

M

Stability

- ...is the capacity of your measurement system to produce the same measurement results over time when measuring the same event or item

- Example
  - The tendency of measurements to differ depending on the time of day or the length of time the appraiser is working or measuring.

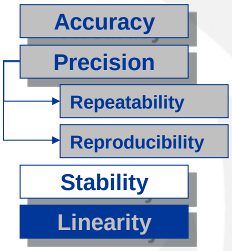
- Accuracy
- Precision
  - Repeatability
  - Reproducibility
- Stability
- Linearity

Definitions: Sources of measurement variation, *Continued*

M

Linearity

- ... measures how well your system maintains its performance over its range of measurement values (for continuous data) or measurement categories (for discrete data)



- Examples
  - Can a scale measure with the same accuracy and precision the weight of a mouse versus the weight of an elephant?
  - Are we more prone to accuracy and precision issues when we evaluate applications with 10 fields versus applications with 100 fields?

Causes of measurement variation

M

Draw on our personal work experience and as a class brainstorm five causes for poor:

- **Accuracy**
- **Repeatability**
- **Reproducibility**

Use flipchart paper and be prepared to present back

Time - 20 minutes

What is Measurement Systems Analysis?

Measurement System Analysis (MSA) is:

- An analytical procedure to determine how much of the total observed variation comes from your measurement system

There are two different types of MSA:

- Discrete
- Continuous

Discrete MSA overview

Outcomes	• Measurement variation calculated in terms of accuracy, repeatability and reproducibility
Limitations	• Discrete measurements do not describe the extent to which an item falls in its category (e.g. how good or bad the item is)
Common Findings	• Problems with standards or operational definitions (vague, not understood or applied correctly by appraisers)
Frequency of Use	• More common than Continuous MSA

Continuous MSA overview

Outcomes	• Repeatability and Reproducibility
Limitations	• Not as applicable for service industry measurement systems
Common Findings	• Problems with the design of the measurement devices • Problems with the use of the measurement devices
Frequency of Use	• Less common than Discrete MSA particularly within an office environment

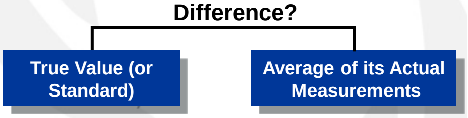
Recap class activity

Instructions:

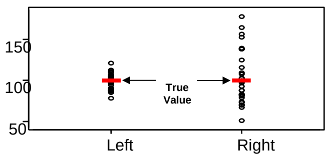
Answer the following questions

Time - 10 minutes

1. What term is used to characterise the difference between the true value (or standard) of a measured item and the average of its actual measurement results?



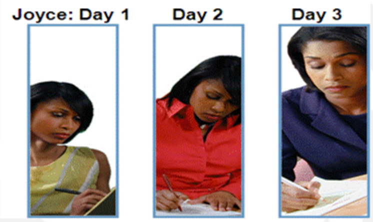
2. Which has better accuracy, the plot on the left or right?
3. Which has better precision, the plot on the left or right?



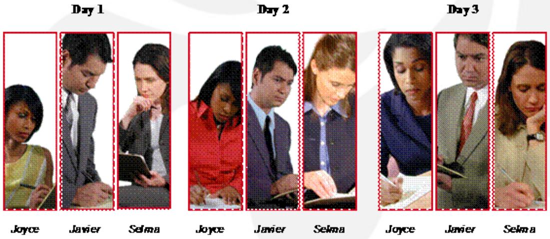
Questions

M

4. Which source of measurement variation are we checking for in this example?



5. Which source of measurement variation are we checking for in this example?



The Discrete MSA procedure

M

1. Confirm the key discrete measures that require an MSA.
2. Confirm the operational definition for each measure.
3. Design the discrete MSA study.
4. Develop data-collection sheets for the discrete MSA study.

Confirm the measures that require an MSA

M

Conducting an MSA procedure can be lengthy and resource-intensive.

Therefore, the first step is to review the various measurement activities within your project/process and determine which ones truly require an MSA.

Consider the following criteria:

- **Significant Risks:** In other words, major costs or problems will occur if the measurements are subject to errors
- **High Levels of Measurement Error:** Your observations and experience tell you that the measurement system is not at an acceptable level of accuracy, repeatability or reproducibility.

Operational definitions

M

The operational definition describes:

- The measure being analysed
- The items that will be measured in the study
- The categorisations used for the measure
- How the standard for each item will be determined

Design the Discrete MSA study

M

Key design considerations for a discrete MSA:

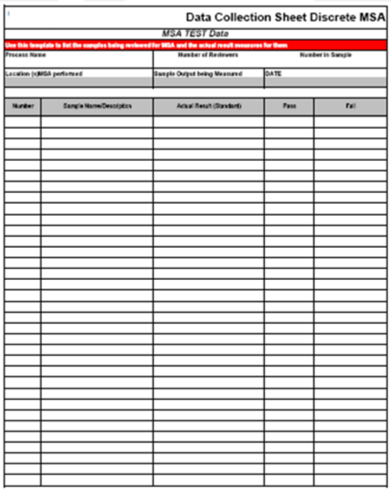
The number and type of items to be measured	• Recommend a minimum of 30 items • Try to distribute items equally among categories
The number of appraisers	• Typically three appraisers • Use more appraisers if issues of reproducibility are suspected
The number of measurement trials	• Two is sufficient
The organisation of the measurement trials	• Randomise trials to prevent memorising • Avoid situations where appraisers may be influenced

Develop data collection sheets for the Discrete MSA study

M

Data collection sheets:

- Define the order in which the items will be presented to each appraiser
- Provide structure for the study
- Are used to record the actual measurement results during the study
- Are provided to each appraiser as separate sheets


Data Collection Sheet Discrete MSA
MSA TEST Data
Use this template to list the samples being reviewed for MSA and the actual result measures for them
Process Name | Number of Reviewers | Number in Sample
Location (s)MSA performed | Sample Output being Measured | DATE

Number	Sample Name/Description	Actual Result (Standard)	Pass	Fail

We're now ready to conduct a study!

Conduct the Discrete MSA Study

Key things to remember:

- Randomise the presentation order.
- Maintain consistent measurement methods.
- Code the entry results for discrete data to simplify data recording.
  - Example: P = pass, F = fail

Discrete MSA Practice Activity

30 mins

The vowels exercise

Objective: To illustrate the use of a discrete MSA

10 images will be displayed on the screen at the front of the classroom.

As you view each image, determine whether the image passes or fails.

A screen passes if it contains no vowels. It fails (is defective) if it contains a vowel.

Record your measurement results in the first trial column of the Data-Collection Sheet shown on the following slide.

Record your findings quickly since a new image will be displayed on the screen every four seconds.

After we complete the first trial, there will be a second trial, and you will record your answers on the following slide.

The findings from some of the class will be used to asses the measurement system.

Data recording sheet 1

M

Trial 1	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Data recording sheet 2

M

Trial 2	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Data recording sheet - combined

M

	Trial 1	Trial 2	Standard
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

The “Standard”

M

Standard	
1	P
2	F
3	F
4	P
5	F
6	P
7	F
8	P
9	P
10	F

Analyse our discrete MSA results

M

Our assessment of the measurement system should review the between (reproducibility) and within (repeatability) sources of variation.

The following "rules of thumb" should be used when assessing the adequacy of our measurement system

- **% Study Variation Criteria:**
  - **Good: <10%**
  - **Marginal: 10% to 30%**
  - **Bad: >30%**

All Appraisers vs Standard

```
Assessment Agreement

# Inspected  # Matched  Percent      95% CI
       30          22    73.33  (54.1, 87.7)

# Matched: All appraisers' assessments agree with the known
standard.
```

- **Divide the points by the total number of observations.**
- **Math Breakdown: 1 – (22/30) = 1 - .7333 = 0.2667 or 26.67% Study Variation.**
- **How good is the MSA? What do we need to fix?**

How did we do?

M

- From our 10 samples, how many did we get complete agreement (reproducibility and repeatability)?
- What is our measurement system variation?

20 mins

Improving the measurement system:

- Identify and implement the appropriate solutions to reduce the level of measurement variation.
- Repeat the MSA study to validate the impact of any solutions to reduce the level of measurement variation.

Summary of key learning points

M

- Measurement variation can negatively impact your decision making.
- The sources of measurement variation:
  - **Accuracy**
  - **Precision**
    - Repeatability
    - Reproducibility
  - **Linearity**
  - **Stability**
- MSA is a procedure to quantify the level and source of measurement variation
- There are two different MSA procedures:
  - Discrete MSA
  - Continuous MSA

Recommended coach support points

M

- Designing the MSA Studies
- If you have continuous data
- Analysis and interpretation of results
- Diagnosis of root-level causes for excessive measurement variation

FIREBRAND

MEASURE

Process stability and capability

M

Step 5: Stability and capability

Define tollgate successful	Process Mapping	Y = f(x)	Basic Statistics	Measurement Systems Analysis	Stability and Capability	Data collection and sampling	Measure tollgate successful
	Value stream mapping	C&E diagram	Data types	Sources of measurement variation	Special and common cause	Sampling strategy	
	Activity of the product	C&E matrix	Shape	Planning an MSA	Control charts	Data collection planning	
	Block diagrams	FMEA	Centre	Operational definitions	Calculating capability	Sample size	
	Detailed process maps		Spread	Conduct a discrete MSA	Calculating stability		
			Normality	Analyse MSA results			
			Graphs for comparison				

Preview of the lesson

In this module we will learn how to

- "Check" the stability of data before using it to assess the inherent performance of a process
- "Compare" the capability of process performance against the desired performance

You're at a point in DMAIC where you need an accurate and predictable base line measure of your problem by using the project metrics.

- The metric data needs to be assessed for its stability.
- If the data is influenced by special causes or unusual circumstances, your base line measure will be inaccurate.

Stability - Introduction

What is process stability?

Process stability is the ability of the process to perform in a <u>predictable</u> manner over time

- A project metric is stable when it varies in a predictable manner over time or is in a state of statistical control.
- In a Lean Six Sigma project, stability is determined by:
  - Evaluating the project's primary/secondary metrics in the Measure phase
  - Managing the confirmed vital few inputs (x's) of a process in the Control phase
- Stability is determined by examining whether common or special causes of variation are present.
- Stable processes experience only common causes of variation.
- Unstable processes experience special causes of variation.

Understanding Common and Special Causes of Variation

M

Variation can be common cause or special cause.

Common Causes of Variation (systematic, random, normal, in-control or expected, natural)	▪ Are present in all processes ▪ Are comprised of the variation inherent to the combination of all process elements (people, equipment, environment, methods and materials) ▪ Produce random, predictable fluctuations in the x or project metrics over time **When only common cause variation is present, the process is stable and predictable.**
Special Causes (abnormal, non-random, out-of-control or unexpected)	▪ Are large or unusual differences in variation due to some "hiccup" in the process **When special cause variation is present, the process is unstable and unpredictable.**

The two causes of variation

M

How you interpret variation …

True variation type …

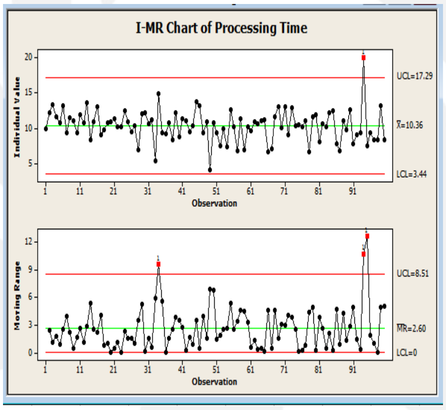
	Common Cause	Special Cause
Common Cause	Focus on step changes to processes	Type 1 Tampering (increases variation)
Special Cause	Type 2 Under-reacting	Investigate causes

Introduction to Control Charts

M

What are control charts and why are they useful?

- Display a project metric in the order it is collected over time
- Are used to determine whether a process measure is stable (in a state of statistical control)



The two categories of Control Charts

M

Control Charts can be used for continuous or discrete data.

Category	Type of Charts	Displays
Continuous	I-MR	Individuals and Moving Range
	Xbar and R	Xbar and Range
	Xbar and S	Xbar and Standard Deviation
Discrete	P	Proportion defective
	NP	Number defective
	U	Defects per unit
	C	Number of defects

The components of a Control Chart

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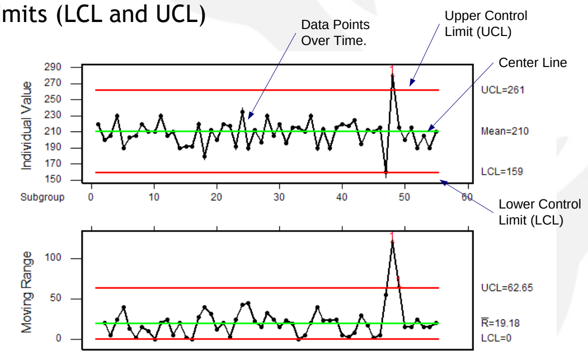
All Control Charts have three components:

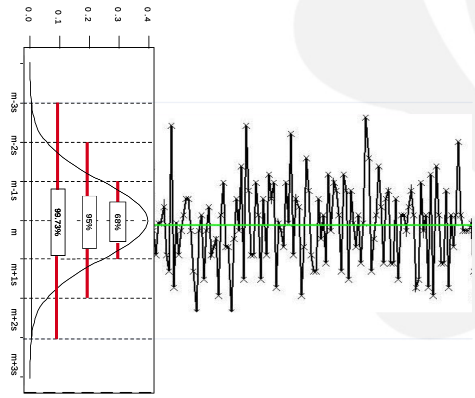
- Performance over time
- A centre line
- Control limits (LCL and UCL)



Understanding Control Limits, *Continued*

M

How control limits work:



- We should expect to see all of our data points (99 to 100%) fall between the control limits with no patterns.
- If a data point falls outside the limits, we detect patterns or both, these are signals of out-of-control or special cause conditions.

Control limits are not specification limits

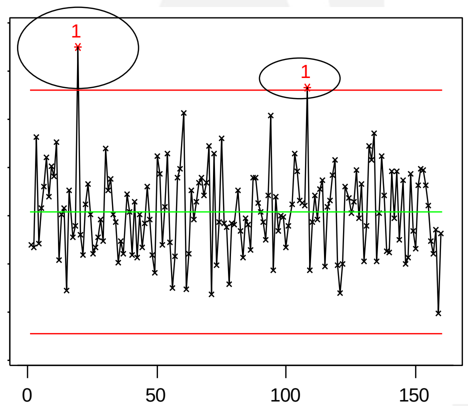
Control limits should not be confused with specification limits:

- **Control limits represent the Voice of the Process (VOP).**
  They tell you how the process is expected to perform when no special causes of variation are present.

- **Specification limits are the Voice of the Customer (VOC).**
  They tell you what your customers (internal or external) want from the process.

The two indicators of a special cause of variation

1. Any point outside a control limit



The two indicators of a special cause of variation

Continued

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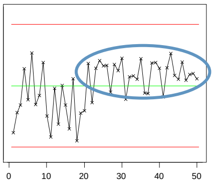
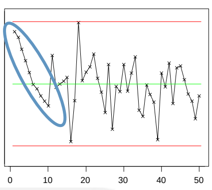
2. A non-random pattern of data points within the control limits

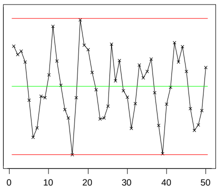


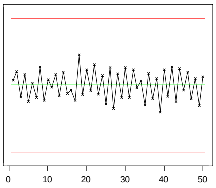
Shifts
A series of points above or below the centre line



Trends
A series of data points that continuously increase or decrease

Cycling or Alternating
Non-random patterns seen in the data points





Applications of Control Charting in DMAIC

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The two primary applications for Control Charts in DMAIC

Phase	Application
Measure Phase	• To assess the nature of the process variation – are the metrics' performance over time stable?
Control Phase	• To control the vital few inputs (x's) • Control Charts are an integral part of the control plan

Selecting the best control chart for the Measure Phase

M

How do I choose the correct chart for my project?

- Questions to ask:
  - Is my data discrete or continuous?
  - If the data is discrete, do I want to monitor the number of defects or the number of defective items?
    - Defect: A flaw (not meeting customer specifications)
    - Defective: A product or service with one or more defect
- Control Charts used to assess stability of the primary metric

Type of Data	Measurement	Chart
Continuous	Continuous Value	I-MR Chart
Discrete	Defects	C Chart
	Defective Items	NP Chart

Structure of the Individuals and Moving Range Chart

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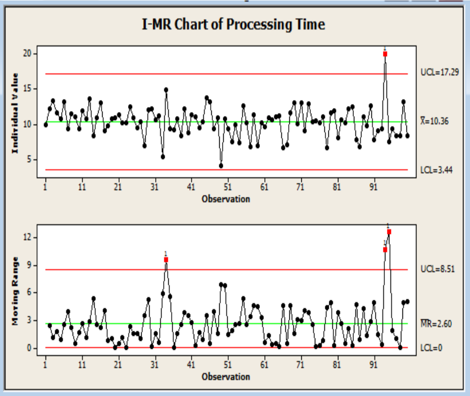
The Individuals-Moving Range (I-MR) Chart is comprised of two charts:

- Individuals Chart monitors the individual observations over time.
- Moving Range Chart monitors the change of the individual observations over time.



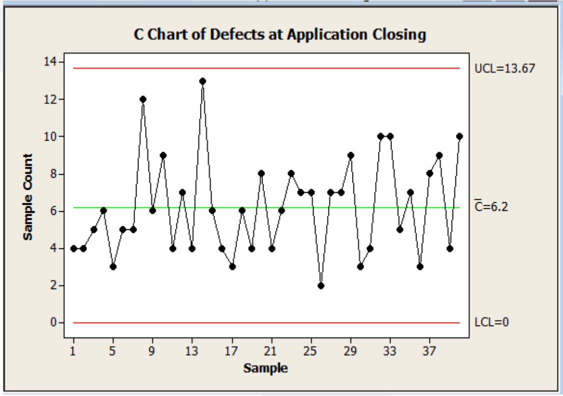
- ***Is this process stable or not?***
- ***Why?***
- ***What is the appropriate next step?***

The C Chart

M

The C Chart is used when your metric involves a count of the number of defects:

- ***Is this process stable or not?***
- ***Why?***
- ***What is the appropriate next step?***



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The NP Chart

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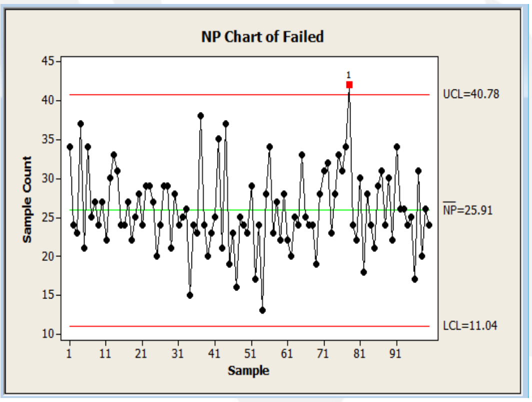
The NP Chart is used to plot the number of defective items/units for a constant subgroup size.

Differs from the C Chart:

- The **C Chart** plots the number of defects (flaws).
- The **NP Chart** plots the number of defectives (an item or unit that contains one or more defects).

- ***Is this process stable or not?***
- ***Why?***
- ***What is the appropriate next step?***



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The importance of identifying special causes

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Special cause variation indicates a need to investigate:

- Points outside of the control limits
- Trends
- Shifts
- Cycles
- Alternating patterns

		How you interpret variation ...	
		Common Cause	Special Cause
True variation type ...	Common Cause	Focus on systemic process change	Type 1 Tampering (increases variation)
	Special Cause	Type 2 Under-reacting	Investigate special causes

Identify when the special cause occurred and identify the factors that contributed to it.

Don’t quantify process capability before understanding whether the process is statistically stable.

Definition of Process Capability

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Process capability is the ability of a ***stable*** *process to meet customer requirements.*

We can use capability analysis to compare the performance of very different processes.

Picturing capability

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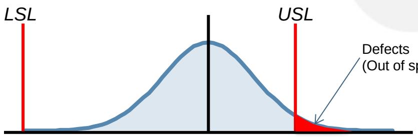
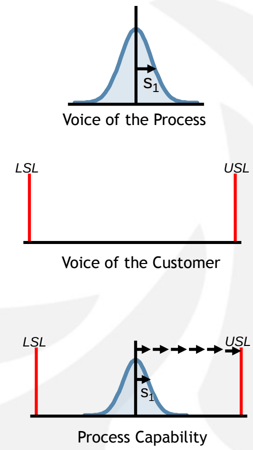
A universal business metric that can be used to indicate the capability of the process (VOP) to meet an output specification (VOC)

It is the number of standard deviations that can fit between the mean and the nearest specification

Performance that is outside of the specification is a “defect” – not meeting the customer specifications





The first measure of capability: Sigma Level

M

- Sigma Level is a measure of how well a process performs relative to its requirements.
- The higher the Sigma Level, the more capable the process.
- The appropriate Sigma Level depends on the importance and cost of poor quality for the characteristic.

Sigma Level	Yield	Percent Defective
1	30.9%	69%
2	69.1%	31%
3	93.3%	6.7%
4	99.38%	.62%
5	99.977%	.023%
6	99.99966%	.00034%

The higher the sigma level, the more capable the process.

The appropriate sigma level depends on the importance and cost of poor quality for the characteristic.

The second measure of capability: DPM

M

We tend to use DPM when dealing with discrete measures of capability.

The relationship between DPM and Sigma Level:

Sigma Level	DPM
1	691,462
2	308,538
3	66,807
4	6,210
5	233
6	3.4

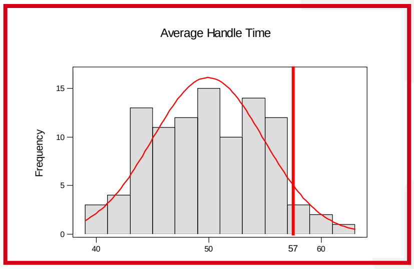
DPM is the number of defectives in every million units.

Note that it is "defectives per million" rather than "defects per million."

Calculating sigma with continuous data

M

First we calculate the Z-score for the process, then add 1.5 sigma shift. The "+1.5" represents short-term and long-term views of the process.



- **Average handle time = 50 seconds**
- **Standard deviation = 5 seconds**
- **Data is normally distributed.**
- **Customer requirement = 57 seconds.**

What is the sigma level for 57 seconds?

$$Z = \frac{\text{Value of Interest} - \text{Mean}}{\text{Standard Deviation}}$$

$$Z + 1.5 = Sigma$$

Note that the z-score can only be used when we have a normal distribution, otherwise we need to use another distribution or DPMO

The Sigma Calculator

The Sigma calculator quickly determines the Sigma Level and DPM for your data.

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Sigma Level Calculator (Instructions in red text below)

Calculating Sigma Level for Continuous Data

Note: This calculator can only be used with Normally distributed data.

Enter the calculated average, X-bar	10
Enter the calculated standard deviation, s	2
Enter the Upper Spec Limit, leave blank if none	15
Enter the Lower Spec Limit, leave blank if none	
This is your Sigma Level	4.00
This is the Z value for your Upper Spec Limit	2.50
This is how much is out of spec	0.62%
This is the Z value for your Lower Spec Limit	N/A
This is how much is out of spec	0.00%
Your Percentage Yield is then	99.38%
Your DPM will be	6,210

Calculating Sigma Level for Discrete Data

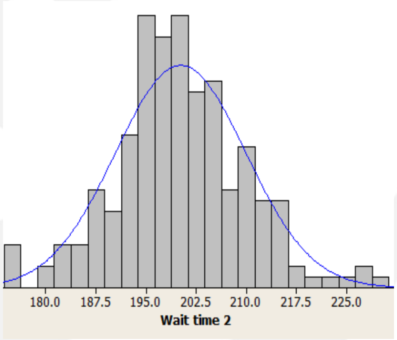
Enter Number of Items Evaluated	30
Enter Number of Defective Items	1
This is your Sigma Level	3.33
This is your Yield	96.67%
This is your DPM	33,333

Directions for Template: Provide the required data in the gray boxes for either continuous or discrete data types and the blue boxes will be calculated automatically.

Steps to calculate sigma level for continuous data

Three Requirements

1. Data must be normally distributed.
2. The process must be stable.
3. You must have a valid measurement system.



Steps to calculate sigma level for continuous data

M

Steps to use the Sigma Calculator for continuous data:

Calculating Sigma Level for Continuous Data	
Enter the calculated average, X-bar	3.5
Enter the calculated standard deviation, s	1
Enter the Upper Spec Limit, leave blank if none	5
Enter the Lower Spec Limit, leave blank if none	
This is your Sigma Level	**3.00**
This is the Z value for your Upper Spec Limit	1.50
This is how much is out of spec	6.68%
This is the Z value for your Lower Spec Limit	N/A
This is how much is out of spec	0.00%
Your Percentage Yield is then	93.32%
Your DPM will be	**66,807**

1. Enter the average (x bar).

2. Enter the standard deviation (s).

3. Enter the specification limits for the project metric.

4. The calculator displays these values automatically.

Calculating sigma with discrete data

M

Defectives per million opportunities (DPMO) can be used to quantify capability for discrete output metrics

$$DPMO = \frac{D \times 1{,}000{,}000}{N}$$

When:

D = total number of defective units in the sample evaluated: a defective unit does not meet the customer specification

N = Number of units evaluated

Steps to calculate sigma level and DPM for discrete data

Steps to use the Sigma Calculator for discrete data:

Calculating Sigma Level for Discrete Data	
Enter Number of Items Evaluated	30
Enter Number of Defective Items	2
This is your Sigma Level	**3.00**
This is your Yield	93.33%
This is your DPM	**66,667**

1. **Enter the number of items in the sample.**
2. **Enter the number of defective items.**
3. **The calculator displays these values automatically.**

Table exercise: Quantify process capability

Capability Analysis

Objective: Practise using the sigma calculator to calculate the **sigma level and DPMO** for the following examples:

Time - 5 mins

1. Time to process mobile phone application:
- Historical average is seven minutes (420 seconds)
- Historical standard deviation is 1.5 minutes (90 seconds)
- Upper specification limit is 10 minutes (600 seconds)
- There is no lower specification limit

2. Percentage of transactions completed within seven minutes at banking centres:
- Total number in sample = 1,000 transactions
- # defective from sample = 73 transactions during 7 minutes

3. Lead time to issue orders:
- Historical average is 20 days
- Standard deviation is 10 days
- Upper specification limit is 25 days
- There is no lower specification limit

Summary of key learning points

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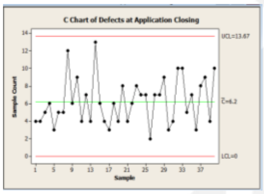
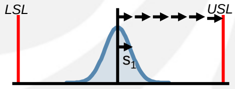
- Assessing the stability of the metrics using control charts driven by the type of data and the metric you want to control
- Remove special causes but avoid tampering by reacting to common cause variation
- Determining the capability of the process by reference to customer requirements





Process Capability

Recommended coach support points

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- Choosing the appropriate control chart
- Sampling strategy for control charts
- Analysis and interpretation of results
- Determining the best approach when continuous data is not normal
- Interpreting sigma level and DPM data relative to the goals for your project metrics

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Data collection and sampling

M

Step 6: Collect data

Define tollgate successful → Process Mapping → Y = f(x) → Basic Statistics → Measurement Systems Analysis → Stability and Capability → **Data collection and sampling** → Measure tollgate successful

Process Mapping	Y = f(x)	Basic Statistics	Measurement Systems Analysis	Stability and Capability	Data collection and sampling
Value stream mapping	C&E diagram	Data types	Sources of measurement variation	Special and common cause	Data collection planning
Activity of the product	C&E matrix	Shape	Planning an MSA	Control charts	Sample size
Block diagrams	FMEA	Centre	Operational definitions	Calculating capability	Sampling strategy
Detailed process maps		Spread	Conduct a discrete MSA	Calculating stability	
		Normality	Analyse MSA results		
		Graphs for comparison			

Preview of lesson

M

A Lean Six Sigma project team working in a 24 hour car manufacturing facility has identified one of the project metrics as end-to-end lead time.

The team wants to create a baseline measure for the metric before beginning its analysis.

What decisions would the team need to make to ensure that the data it collects is useful and reliable?

Preview of lesson

M

In this module we'll discuss the need for data within Lean Six Sigma projects as well as:

- Determine what to measure
- Determine sample size
- Select the appropriate sampling strategy

Data collection overview

The need for data

- Teams need data to speak with facts
- "In God we trust, everybody else brings data"

Data is the "facts or figures from which conclusions can be drawn"

- Information collected about a product, service, process, person or machine is called data
- Data, when properly organised and analysed, provides useful information and serves as the basis of decision making and action

Data collection for hypothesis testing

In addition to quantifying the process baseline, we gather data to hypothesize on the drivers of process performance (Y)

$$Y= f(x_1; x_2; x_3.....x_n$$

Examples include;

Shift
Time of Day
Day of Week
Week of Month
Season of Year
Employee
- **Name**
- **Grade**
- **Training**
- **Experience**

Location on Unit
- **Inside/Outside**
- **Left Side/Right Side**
- **Top Side/Bottom Side**
- **Leading Edge/Trailing Edge**
- **Orientation**

Temperature
Humidity

Valve Model #
Instrument Tag #
Equipment #
Cable #
Raceway #
Design
Revision #
Supplier

Data Collection

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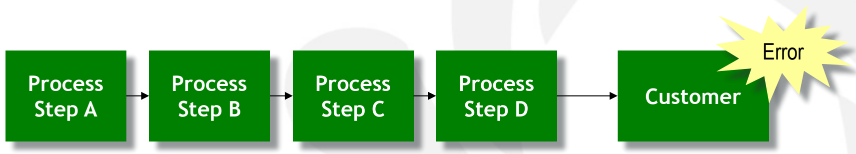

Factors	Factors	Factors	Factors	=	Outcome
X_1	X_2, X_3	X_4	X_5, X_6	=	Y

- Where did the error occur? (which process step)
- Could we have caught it before the customer “found” it?
- How much “wasted” effort did we spend working on the item that was erroneous?
- How much will this dissatisfaction cost us in the long term?

The outcome is a function of the factors within the process

Components of a typical data collection plan

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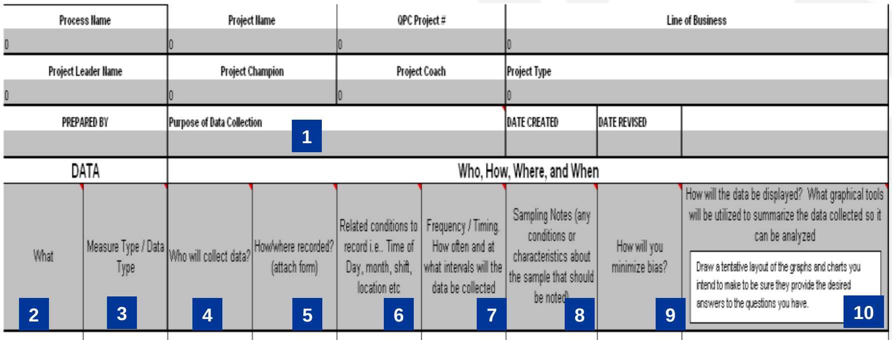

The Purpose for Collecting the Data

1 The question(s) you want to answer

The Data to Collect

2 How/where recorded

3 Measure type/data type

The Who, How, Where and When

4 Who will collect the data?

5 How/where recorded?

6 Related conditions to record

7 Frequency/timing

8 Sampling notes

9 Strategies to eliminate bias

10 How the data will be displayed

Finding the right data

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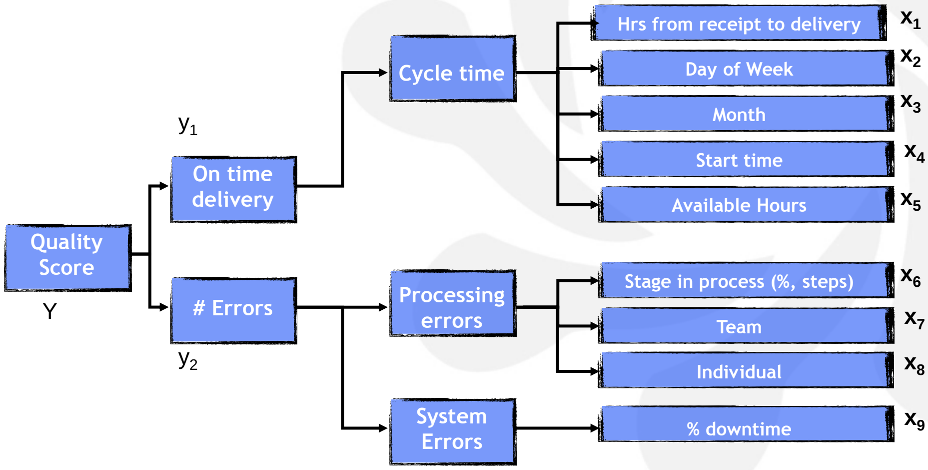

Example completed data collection plan for contact centre

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PREPARED BY	Purpose of Data Collection					DATE CREATED	DATE REVISED	
Jake Calc	Baseline credit card operation performance for service level, 1st call resolution, and handle times					5/29/2006		
DATA		**Who, How, Where, and When**						
What	Measure Type / Data Type	Who will collect data?	How/where recorded? (attach form)	Related conditions to record ie. Time of Day, month, shift, location etc	Frequency / Timing. How often and at what intervals will the data be collected	Sampling Notes (any conditions or characteristics about the sample that should be noted)	How will you minimize bias?	How will the data be displayed? What graphical tools will be utilized to summarize the data collected so it can be analyzed
% calls answered within 30 seconds	Discrete: binary	Jake C using automated system	Excel report from automated system	Date and time Call volume	Sample 100 calls every 2 hours	Randomly sample the 100 calls for each time period	Random sampling will provide representative sample for this metric	Data will be used for stability and capability studies
% first call resolution	Discrete: binary	Sally S and Q&P	Record results on attached form	Date and time Associate Call type Call volume	Total sample size of 369 stratified based on call type: 185 Balance Inquiry 111 Change of address 19 Drop terms 56 Drop rate	Q&P will randomly record calls based on VRU responses	SMEs will evaluate each call. Prior to evaluating, all SMEs will review the established standard for 1st call resolution. MSA will be performed for each SME	Data will be used for baseline capability for secondary metric. Data can support pareto analysis
Call handle time	Continuous	Sally S and Q&P	Record results on attached form	Date and time Associate Call type Call volume	Total sample size of 369 stratified based on call type: 185 Balance Inquiry 111 Change of address 19 Drop terms 56 Drop rate	Will use the same samples for % first call resolution.	Stratfied random sampling will provide a representative sample	Data will be used for baseline capability for secondary metric. Performance by call type and associate will be plotted using boxplots &/or dotplots

Sampling requirements

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There are two basic needs for data:

<u>Estimation</u>

- **Your focus is to collect enough representative data to give you a “good” estimate of the parameters of the process. “Good” is defined by confidence level and margin of error.**
- **If historical data is not available, a data collection plan should be created to collect the appropriate data.**
- **<u>The rest of this module deals with sampling for estimation.</u>**

<u>Hypothesis Testing</u>

- **Your focus here is to collect data on the Y and different Xs to determine if there are differences in how the Xs affect the Y, or if different values or levels of an X affect the Y.**
- **Here again we need enough representative data to be able to prove the significance of the effects of the Xs.**
- **<u>We will cover sampling for testing in the Analyse phase</u>**

How much data to collect

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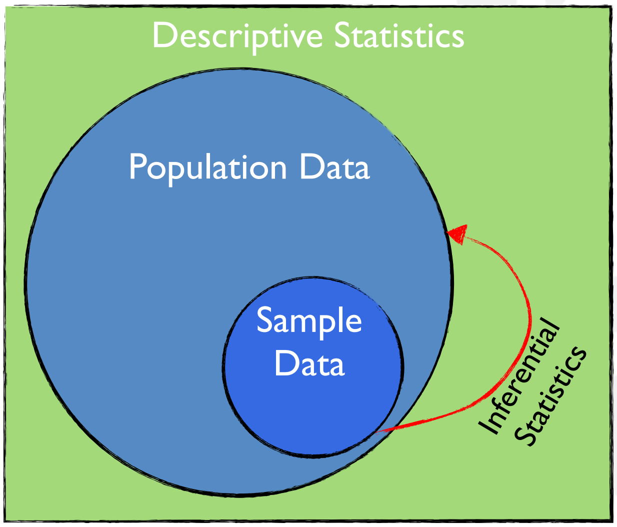


Descriptive Statistics
Characterises
- Shape
- Centre
- Spread

Summarises
- Percentile
- Proportions
- Rankings

Inferential Statistics - typically used to infer information about populations from sample data

The concepts of populations and samples

Population

Collection of all objects or individuals with at least one common characteristic

Sample

Collection of measurements selected from the population

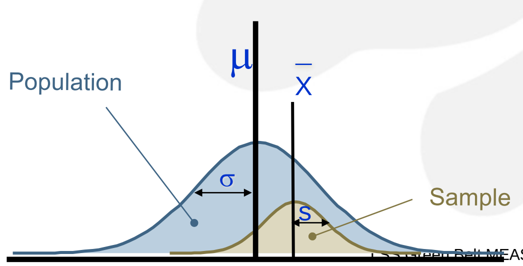
Population Parameters vs. Sample Statistics

Population

- Data describing the whole of the population are known as PARAMETERS
- An entire group of objects that have been made or will be made containing a characteristic of interest.
- “Population Parameters”
  - μ = Population Mean
  - σ = Population Standard Deviation

Sample

- Data describing a sample of the data are known as STATISTICS
- The group of objects actually measured in a statistical study.
- “Sample Statistics”
  - $\bar{x}$= Sample Mean
  - s = Sample Standard Deviation



The value of sampling

Why do Lean Six Sigma projects use samples instead of populations?

- Costs less to collect a sample than an entire population
- Requires less time to collect than a population
- Enables you to collect data when it is impossible or impractical to evaluate the entire population

Populations vs. Samples

You are looking at the effectiveness of online orders and you have access to every online transaction for the last six months.

Do you have a population or sample? Why?

You need to estimate the average income of football season ticket holders in Glasgow, UK?

What would be the population in this example?

What would be a sample?

Would you collect population or sample data? Why?

Sampling can be applied to populations and processes

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Sampling from populations

- A relatively fixed, static base
- Typical for surveys or baseline studies at one specific point in time
- Examples: registered voters and employee satisfaction surveys

Sampling from processes

- A dynamic flowing base
- Typical for studies evaluating performance over time
- Examples: Sampling in-process applications to determine time it takes to perform a process step or sampling process bake time within a galvanising plant

Factors affecting sample size

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Four factors determine how much data is needed:

Factor	Effect
Data Type	Discrete data requires larger sample sizes than continuous data.
Required Confidence Level	The required sample size increases as the confidence level increases.
Margin of Error	The required sample size increases as the margin of error decreases.
Variation in the Population or Process	Variation has an impact on the sample size. The sample size increases as the variation increases.

What factor might you think is missing?

Example for factors impacting sample size

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- We have a survey measuring job satisfaction specifying a 95% confidence level and with a margin of error of ±3%.
- The survey results indicated an satisfaction rate of 65%.
- This means we have a 95% chance that the true population satisfaction rate falls between 62% and 68%.

- **What is the data type?**
- **What type of sampling are we using (population or process)?**

Using the sample size calculator

M

Continuous Data

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Estimated Sample Sizes for Continuous Data at 99%, 95% and 90% Confidence Levels

Enter Estimated Standard Deviation Here: 17
(If unknown, use 1/6 of the known range of the data)

For process Sampling use the total number of items produced in the time period you wish to characterise.

Margin of Error	Sample Size 99%	Sample Size 95%	Sample Size 90%
1	1,924	1,111	783
2	481	278	196
3	214	124	87
4	121	70	49
5	77	45	32
6	54	31	22
7	40	23	16
8	31	18	13
9	24	14	10
10	20	12	8
11	16	10	7
12	14	8	6
13	12	7	5
14	10	6	4
15	9	5	4
16	8	5	4
17	7	4	3
18	6	4	3
19	6	4	3
20	5	3	2

1. Select the **Sample Size Continuous** tab.
2. Enter the estimated standard deviation for the process or population.
3. Establish the acceptable margin of error for your sample.
4. Determine the required confidence level for your sample results.
5. Locate the sample size requirement for the confidence level and
6. Determine if the sample size is feasible.

Using the sample size calculator, *continued*

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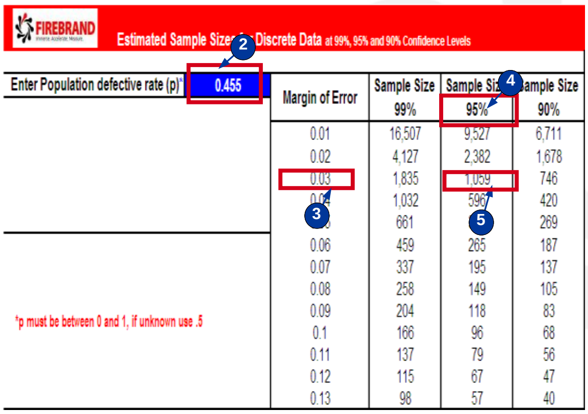
Discrete Data



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Estimated Sample Size for Discrete Data at 99%, 95% and 90% Confidence Levels

Enter Population defective rate (p)*: 0.455

*p must be between 0 and 1, if unknown use .5

Margin of Error	Sample Size 99%	Sample Size 95%	Sample Size 90%
0.01	16,507	9,527	6,711
0.02	4,127	2,382	1,678
0.03	1,835	1,059	746
0.04	1,032	596	420
[illegible]	661	[illegible]	269
0.06	459	265	187
0.07	337	195	137
0.08	258	149	105
0.09	204	118	83
0.1	166	96	68
0.11	137	79	56
0.12	115	67	47
0.13	98	57	40

1. Click the **Sample Size Discrete** tab.
2. Enter the estimated defective proportion for the population.
3. Establish the acceptable margin of error for your sample.
4. Determine the required confidence level for your sample results.
5. Locate the sample size requirement for the confidence level and margin of error.
6. Determine if the sample size is feasible, given project restraints.

Class activity: using the sample size calculator

M

Sample size

Objective: How to use the sample size calculator to quantify data collection efforts

For the following two scenarios:

- Which type of data is being collected?
- How confident do you need to be?
- What is the margin of error?
- What is the estimated standard deviation for the process?
- What is the required sample size from the Sample Size Calculator?

Time - 10 mins

Scenario 1: You need to estimate the average call length in the call centre.
Typical call length is from 30 seconds to three minutes. The standard deviation is 30 seconds. A confidence level of 95% is required.

Scenario 2: You need to estimate the percent of calls in the call centre that were within the call-handling specification of three minutes. The estimate should be accurate within + or - 2%. You believe that 90% of the calls meet the call handling specification. A confidence level of 95% is required.

Is sample size all that matters?

The 1936 Presidential Election:

- The Story of Alf Landon

Source	Sample Size	Predicted Winner
Literary Review	2 million	Alf Landon
George Gallup	2,500	Franklin D. Roosevelt

How could a sample of 2 million voters be less accurate than a sample of 2,500 voters?

The four methods to select your sample data

Sampling strategies

	Sampling from a Population	Sampling from a Process
Random Sampling	X	
Stratified Random Sampling	X	
Systematic Sampling	X	X
Rational Subgrouping		X

Random Sampling

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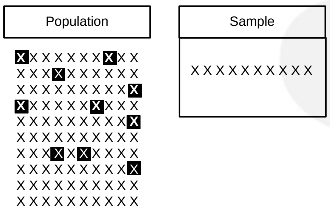


Every member in the population has an equal chance of being selected.

Application	Population sampling
Advantages	Easy to understand and explain
Limitations	Not an appropriate strategy for process sampling If there are segments within the population, they may not be represented in the random sample

205

Stratified Random Sampling

M

Population

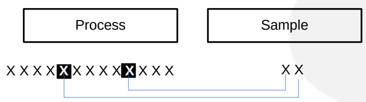
Type of Call	Units	Sample
Balance Inquiry	X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X	X X X X X X X X X X X X X X X X
Change of Address	X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X	X X X X X X X X X X
Drop Terms	X X X	X
Drop Rate	X X X X X X X X X X X X X X X	X X X X X

Application	Population sampling
Advantages	All segments within the population are represented
Limitations	Not an appropriate strategy for process sampling

Population is divided into distinct segments (or stratified layers) and then a random sample is taken within each segment

Systematic sampling

M



Sampling frequency is based upon a specified number of observations or units.

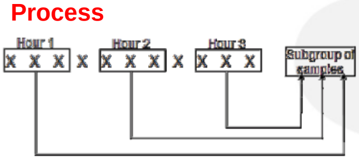
For example, we will select every 5th survey for detailed review in a customer satisfaction survey

Application	Population or process sampling
Advantages	Can maintain the time order of the data for process studies Easy to explain
Limitations	Potential for bias based on the systematic scheme.

Rational subgrouping

M

Process



Sub-grouping applies to how many samples we need to collect at each defined time interval (frequency).

Application	Process sampling (Statistical Process Control)
Advantages	Maintains the time order, so you can observe trends Provides insight as to sources of variation in the process
Limitations	More complicated to design and conduct the rational subgrouping sampling strategy

Class activity: sample strategy

Sample strategy

Objective: How to adapt how you select the calculated sample size based on the nature of the population

- In the slide that follows answer the questions posed and be prepared to share your thoughts with your classmates

Time - 5 mins

Scenario: Sampling Strategy

A call centre has had issues with meeting the customer requirements for speed of answering calls. The call centre team decided to take a sample of its calls to estimate the percentage of calls that were within the call handling specification of three minutes (primary metric) as well as the average call length (secondary metric).

Four types of calls are handled by the call centre:

- Balance Inquiry (50%)
- Change of Address (30%)
- Drop Terms (5%)
- Drop Rate (15%)

1. **Which strategy would you recommend to collect the data?**
2. **How would you change the strategy if the team is interested in how the call length performs over time?**

Summary of key learning points

M

- Every piece of data, potentially costs time and money to collect, analyse and to store. It is important that the benefit of collecting data outweighs the cost
- Having a solid data collection plan is vital
- Collecting samples of data can save time and money
- We need to be aware of sampling risks and ensure these are considered when choosing sample size and sampling strategy

Recommended coach support points

M

- When determining the appropriate sample size when there is a small population size
- Calculating sample size when the current proportion defective is unknown
- Choosing your sampling strategy

Key points of the Measure phase

M

- Use mapping techniques to help understand the current process
- Identify potential root causes
- Understand the basics of data
- Baseline the performance of your the process relative to customer requirements
- Create and execute a data collection plan ready to move into the Analyse phase
- Ensure appropriate care is taken when calculating sample size and selecting sampling strategy

Lean Six Sigma simulation: Round 3

M

The coin simulation

Objective: Use the tools covered in this module to prepare

- The current state value stream map for the process.
- Highlight the location of any potential opportunity area
- Re-run the simulation implementing 1 more change.

60 mins

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ANALYSE

Lean Six Sigma

Green Belt

Objectives of this module

At the end of the module, you will be able to:

- Create a future state process map
- Quantify demand and capacity for the process
- Analyse the key equipment and activity constraints
- Perform correlation and regression analysis
- Understand basic hypothesis testing

Analyse Phase overview

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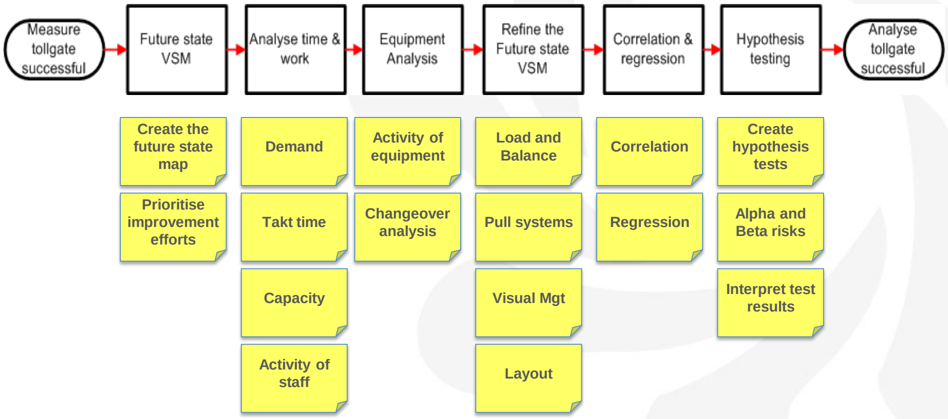

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ANALYSE

Future state value stream mapping

Future State VSM

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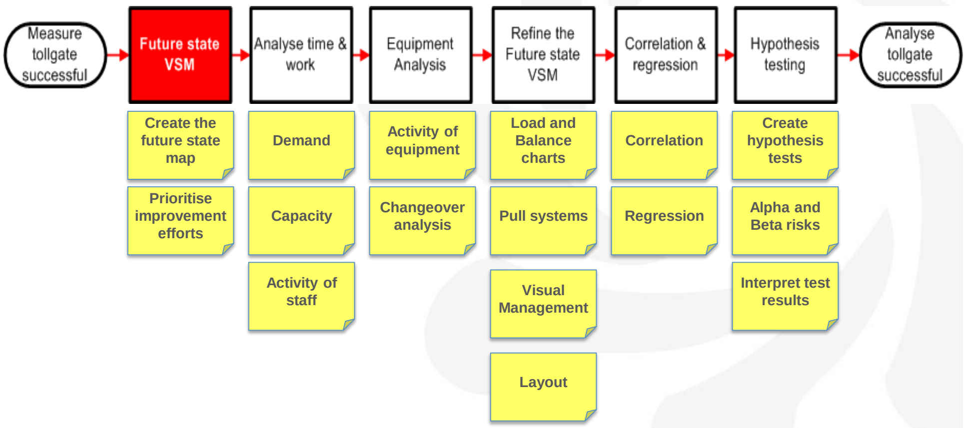


Creating the future state

A

Having mapped the existing process as part of the Measure phase we're now going to create the future state Value Stream Map (VSM).

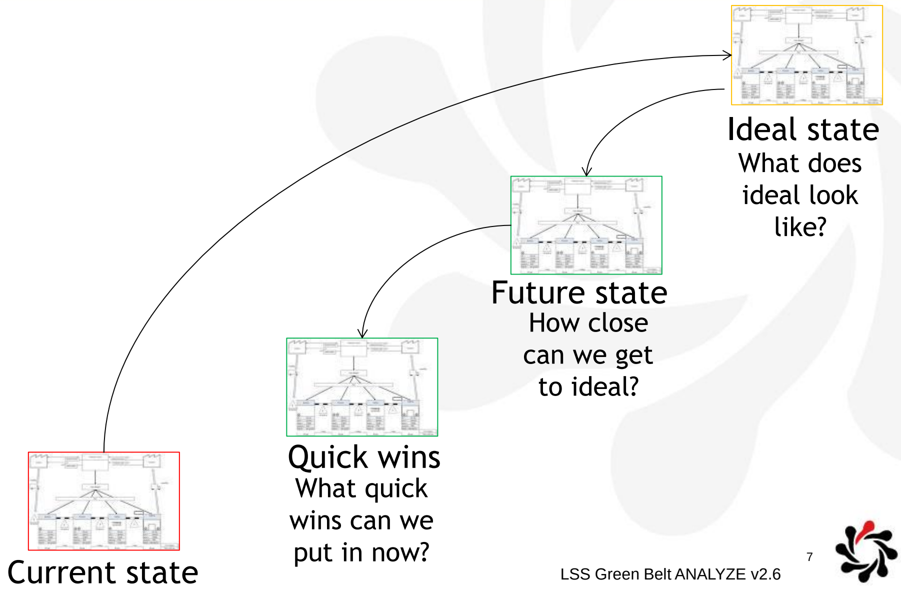
A future state VSM should be made up of value-added activities that produce:

- What the customer wants
- How much the customer wants
- When they want it
- Where they want it

A <u>lean value stream</u> has the <u>shortest lead time</u>, <u>highest quality</u> and <u>lowest cost</u> possible

Approach

A



Ideal State VSM

A

An ideal state value stream map is a <u>theoretical process</u> created <u>free of any constraints</u> on time, money or even current technical feasibility.

So why create it?

One of the principals of Lean is continuous improvement.

The creation of an ideal state value stream map ensures, that after delivery of the project solutions, <u>the Process Owner is challenged to strive closer to this vision avoiding stagnation</u>.

Creating the ideal map will also help those taking part to <u>think in a creative and innovative way about how value could be delivered</u>.

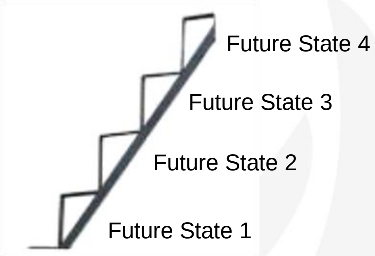
Future State VSM

A

The Future State VSM is created by tackling some of the problems currently faced by the Current State while aiming as close to the Ideal State VSM as possible.

As we solve the problems of the current state, a number of iterations of future state could be created.

The remaining sections of Analyse training is focused on finding the root causes of these issues so that solutions can be generated to reduce or eliminate these root causes.



Prioritising improvement efforts

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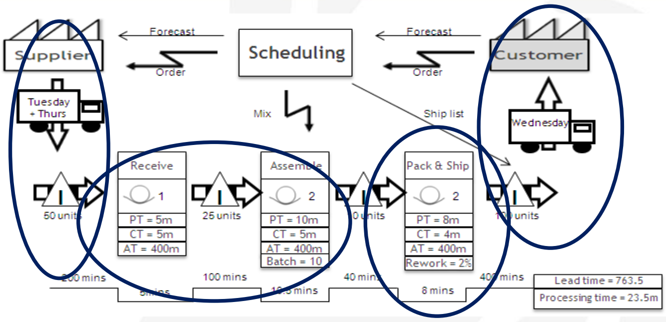
The amount of change required to move from the current state to future state is normally too great to be done in one step.



Breaking the value stream up into project loops makes change more digestible.

But where should we start?

Prioritising improvement efforts, *continued*

A

There is no prescribed rule for prioritising which loop should be worked on first but the following should be considered:

- Begin as close to the customer as possible so improvements are visible to the customer sooner
- Focus on the pacemaker process or cell, since this will set the pace to takt (see next module) for the full value stream
- Work on the processes within your control before branching out to suppliers and customers; your internal work may change requirements
- Learn as you go and apply what you learn; feel free to adjust the future state design as you learn more
- Ask which loop has the best chance of making the greatest improvement considering the customer and business?

Quick Wins

A

Just mapping the value stream alone may yield some obvious improvement opportunities. These opportunities are sometimes referred to as "low hanging fruit" or "quick wins".

Teams should be prepared to pursue these opportunities – the return on investment can be very high.

Typical criteria for quick wins are:

- **Easy to implement** (no significant co-ordination or planning required)
- **Easily reversed** if not successful
- **Fast** to implement
- **Cheap** to implement
- **Within the teams control**

Summary of key learning points

A

- Create an Ideal State to give the team something to aim for and avoid stagnation after the project solutions are implemented
- The Future State map is created based on what is realistically achievable by tackling the existing issues with the current process
- Create project loops to make the scale of change more digestible for the business and easier to manage for you
- Seek to identify and implement quick wins, you can get an early return on investment and start the momentum for change.

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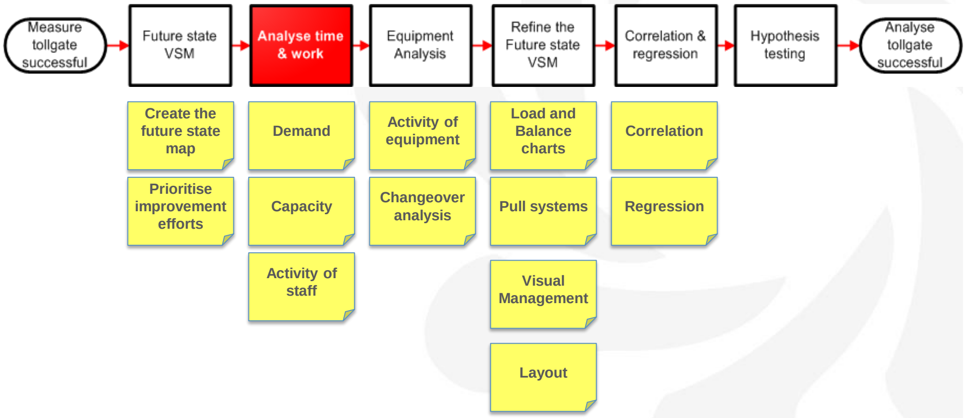
ANALYSE

Analyse time and work

Analyse time and work



Preview of the lesson

In this module we'll discuss:

- Quantifying customer demand
- Takt time
- Quantifying capacity to meet demand
- Standard work

Customer demand

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A customer demand requirement specifies:

- What …
- How much …
- When …
- Where …

… your customer base requires

There are three different types of demand

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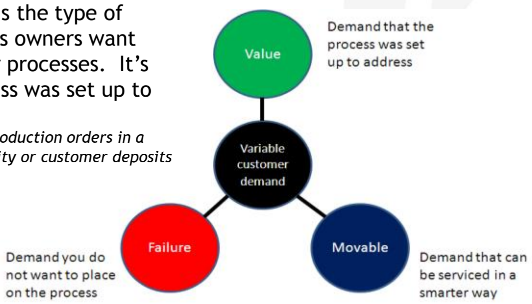
Value demand is the type of demand process owners want placed on their processes. It's what the process was set up to deliver.
Examples include production orders in a manufacturing facility or customer deposits at a bank.



Failure demand is considered "bad demand" as you want to minimise the resources spent dealing with it.
Customer Complaints and many types of customer inbound calls represent significant investment by organisations to deal with this type of demand

Moveable demand is demand that can be placed on an alternative process for the benefit of the business and/or customer.
The growth in online customer servicing is a great example of how this area has grown

When mapping processes be aware of the "hidden factory" – processes set up to deal with errors in the standard process (failure demand).

Identifying types of customer demand

A

- For the following examples, identify the demand being placed on each process
- Classify the demand as: 1) value 2) failure or 3) moveable demand
- For the value and failure demand, identify opportunities to convert the demand to an alternative process that is more effective or efficient.
- For each opportunity, describe how the customer and/or organisation handling the demand could benefit.

5 minutes

1. Coffee/tea served at a staff restaurant
2. Ordering a new mobile phone
3. Logging a software fault
4. Requesting a replacement credit card
5. A quality inspection function at the end of a manufacturing line

Quantifying demand

A

Quantifying the demand on resources requires us to:

- Identify the different demands
- Create an operational definition of each demand and time interval
- Determine the size of the time interval between each demand measure
- Quantify how much data is to be gathered
- Collect the data

Quantifying demand

A

Customer demand is unlikely to occur in an even pattern.

Understanding when peaks and troughs occur is important in the management of resource.

We need an appropriate increment of time to acquire each demand measure

An interval too large or too narrow hides the true pattern and variability of demand.

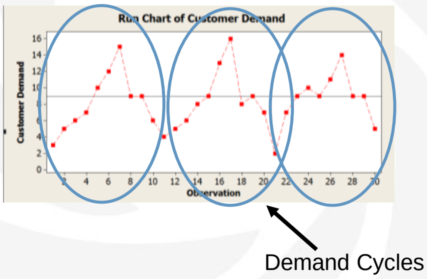
- Talk to people who work in the process, the Process Owner and your Coach to determine:
  - The current volume of demand
  - How demand varies over time
  - The size of a time interval (such as hours, days or weeks) to depict the variability in demand
  - The relationship of cycle time to customer lead time

Determining how much data to gather

A

We need to collect enough data to capture a minimum of one demand cycle.

- Customer demand is often cyclical.
- A demand cycle is the time before each pattern begins to repeat itself.



- Knowing whether the demand data occurs in cycles and the length of each cycle requires historical data and/or experience with the process and its past demand patterns.
- If no historical data exists, talk to the Process Owner, process Subject Matter Experts (SMEs) and/or your Coach to decide on the appropriate number of samples.

Demand volume is derived from historical data and forecast volumes

A

Historical view

Analysis of historical demand up to and including current demand

Forecast

Analysis of demand forecasts and any other factors which have arisen since publication of the forecast

There is no guarantee that your estimate for demand will be accurate but taking a combination of historical and forecast demand volumes is a good place to start

Takt Time

A

Takt comes from the German word for rhythm.

It can be thought of as the rate the process has to run at to keep up with customer demand.

Takt Time (cont'd)

A

We calculate the takt time as follows:

$$\textbf{Takt Time} = \frac{\text{Available Time}}{\text{Demand Requirement}}$$

Available time to run the process doesn't include breaks, lunch etc. It's the amount of actual time available to produce output.

In order to increase takt time (slow production rate), what could we do with breaks, lunch etc?

Takt time does not account for variation in demand which may be caused by changes to:

- customer demand requirements
- the hours of operation

Takt Time v Cycle Time

A

We look to synchronise takt time and cycle time

Cycle time is a rate measure quantifying how long a process step takes to produce one unit of output

$$\textbf{Cycle time} = \frac{\textbf{Available time}}{\textbf{Output}}$$

If the cycle time is:	Then:
Less than the Takt time	Work is being completed faster than required. The waste of overproduction, inventory or waiting will occur.
Greater than the Takt time	The process is unable to meet the pace of customer demand.

Takt time

A

- For the following example,
  1. Calculate the takt time of the process
  2. Calculate the process cycle time
  3. Advise on next steps

5 minutes

Work hours are 09:00 to 17:00 with one hour for lunch

Customer demand is 200 units per day

Output rate is 220 units per day

Capacity

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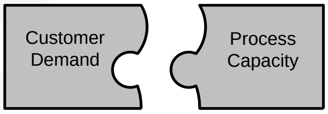
Customer demand and process capacity should match like two pieces of a puzzle.

- Customer Demand - Defines how much is needed
- Process Capacity - Defines how many can be produced



Once both are quantified, they are compared to acquire a baseline of how the capacity differs from the demand.

Approaches to quantify capacity

A

Capacity is expressed based on the degree to which resources are dedicated to the process.

Processes with dedicated resources:

- Capacity is expressed in terms of the **ability to process units** in a given period of time (3,135 applications per day)
- Capacity is expressed for the process as a whole

Processes with shared resources

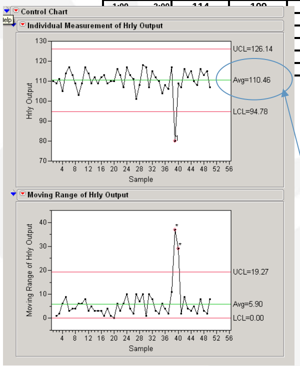
- Capacity is expressed in terms of **available time**
- Capacity is expressed for a resource or resource group
  (Six operators working between 9:15 a.m. and 9:30 a.m. on Monday provide 90 minutes of capacity)

Capacity with dedicated resources

A

- Is the average of the actual output levels of the product/service collected from the process per unit of time
- Uses the same sampling approach as the Demand Analysis
- Is compared with the average demand level identified from the Demand Analysis

	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 – 9:00	110	117	116	107	107
9:00 – 10:00	109	114	113	115	116
10:00 – 11:00	111	109	107	112	112
11:00 – 12:00	105	112	117	110	115
12:00 – 1:00			Lunch		
[illegible]	[illegible]	[illegible]	113	104	110
[illegible]	[illegible]	[illegible]	111	108	108
[illegible]	[illegible]	[illegible]	101	106	116
[illegible]	[illegible]	[illegible]	108	117	113
[illegible]	[illegible]	[illegible]	118	80	115
[illegible]	[illegible]	[illegible]	117	109	107



Capacity = 110.4 units per hour

A process with shared resources

The capacity is measured for each resource group:

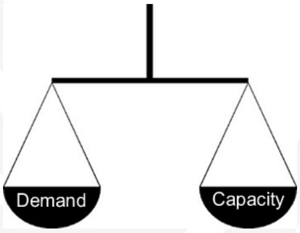
- A resource group is an employee or piece of equipment (single or group) capable of performing similar work.
- The resource group's capacity is its "*ability to do work per interval of time*."
  - A Banking centre measures capacity in 15-minute increments
  - Capacity is the ability to perform "x" amount of teller work per 15-minute increment.

	Tellers Present	Tellers on Break	Tellers at Station		Time Interval		Teller Capacity
9:00 - 9:15	5		5	x	15 min.	=	75
9:15 - 9:30	5		5	x	15 min.	=	75
9:30 - 9:45	5		5	x	15 min.	=	75
9:45 - 10:00	5	1	4	x	15 min.	=	60
10:00 - 10:15	5	2	3	x	15 min.	=	45
10:15 - 10:30	5	2	3	x	15 min.	=	45

The four strategies to balance demand and capacity

There are four general strategies to balance the demand and capacity of a process:

- A Provide strategy
- A Match strategy
- An Influence strategy
- A Control strategy



You need to determine which strategy, if any, is used for your process.

Keep in mind that a combination may be used.

The Provide Strategy

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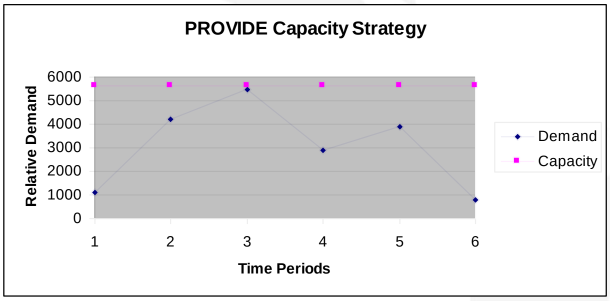
Provide sufficient capacity at all times to meet peak demand.

- Sets the capacity equal to the peak demand
- Assumes enough capacity is available to meet demand

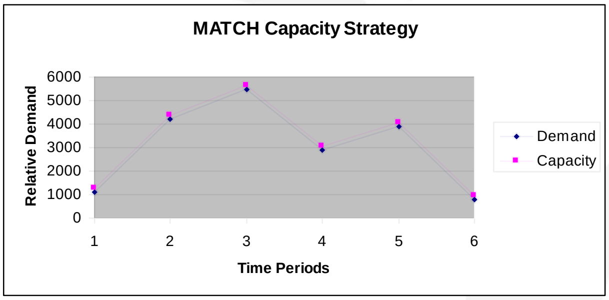


The Match Strategy

A

Anticipate the expected demand to match capacity to demand.

- Sometimes possible with employees
- Is difficult to accomplish with equipment and facilities



The Influence Strategy

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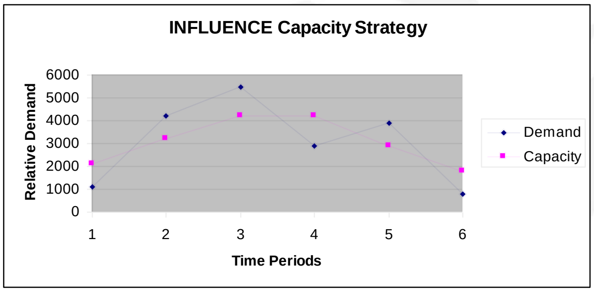
Attempts to influence customer demand patterns to obtain a good utilisation of resources.

- Influences demand by moving demand from the highest demand period to the lowest
- Influences lowest demand by having fixed hours of operation
- Reduces the amount of demand variation



The Control Strategy

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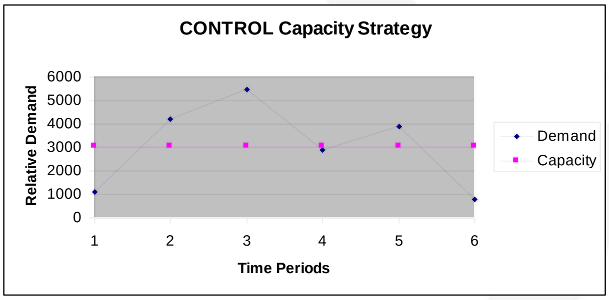
Sets capacity to equal the average demand.

- Uses some means of accommodating (controlling) excess demand until capacity is available
- Uses queues to accommodate excess demand



Activity of the Staff (AoS)

A

Activity of the staff studies require us to

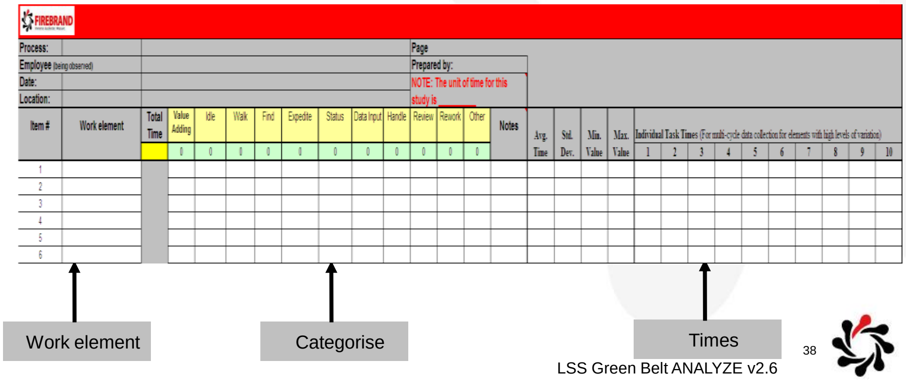
1. Optimise the activity of staff engaged in process steps that will remain in the future state process
2. Identify and **standardise** the one and best way to complete activities
3. Define the activity of staff on new process steps introduced by the future state design

Optimise the activity of staff (AoS) for the Current-State Process Steps in the Future-State Product Flow

A

An activity of staff worksheet can be used to:

- Identify each work element
- Time each work element
- Categorise activities for each element



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Process:

Employee (being observed)

Date:

Location:

Page

Prepared by:

NOTE: The unit of time for this study is ______

Item #	Work element	Total Time	Value Adding	Idle	Walk	Find	Expedite	Status	Data Input	Handle	Review	Rework	Other	Notes	Avg. Time	Std. Dev.	Min. Value	Max. Value	Individual Task Times (For multi-cycle data collection for elements with high levels of variation)									
			0	0	0	0	0	0	0	0	0	0	0						1	2	3	4	5	6	7	8	9	10
1																												
2																												
3																												
4																												
5																												
6																												

How AoS studies are conducted

AoS studies are comprised of five steps:

1. Identify those employees to participate in the study
2. Determine the number of cycles and the sampling strategy for the study
3. Prepare a data collection plan to acquire the activity times for each step
4. Conduct the study and complete the AoS worksheet
5. Determine the baseline measures of non-value-adding time the employee experiences.

We will look at steps 1 and 4 in more detail.

How AoS studies are conducted, *continued*

Step 1: Identify the employees to participate in the study.

- Identify the staff position/group performing the step.
- Include a representative sample of the best, average and poorest performing employees.
  - All employees may have best practices that can be carried forward.
- Secure any approvals to observe the employees.
- Communicate the purpose of the study to the affected employees.

How AoS studies are conducted (Cont.)

A

Step 4: Conduct the study.

- Capture all work elements that comprise the process step
  - A work element is the smallest increment of work that can be transferred from one person to another.
- The level of detail for the activities depends on the cycle time for the step.
  - A step with a cycle time of minutes will have activities defined in seconds.
- You may encounter “foreign activities” during the study.
  - Foreign activities are not part of the designed work for the process step (employee adjusts their glasses, equipment failures, etc.). They are special cause variation.
  - They should be captured in the study.

The primary methods to acquire the AoS data

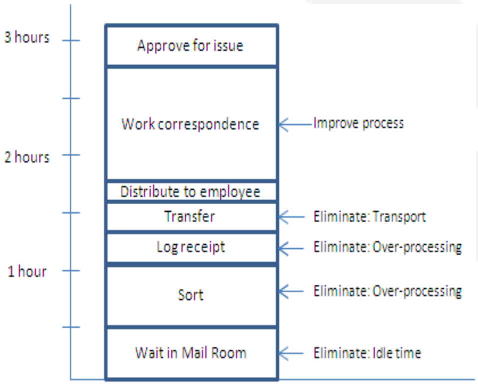
A

The data for the AoS worksheet can be acquired by:

- Videotaping the employees performing the process
- Observing the process in-person, using a stopwatch to acquire the time data
- Having employees self-record the AoS data

Stacked bar – current state

- Creating a single stack of time ordered activities from the Activity of Staff worksheet immediately provides a visual on potential opportunities for improvement



- This stacked bar chart illustrates employee work elements within a correspondence process

The definition and importance of standard work

Standard work is defined as:

An agreed-upon set of work procedures that establish the best, most reliable methods and sequence for each step and employee in the process.

- Standard Work reduces variation in how work is performed
- Standard Work alone does not result in “work standardisation”
- Standard Work provides …
  - A foundation for continual improvement
  - A common process language among all employees

Use mock-ups to define employee activity in new process steps

A

A mock-up is:

A model of a proposed process step or activity in a controlled environment.

Mock-ups are used to:

- Test and improve the design of a process step in a safe environment
- Enable the acquisition of cycle time data for a process step

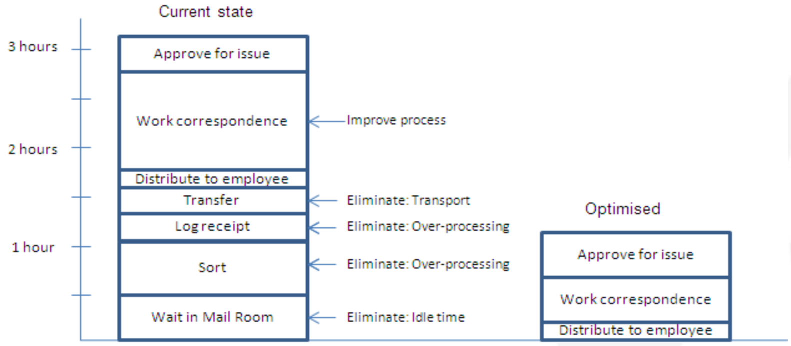
Use mock-ups when:

- The process step is new
- The sequence of the process steps is new
- The risk employed with the new process step is high

Stacked bar - optimised

A

- Implementing standardised work processes, delivering mail directly to the correspondence team significantly reduced employee activity



Summary of key learning points

A

- Demand analysis is used to quantify the pull on resources from the customer
- Takt sets the rate at which output should be produced to keep up with customer demand
- Capacity is the volume of staff or equipment available to meet demand
- Conduct an Activity of Staff (AoS) study to identify opportunities to improve and standardise work content

Recommended coach support points

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- Quantify the length of a demand cycle
- Quantifying sample size for AoS studies
- Quantifying capacity for processes with shared resources


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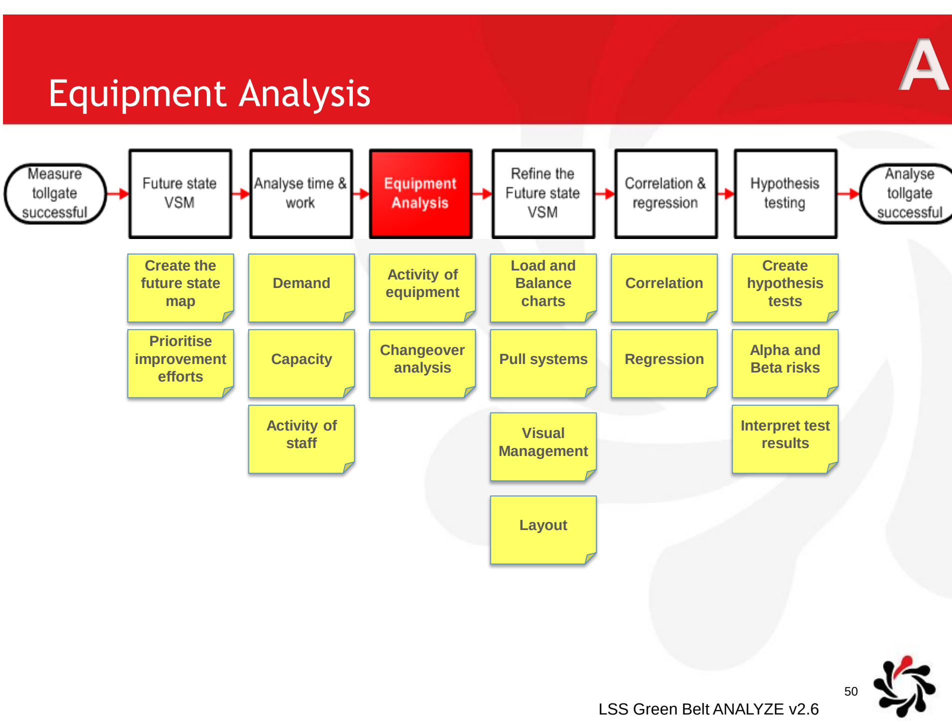
ANALYSE
Equipment Analysis


Equipment Analysis
A
Measure tollgate successful
Future state VSM
Analyse time & work
Equipment Analysis
Refine the Future state VSM
Correlation & regression
Hypothesis testing
Analyse tollgate successful
Create the future state map
Prioritise improvement efforts
Demand
Capacity
Activity of staff
Activity of equipment
Changeover analysis
Load and Balance charts
Pull systems
Visual Management
Layout
Correlation
Regression
Create hypothesis tests
Alpha and Beta risks
Interpret test results
LSS Green Belt ANALYZE v2.6
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Lesson objectives

A

At the end of this module, you will be able to:

- Identify and classify the equipment in the process that requires an Activity of the Equipment (AoE) study
- Conduct and analyse an AoE study
- Apply the **ICE** (Identify, Convert and Eliminate) method to reduce equipment **changeover time** in a process
- Develop **standard work for the use of process equipment**
- Select and apply the appropriate equipment **optimisation strategy to reduce the cycle time** of an equipment activity

Activity of the Equipment (AoE)

A

Equipment activities, like employee activities, include waste.

- The tools and procedures in this section will help you identify and eliminate equipment waste
- Equipment waste is important to eliminate because it:
  - Results in lost employee time/costs, including injuries
  - Prevents you from meeting customer demand without heroic employee efforts
  - **Creates defective products, leading to inspections**
  - Generates a need to process in batches versus one-piece flow
  - Builds up WIP inventory
  - Frustrates employees and customers

Identify the equipment within the process that require analysis

A

There are three general types of equipment in a process.

1. Equipment dedicated to one employee performing:
   - One/multiple steps in a process
   - Steps in many processes (A personal laptop or a telephone)
2. Equipment shared among multiple employees performing:
   - One/multiple steps in a process (A shared copier, fax machine)
   - Steps in many processes (Shredding equipment, a shrink wrapping machine)
3. Equipment where **the customer is the operator**.
   - For example, petrol pump, cash machines and telephone IVRs

How to determine which equipment to analyse

A

- Identify the equipment using the Value Stream Map
- For each piece of equipment ask:
  - "If the equipment was unavailable for any reason, would it impact the ability of the process to produce the desired results?"
  - "Does this equipment affect the ability of the process to meet its Takt time?"
  - "Does the equipment negatively affect the customers in the process?"

An AoE study is recommended if you answer "yes" to any question

Conduct an Activity of the Equipment (AoE) study for the selected equipment

AoE studies typically require the help of equipment SMEs.

- Most project team members lack detailed knowledge of the equipment in the process.
- The employees who operate the equipment daily are ideal SMEs.
  - Be sure to review their roles/responsibilities as a SME.
  - Include their managers in any discussions of roles and responsibilities.

The general activities of the equipment in a process

There are **10** general **equipment activities** that are **observed** and **timed** during an AoE study

The Equipment →

- Setup Time
- Load Time
- Start Time
- Run Time
- Complete Time
- Unload Time
- Replenish Time
- Maintain Time
- Downtime
- Idle Time

The structure of the AoE template

A

The AoE Analysis Worksheet has the same structure as the AoS worksheet

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Process: | Page: ___ of ___

Equipment: | Prepared by:

Date:

Location:

NOTE: The unit of time for this study is _______ (enter hours, minutes, or seconds)

Item #	Description (From the view of the equipment)	Total Time	Auto Run	Manual Run	Setup	Load	Start	Replenish	Complete	Unload	Idle	Maintain	Other	Notes	Avg. Time	Std. Dev.	Min. Value	Max. Value	Individual Task Times (For multi-cycle data collection for elements with high levels of variation)									
		0																	1	2	3	4	5	6	7	8	9	10
1	equipment: activity																											
2																												
3																												
4																												
5																												

The structure of the AoE template

A

Like staff studies, AoE studies should be planned carefully and executed well.

1. Plan the AoE study with equipment operators/experts
2. Develop the data collection strategy for the AoE study
3. Analyse the AoE study to identify waste in the usage of equipment. Identify the root causes of the waste
4. Optimise the use of the equipment at process steps
5. Develop standard work for use of the equipment

How to identify equipment monuments in a process

A

A process monument is:

A resource that serves more than one process step that cannot be moved or decentralised due to cost, environmental or control issues

- Monuments can be equipment, facilities, organisations or employees.
- Monuments occur when:
  - Many process steps feed into one resource
  - One resource feeds many process steps
- You often have to work around a monument in the short-term until a longer-term solution is created.

How are your tyre changing skills?

A

- Assume one day next week you get a flat tyre during your drive home from work.
- From the time you stop your car on the shoulder of the road, how long will it be before you are on the road again?

How the ICE method is used to reduce equipment changeover time

A

Identify, Convert and Eliminate (ICE) is a method to reduce the changeover time for a piece of equipment.

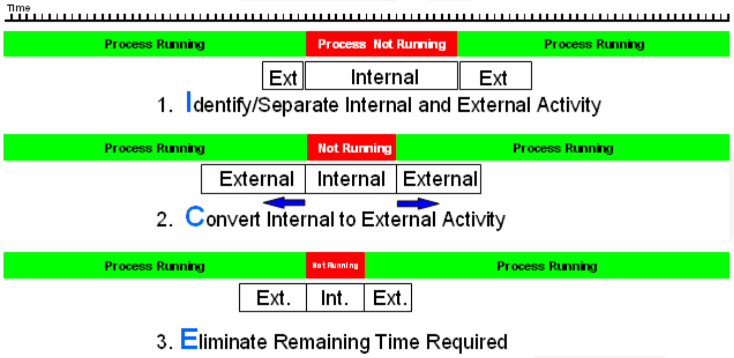


Table exercise: ICE

A

Objective: Understand the practical application of the ICE method

- Think of a process from your organisation in which the changeover from one product or service is important.
  - Why is it important?
  - What are the high level steps and could any of these benefit from the ICE method?

Time - 15 mins

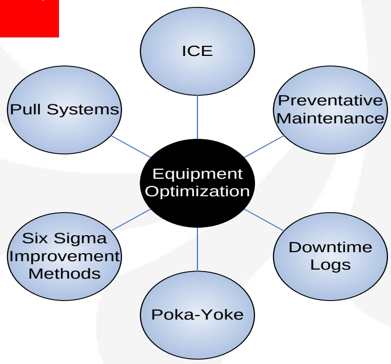
Other equipment optimisation strategies

A

The Lean equipment philosophy is simple:

Equipment should be available to run when needed, but should be run only when needed

There are six key strategies to support the Lean equipment philosophy



Some businesses believe it is wasteful to have idle equipment (even when there is no customer demand)!

Summary of key learning points

A

- An AoE study is used to quantify the level of equipment waste
- If a monument exists in the process, plan to work around it in the short term until a longer-term solution is created.
- ICE is a method that converts set-up and changeover activity to reduce equipment downtime
- ICE is one of six methods used to get the most out of equipment within the process

Recommended coach support points

A

- Quantifying sample sizes in AoE study
- Working with monuments in a process
- Further information on other strategies to optimise the use of equipment.

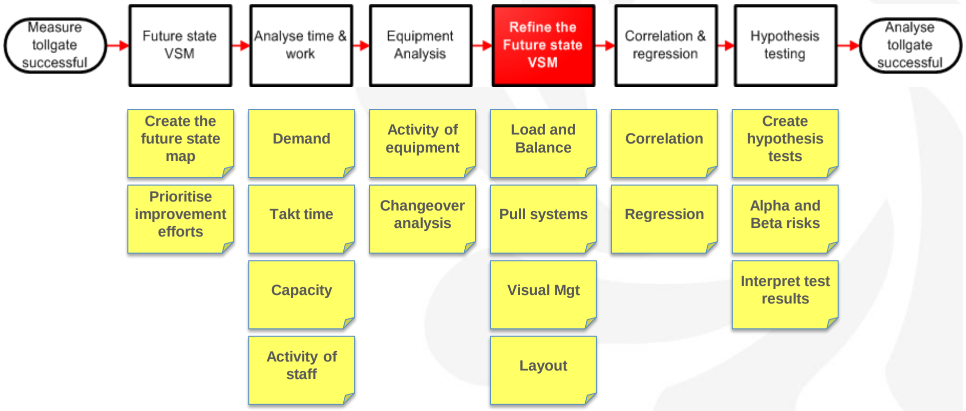
FIREBRAND

ANALYSE

Refine the Future State VSM

Refine the Future State VSM

A



Preview of the lesson

A

After completing this lesson, you will be able to:

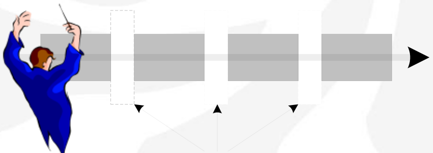
- Use Load Charts and Balance Charts to balance the cycle times of the process steps
- Design a pull system to flow the product continuously through the process steps
- Determine where and how visual management methods should be applied in the future-state process
- Develop a conceptual design of the physical layout of the future-state process

How to refine the initial process design to achieve continuous flow

A

A major focus of Lean is the design of a continuous flow system for the process.

- The continuous flow system is the conductor of the process.
- It connects the "white space" between process steps, ensuring that all steps work in unison.
- A well-designed system:
  - Hinders the creation of waste in a process (since the majority occurs in the white space)
  - Minimises interruptions to the flow of the product
  - Reduces the time to complete the product



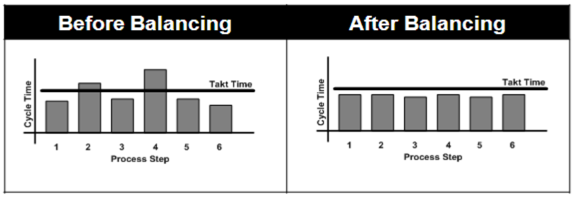
Balance the standard work content of the future-state process

A

Work content balancing is:

A method to compare and adjust the cycle times of the individual steps in a process so that the cycle times of all steps:
1. are similar and
2. fall just below the Takt time for the process

- Balancing is performed <u>after</u> you have optimised the design of the process steps in the "Activity of " studies



Factors to consider when structuring the standard work content

A

There are many strategies to structure the work content within a process. Two car manufacturers illustrate the extremes:

Henry Ford's Approach	Volvo's Approach
Narrowly structure the work content to produce a car • Thousands of employees were involved in the production of a car	**Broadly structure the work content** • At one time, Volvo employed a production model using a team of 10 employees to build a car

What are some of the advantages and disadvantages of each approach?

Factors to consider when structuring the standard work content

A

Factor	Does the work …
Geographical/ Environmental	Need to be performed at certain physical sites or controlled environments?
Vocational	Require unique employee skills?
Lead Time	Need to be performed in parallel or around the clock to reduce lead or cycle time?
Equipment	Have unique equipment requirements?
Risk Mitigation	Need to be performed by different employees for a "check and balance" within the process
Training	Allow for efficient new employee ramp-up?
Job Enrichment	Need to increase or decrease to mitigate employee turnover?

How to estimate the number of employees required for the process

The number of people required for a process can be estimated once the Standard Work content has been defined:

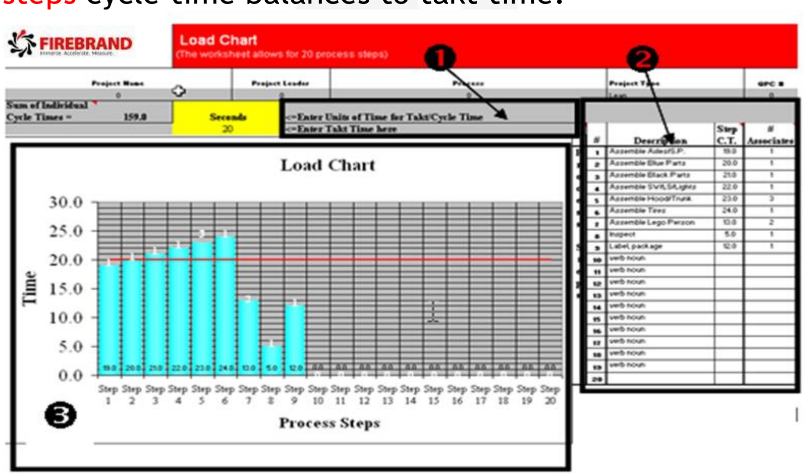
$$\text{Number of people required} = \frac{\text{Sum of the work content}}{\text{Takt time}}$$

* Round up to the next whole number.

How work is assigned to these employees will depend on the work structure and the extent to which the cycle times balance for the process steps.

How Load Charts are used and constructed

A Load Chart depicts the extent to which the process steps cycle time balances to takt time.



How balance charts are used and constructed

A Balance Chart is used to analyse and “balance” the work content at the activity level of a process.

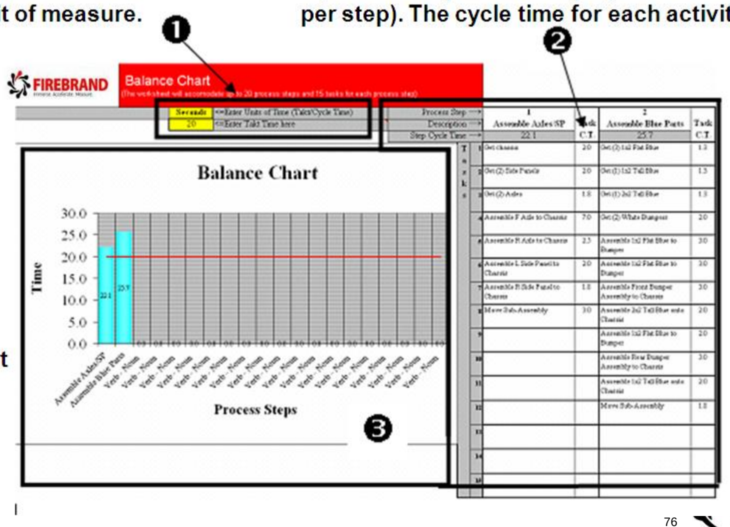
- The Balance Chart uses time data at the activity level for each process step.
- Activity-level data is needed to shift the work content among the process steps
- The activity cycle times are added to arrive at a step-level cycle time.

How balance charts are used and constructed (Cont.)

Takt time and its unit of measure.

Space for 20 process steps (15 activities per step). The cycle time for each activity

The completed Balance Chart



How the charts are constructed for process steps with multiple employees

A

A five-step process has a Takt time of 12 minutes and the cycle times below.

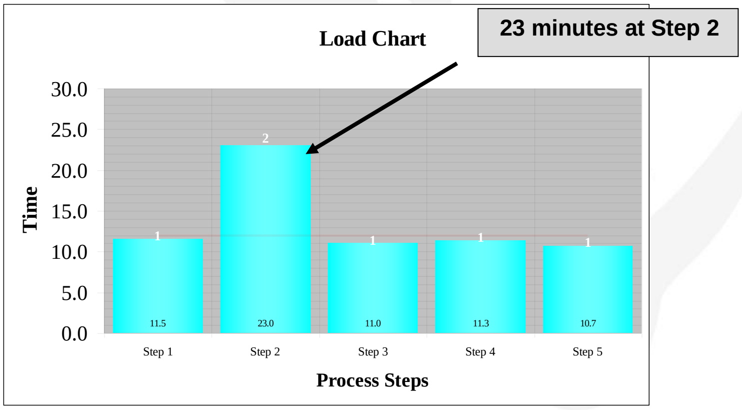
Process Step	Cycle Time	Number of Employees to Meet Demand
1	11.5	1
2	23.0	2
3	11.0	1
4	11.3	1
5	10.7	1

Two employees must be staffed at Step 2 to meet customer demand

How the charts are constructed for process steps with multiple employees (Cont.)

A

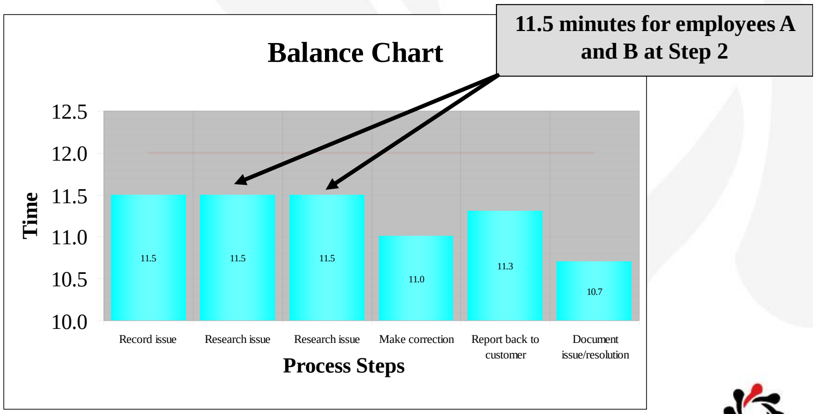
The Load Chart should display the overall cycle time of the work content at each process step.



How the charts are constructed for process steps with multiple employees (Cont.)

A

The Balance Chart should display the work content assigned to each employee at each process step.



How the charts are used for process steps with equipment resources

A

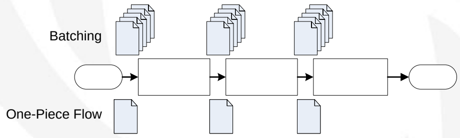
Apply the following rules for process steps with equipment resources.

Use the:	To display:
Load Chart	The **overall cycle time for each process step**. The cycle time includes the equipment's run time and the time to complete any employee-performed tasks while the equipment is not running.
Balance Chart	**The equipment and employees as separate resources**. This will show the elements constituting the cycle time of: • The <u>equipment and how it</u> compares to the Takt time • The <u>employee operating the equipment</u> and how it compares to the Takt time

Design the Pull System to flow the product through the process steps

A

As a general rule, “Flow when you can, batch when you must.”



Batching might be required when:

- The design of any materials, supplies or equipment hinder one-piece processing
- The product is easier to process (or monitor) in batches.
- The movement of one product at a time is cost or time prohibitive
- The suppliers of an input cannot deliver the input when needed to achieve one-piece flow at the consuming process step
- The software used in the process automatically batches the product and changes to the software are not possible

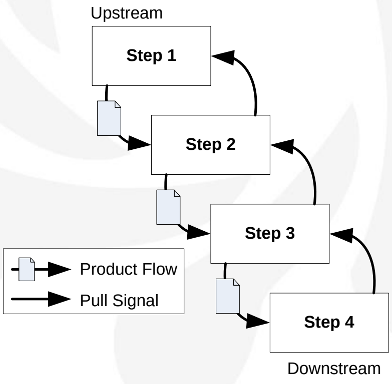
How pull systems work

Key content

A

Pull systems use signals to control when a product (or batch) is processed at each step in a process.

- Pure pull systems are used for commodity items such as cash in the ATM channel
- In-process pull systems are used to control the work flow of unique items such as loan applications



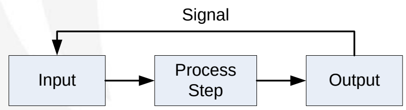
The rules of a pull system

Key content

A

The employees or equipment at a process step should work only when:

- A signal to work is received from the downstream step
- There is product to work on from the upstream step



Input Status	Process Status	Output Status
Not Open	**Cannot Work**	Not Open
Open	**Cannot Work**	Not Open
Open	**Cannot Work**	Open
Not Open	**Work**	Open

In all other circumstances, the employees and equipment at the step remain idle.

The signals are usually visual cues such as signs, cards, flags, level indicators and electronic messages. These signals are known as Kanban

The process characteristics that maximize the value of a Pull System

A

A pull system is best applied to a process that is:

- Reliable. Dependable equipment, a flexible, multi-skilled workforce and no delays due to materials movement
- Organised. Well-structured with minimal physical travel for the product
- Repeatable. Work content performed consistently, with clearly defined and understood Standard Work
- Balanced. Cycle times of steps are balanced within Takt time. Lot sizes are small; ideally, the process uses one-piece flow

Pull systems are most easily applied to high volume, repetitive processes. They can be applied to one-of-a-kind processes (such as software or new product development).

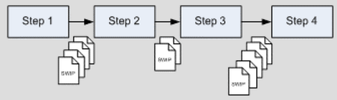
The concept of Standard Work in Process (SWIP)

Key content

A

Standard Work in Process (SWIP) is:

The amount of work in process for the product that should be in place at any time at each step to protect the flow and efficiency of the process



SWIP is usually required because:

- It may not be possible to perfectly balance all steps
- The cycle times of the process steps will always vary
- Monuments can exist in some future-state designs
- Customer demand will vary
- Supplier delivery performance can vary

The different approaches to determine the SWIP quantity

A

The trial and error approach.

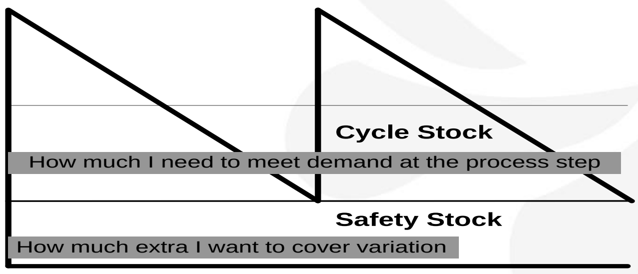
- You perform a root cause analysis of the WIP at each step:
  - Every piece of inventory exists for a reason (some are valid; most are not).
  - Most processes suffer from too much (rather than too little) WIP.
  - Begin with the average WIP level at the step. Repeatedly ask, “Why does this exist?”
- You determine a reasonable starting WIP for a trial and error process.
- You slowly remove (or add) WIP to the process step until the process flows continuously and efficiently.

The different approaches to determine the SWIP quantity (Cont.)

A

An alternative approach is to calculate the cycle stock and safety stock requirements using statistical methods.

- The SWIP quantity is calculated using the following formula:
  - SWIP Inventory = Cycle Stock Inventory + Safety Stock Inventory



Visual Management

A

Visual management systems create the visibility to operate and manage the process.

- They display vital process information so you can see what's happening allowing you to:
  - Respond to issues rapidly
  - Avoid wasting time and energy trying to figure out things
- They control or guide the actions in the process to prevent errors or mistakes from occurring.

Where Visual Management systems are normally applied

A

Visual management systems are used to display.

1. Important status and failure messages to employees and customers
2. Vital information about the performance of the process (or process step)
3. Who is trained (or has demonstrated the ability) to complete the steps, activities or tasks in the process
4. Samples of items with defects (or prototypes of items that are processed correctly)
5. The Standard Work for a process step

The scope of Visual Management design activities in the Analyse Phase

A

You create a conceptual design of any visual displays or controls for the process.

A conceptual design is a sketch or written description of the system and how it would work.

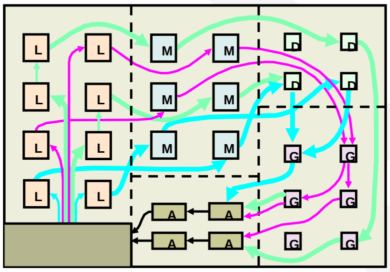
- The visual management systems will be evaluated as part of the pilot test in the Improve phase:
  - Simple displays/controls will be developed as designed.
  - More complicated, costly displays/controls will be mocked up.

Layout for the future-state process

A

A process layout is:

The arrangement of the materials, equipment and employees (such as their workstations) used within a specific process



When process layouts are important

A

Layouts are very important in physical processes.

- Depicting the layout helps minimise:
  - The transportation of the product from one process step to the next
  - Movement of materials, people and equipment within each process step
- Depicting the layout helps optimise the ability for employees to:
  - Share information
  - Assist each other

When process layouts are important, *continued*

A

Layouts are less important in virtual processes.

- A layout of a virtual process is usually not required.
  - It may be impractical to rearrange (or co-locate) the employees or equipment in a virtual process.
  - The VSM and the "Activity of ___" studies depict the movement of the product in a virtual process.
- You may need to define the location of any centralised electronic files in the process to facilitate employee access.

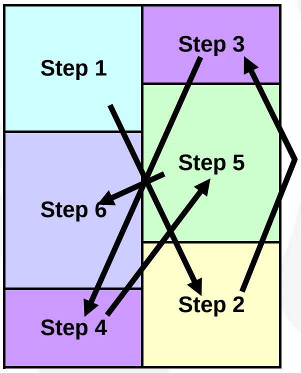
The types of process layouts: Process-Oriented

A

A layout in which the employees and equipment performing the same process steps are grouped together.

Each group is usually organised as a separate department having different managers and separate performance metrics.

What are the advantages and disadvantages of using a process layout?

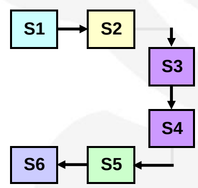


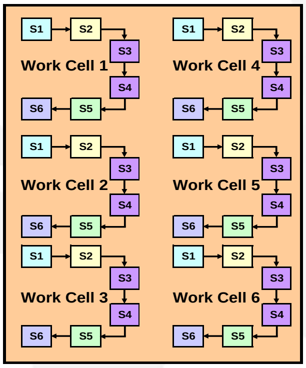
Process-Oriented Layout

The types of process layouts: Product-Oriented (Work Cell)

A layout in which the employees and equipment performing the process steps are co-located into an end-to-end continuous workflow called a **work cell.**

Each group is usually organised as a separate department having different managers and separate performance metrics.





Product-Oriented Layout

What are the advantages and disadvantages of using a work cell?

Other types of process layouts

Office Layout	• Designed to maximize the utilisation of space while providing employees with cubicles for some level of privacy and quiet.
Retail Layout	• Organises a sales and service area to respond to or drive specific customer behaviors. • Banking Centres and grocery stores are examples.
Warehouse Layout	• Optimises the usage of space, while minimising the effort to store and retrieve the materials. • Examples are storerooms.
Fixed Position Layout	• The product stays in one location. The employees in the process, and supplies move to the product. • Examples are the construction of a building.

When to organise the process layout in a work cell

A

Work cells are the preferred layout for processes that produce a single product or product family.

- Each cell initially may process a narrow range of highly similar products. Over time, the products may be broadened.
- Work cells are self-contained with all necessary equipment and resources.
- There are five work cell configurations:

1. U-Shaped (employees on outside)
2. U-Shaped (employees on inside)
3. Straight Line
4. L-Shaped
5. Converging Line

Summary of key learning points

A

- Refine your initial future state value stream design so that product flows from one end of your VSM to the other in a smooth uninterrupted flow
- The use of Load and Balance charts help you balance takt with work content and resourcing requirements
- Pull systems ensure you minimise over-production and should be included in future state design where possible
- Visual Management guides the actions in the process to prevent errors or mistakes from occurring.
- Layout is important to minimise the transportation/movement of employees, equipment and product

Recommended coach support points

- Creating pull systems
- Calculating SWIP
- Designing your layout

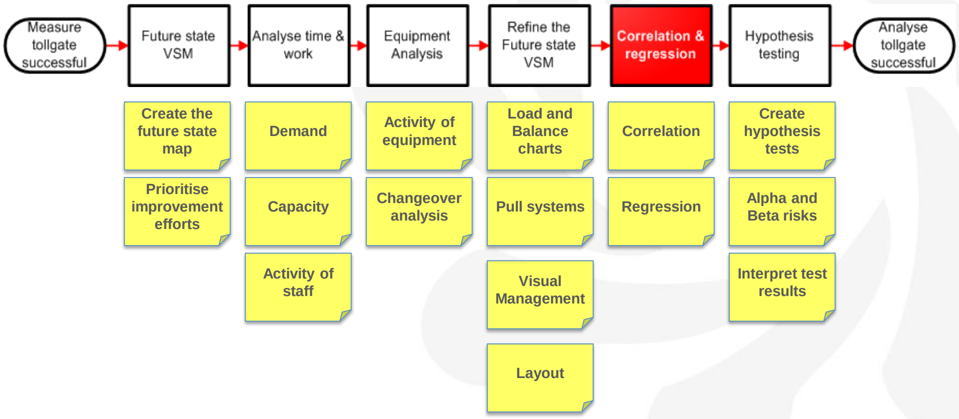
FIREBRAND

ANALYSE

Correlation and regression

Correlation and Regression

A



Preview of the lesson

A

After completing this lesson, you'll be able to:

- Use a Scatter Plot to assess the shape, strength, direction and presence of outliers for a relationship between a continuous x and a Y
- Understand how predictive equations for a continuous x and a Y using simple linear regression are created

The purpose of correlation and regression analysis in the Analyse Phase

Key content

A

Correlation and regression analysis are used to confirm the significance of continuous x's:

The method used depends on the type of data for the Y:

- Logistic regression analysis is used when the Y is discrete.
- Correlation analysis and regression analysis are used when the Y is continuous.

Potential Vital Few Input (x)
(from the Measure phase)

Project Y	Discrete	Continuous
Discrete	Discrete Hypothesis Testing	**Logistic Regression**
Continuous	Continuous Hypothesis Testing	**Correlation and Regression**

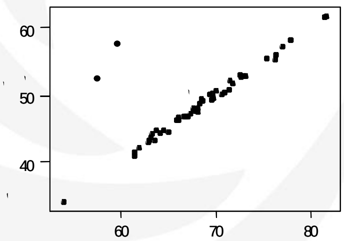
The basic principles/approach of correlation analysis

Key content

A

Correlation analysis is a method to evaluate a potential relationship between a continuous input (x) and a Y.

- The relationship is depicted graphically through a Scatter Plot
- Limitations of using correlation analysis:
  - Does not provide a predictive equation
  - Does not confirm causality

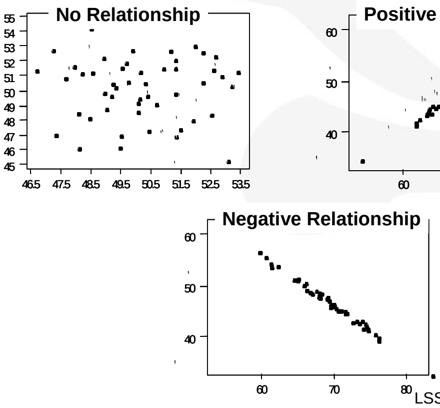


How scatter plots are used

A

Scatter plots are used to evaluate the direction of a potential relationship:

- As the x increases, what happens to the Y?

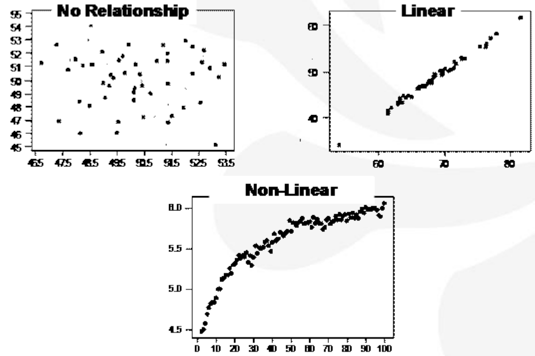


How scatter plots are used, *Continued*

A

Scatter plots are used to depict the shape of a relationship:

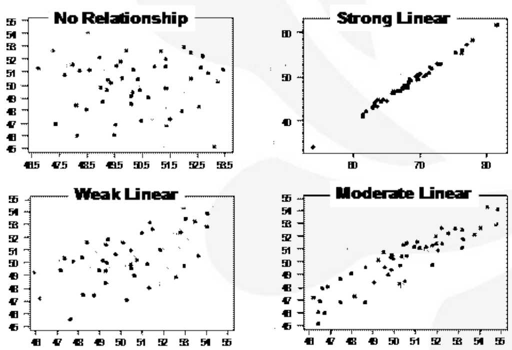
- What shape best describes the relationship between the x and the Y?



How Scatter Plots are Used, *Continued*

Scatter plots are used to depict the **strength** of a relationship:

- How tightly grouped are the data points along the shape?



How Scatter Plots are Used, *Continued*

Scatter plots are used to identify suspicious outliers

- Are there any data points that do not fit the shape suggested by a majority of the data?

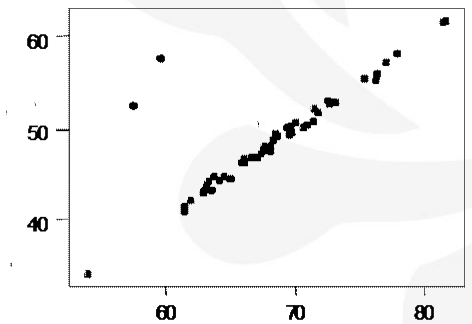
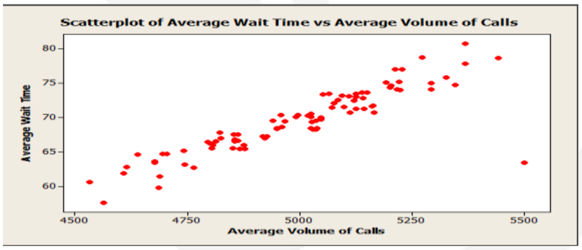


Table exercise: using Scatter Plots

Objective: Interpretation of scatter plots

Review the Scatter Plot below to determine the relationship between volume of calls answered (x) and wait time (Y).

Time - 5 mins



What conclusions can be reached regarding the direction, shape and strength of the relationship? Are there outliers?

- Direction ____________________
- Shape ____________________
- Strength ____________________
- Suspicious Outliers ____________________

Regression

What is Regression Analysis?

- Develops a mathematical equation to **quantify** the relationship.
  - Enables you to predict the Y based on the value of the input (x).
- The model includes a Coefficient of Determination (R^2):
  - Expresses the percentage of total variation in the Y **that can be explained by the changes in the input (x)**
- Regression analysis, like correlation, cannot prove causality

How and when regression analysis is used, *Continued*

A

An example of a mathematical model:

- You can develop a predictive equation for the total amount of change in your pocket:
  - The Y is the dollar amount of change you have in your pocket.
  - The x's are the coins (quarters, dimes, nickels and pennies).

The predictive equation:

- Y (total $) = 0.25 x (number of quarters) + 0.10 x (number of dimes) + 0.05 x (number of nickels) + 0.01 x (number of pennies)
- R^2 = 100%

What would happen to R^2 if you did not include the pennies? How about the quarters?

The types of regression analysis

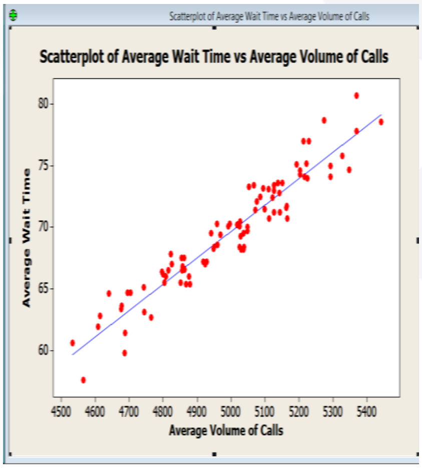
A

There are three types of regression analysis:

Method:	Used to develop a predictive equation for:
Simple Linear Regression	One continuous Y variable and one continuous x variable.
Multiple Linear Regression	One continuous Y variable and multiple (more than one) continuous x variables.
Logistic Regression	Discrete Y variables.

Interpreting the simple linear regression analysis

Minitab will create a line of best fit through the collected data to create a predictive equation, allowing you to estimate the Y for a given value of x



Regression Analysis: Average Wait Time versus Average Volume of Calls

```
The regression equation is
Average Wait Time = - 37.2 + 0.0214 Average Volume of Calls

Predictor                    Coef    SE Coef       T      P
Constant                  -37.186      3.626  -10.25  0.000
Average Volume of Calls 0.0213753  0.0007258   29.45  0.000

S = 1.39314   R-Sq = 90.8%   R-Sq(adj) = 90.7%

Analysis of Variance

Source          DF      SS      MS       F      P
Regression       1  1683.4  1683.4  867.34  0.000
Residual Error  88   170.8     1.9
Total           89  1854.2
```

How to apply the predictive equation

From the previous slide, assume call volume was on average 4,900. You can use the regression equation to estimate the wait time:

Wait Time = -37.2 + 0.0214 x Average call volume

- Wait Time = -37.2 + 0.0214 x 4,900
- Wait Time = -37.2 + 0.0214 x 4,900 = **67.66**

If your goal is to reduce the average wait time to less than 68 seconds, the average call volume should be kept as low as possible and no higher than 4,900 calls.

What things should management consider before taking action?

How to apply the predictive equation (*Cont'd)*

A

The management team now can consider:

- Is it possible to achieve this reduction in calls?
- Does the cost of reducing call volume to achieve this improvement justify the benefit?
- Is there a true causal relationship between typing speed and handle time?

Summary of key learning points

A

- Use correlation to understand the direction, shape and strength of a relationship between a continuous x and continuous y
- Regression analysis creates a predictive equation to quantify this relationship

Recommended coach support points

A

- Reviewing your planned testing strategy
- Reviewing the Correlation results
- What to do if you have more than one continuous x
- What to do if your Y is discrete

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ANALYSE

Hypothesis testing

Preview of the lesson

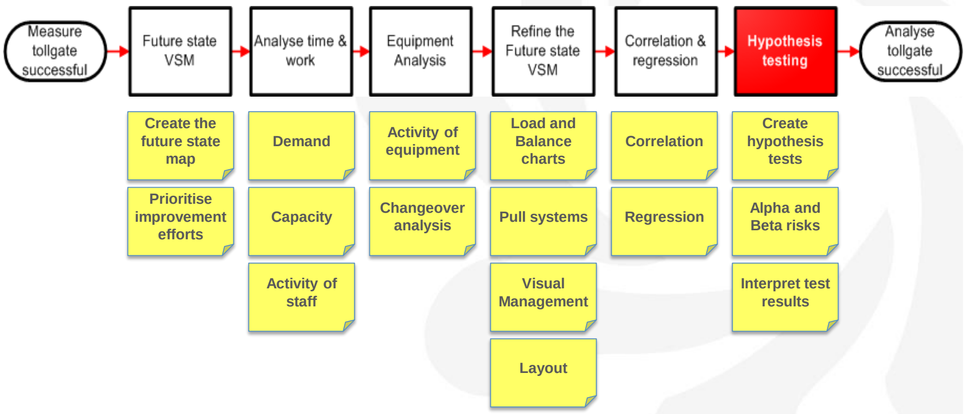
A

After completing this lesson, you will be able to:

- Describe the two primary applications of hypothesis testing in all Lean Six Sigma project types
- Prepare null and alternative hypothesis statements to **confirm the impact of a discrete x upon a project Y**
- Explain how the p-value is used to reach a statistical conclusion for all hypothesis tests

Hypothesis testing

A

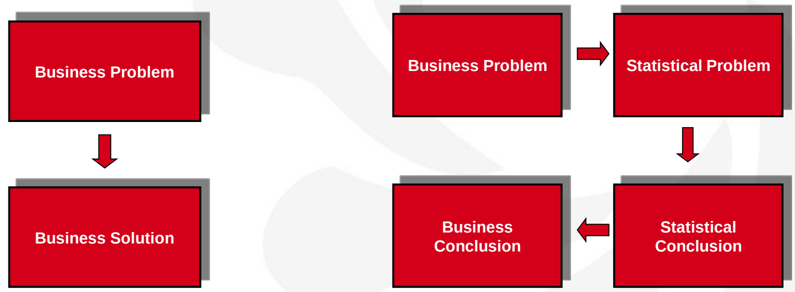


Approaches to Problem Solving

A

The Typical Approach

The Six Sigma Approach



Approaches to Problem Solving. *Continued*

A

Data is collected on the Average Handling Time (AHT) for two teams within a call centre:

- Team 1 average AHT = 4.12 minutes
- Team 2 average AHT = 5.12 minutes

What conclusion(s) would you make from this data?

Approaches to Problem Solving, *Continued*

Uncertainty must be factored into every decision making process:

- Average values alone, when generated from sample data, do not take into account uncertainty
- Uncertainty for a given sample average is a function of:
  - The variation that exists in the data
  - The sample size
  - Measurement system variation

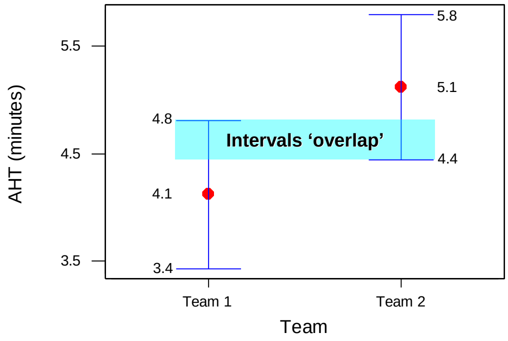
Approaches to Problem Solving, *Continued*

What is a confidence interval?

- **The estimated range**, which is likely to include an unknown population parameter, with a specified level of **confidence**.
  - A 95% level of confidence is used for most Green Belt projects
- Confidence intervals get:
  - Smaller as the sample size increases and/or the sample variation decreases
  - Larger as the sample size decreases and/or the sample variation increases

Approaches to Problem Solving, *Continued*

The 95% confidence intervals for both



Team 1 AHT = 3.4 to 4.8 minutes

Team 2 AHT = 4.4 to 5.8 minutes

The concept of hypothesis testing

What is hypothesis testing?

– Hypothesis testing is a process that enables you to statistically evaluate differences by:

- Converting a business problem into a statistical problem
- Performing the appropriate test to generate the statistical conclusion.

– This provides us with process focused and data driven business conclusions.

The concept of hypothesis testing, *Continued*

Hypothesis testing is used to confirm the significance of discrete x's:

- The Y can be continuous or discrete (but the x is discrete)
- Different statistical tests are used based on what you are testing

Discrete Hypothesis Tests:
- Test Probabilities (1 Proportion)
- Contingency (2 or more Proportions)

Continuous Hypothesis Tests:
- Unequal Variances
- Test Mean
- Two-Sample t
- Means/Anova/Pooled t
- Means/Anova
- Median Test

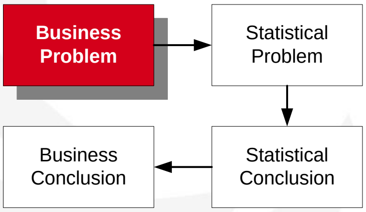
Potential Vital Few Input (x)
(from the Measure phase)

Project Y		Discrete	Continuous
	Discrete	**Discrete Hypothesis Testing**	Logistic Regression
	Continuous	**Continuous Hypothesis Testing**	Correlation and Regression

The prerequisites to conduct a hypothesis test

A well-defined business problem is required to conduct a hypothesis test:

The <u>components</u> of a business problem
- The **purpose** of the test
- The **Y** for the test
- The **x** for the test



The prerequisites to conduct a hypothesis test, *continued*

Assume that a Lean Six Sigma team is working to reduce the percentage of calls that were answered after 30 seconds:

- The C&E matrix identified "*call centre location*" as a potential vital input (x)
- How the team defined the business problem:
  - **The purpose of the test:** To determine if the call centre location is a vital input (x) for the Y
  - **The Y measurement:** The proportion of calls that are not answered within 30 seconds
  - **The x measurement:** The call centre location

The concept of null and alternative hypotheses

Statistical problems are divided into two opposing statements, theories or claims:

The…	States…
Null Hypothesis (H_0)	**Changes in the (x) produce no difference in the Y** • There is no change. • This is often the opposite of what you hope to prove through hypothesis testing
Alternative Hypothesis (H_A)	**Changes in the (x) make a difference on the Y** • There is a change. • An "alternative" to null • The alternative hypothesis is not unequivocally proven

How null and alternative hypotheses are recorded

A

Hypothesis statements are recorded in a mathematical format. They include:

A notation of the population parameter being tested:

Population Parameter	Notation
Mean	μ (mu)
Variance	σ^2 (sigma squared)
Median	η (eta)
Proportion	p

A mathematical symbol for the claim to be tested:

Claim of Hypothesis	Symbol Used
No difference	=
Difference with 1 or 2 groups	≠, <, or >
Difference with more than 2 groups	At least 1 group is different

How null and alternative hypotheses are recorded, *Continued*

A

The null and alternative hypothesis statements for the call centre example:

H_0: $P_{Glasgow} = P_{Edinburgh} = P_{Dundee} = P_{Aberdeen} = P_{Inverness}$

H_A: At least one location is different

Stating Null and Alternative Hypotheses

A

Assume your team is trying to reduce the time to complete orders. Two potential vital few inputs were identified:

1. **The customer entry method to the process.**
   - Internet
   - Call centre
   - Store
2. **Order approval type.**
   - Pre-approved order
   - Standard processing order

Time - 20 mins

Record the statistical problem for each x through statements of the null and alternative hypotheses.

Example Hypotheses

A

Hypotheses for Means (CT = cycletime)

- H_o: $\mu_{CT_A} = \mu_{CT_B}$
- H_o: μ_{CT_A} = Target
- H_a: $\mu_{CT_A} \neq \mu_{CT_B}$
- H_a: $\mu_{CT_A} > \mu_{CT_B}$
- H_a: $\mu_{CT_A} < \mu_{CT_B}$

Hypotheses for Variance

- H_o: $\sigma^2_{After} = \sigma^2_{Before}$
- H_o: σ^2_{After} = Target
- H_a: $\sigma^2_{After} \neq \sigma^2_{Before}$
- H_a: $\sigma^2_{After} > \sigma^2_{Before}$
- H_a: $\sigma^2_{After} < \sigma^2_{Before}$

Hypotheses for Medians

- H_o: $M_{Dayshift} = M_{Nightshift}$
- H_o: $M_{Dayshift}$ = Target
- H_a: $M_{Dayshift} \neq M_{Nightshift}$
- H_a: $M_{Dayshift} > M_{Nightshift}$
- H_a: $M_{Dayshift} < M_{nightshift}$

Hypotheses for Proportions (e.g. defect rates)

- H_o: $p_{Mon} = p_{Tues} = p_{Wed} = p_{Thurs} = p_{Fri}$
- H_a: At least one p_x is different.

State the decision criteria

A

The Two Risks of Hypothesis Testing

Alpha (α) and Beta (β) risk explained:

Conclusion

Truth	H_0	H_A
H_0	Correct Decision	α risk Type I Error
H_A	β risk Type II Error	Correct Decision

α Risk

A

The α risk or risk of making a Type I Error, is the probability that we could be wrong in saying that two or more things are **different**, when in fact, **they are the same**

It is an assessment of the likelihood that the observed difference could have occurred by random chance.

α is the primary decision-making benchmark of most statistical tests.

Conclusion

Truth	H_0	H_A
H_0	Correct Decision	α risk Type I Error
H_A	β risk Type II Error	Correct Decision

In the our legal system, the defendant is assumed to be innocent until proven guilty.

In the statistical system, two populations are assumed to be the same until proven different.

The "legal α risk" is the risk that an innocent person could have been convicted of a crime.

α Risk

A

- Examples of Type 1 errors (alpha risk):
  - Concluding Distribution Centre A had longer average cycle times than Distribution B, when in reality they have the same average cycle time
  - Concluding that a Black Belt project successfully reduced cycle time variance, when in reality it did not
  - Fire alarm going off when there is no fire – finding a difference when none exists
- Typically α = 0.05 or 5%

β Risk

A

The β risk or risk of making a Type II Error, is the probability that we could be wrong in saying that two or more things are the **same** when, in fact, **they are different**

β risks are not typically computed directly by statistical tests

		Conclusion	
		H_0	H_A
Truth	H_0	Correct Decision	α risk Type I Error
	H_A	β risk Type II Error	Correct Decision

The "legal β risk" is the risk that a guilty person could have been acquitted of a crime and set free.

β Risk - *continued*

- Examples of Type II errors:
  - Concluding no difference exists between dayshift and nightshift median call response time, when in reality a significant difference does exist
  - Concluding error rates are same every day of the week, when in reality error rates on Mondays are less than the other four days of the week
  - Fire alarm doesn't go off when it should
- Typically β = 0.10 or 10%
- Power = 1 - β

Stating the decision criteria

As a table team, discuss the impact of α and β errors on the successful completion of your project. Answer the questions below:

What problems, costs or frustrations would your team experience if it made:

- **an α error when confirming the vital few inputs?**
- **a β error when confirming the vital few inputs?**

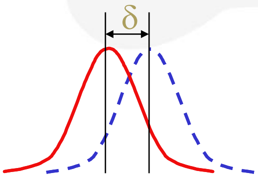
Time - 20 mins

Brainstorm the potential impact of the two risks and record them on flip chart paper.

Each group are to present their results to the class.

Establish δ

- Delta (δ) also known as Precision, is the practical significant difference that you want to detect in your hypothesis test.
- Examples:
  - Detecting average cycle time differences of 10 minutes has been determined to be of practical significance
  - Detecting an error rate difference of 5% has been determined to be of practical significance



Data collection plan guidelines for hypothesis testing

The data collection plan for your hypothesis test should define:

- What data will be collected and when it will be collected
- How much data should be collected
- Where the data should be collected
- Who will collect the data

Data collection plan guidelines for hypothesis testing

Unlike sampling for estimation (covered in the Measure module), sampling for hypothesis testing includes consideration of β risk

Sample size will depend on:

- Hypothesis test selected
- How H_a is defined
- Choice of α risk *(Typically 5%)*
- Choice of β risk (statistical software will often ask for power)
  - Power = 1- β *(β is typically 10%)*
- Choice of δ (known as "difference" in Minitab)
- Other parameters (such as the sample standard deviation for a t-test)

The role of the p-value in reaching a statistical conclusion

The p-value and the stated decision criteria form the basis for the statistical conclusion

- The p-value represents the probability that the null hypothesis is true (that is, there is no change in the Y as we observe change in the x)
- Since the p-value is a probability, values will be between 0 and 1
- p-values and statistical conclusions:

If the p-value is …	Then the statistical conclusion is to …
Less than α **(Typically α = 0.05)**	**Reject the null hypothesis and accept the alternative.** You are concluding a statistically significant difference. Hence, the x being tested is a vital input.
Greater than α	**Fail to reject the null hypothesis.** You are concluding that there is no statistically significant difference. Hence, the x being tested is not a vital input.

If the p-value is low, the null must go. If the p-value is high, the null must apply.

Hypothesis testing roadmap

Let's explore the 'Hypothesis Testing Roadmap' in the 'Student Data Files' package

Conducting statistical tests

- Review underlying assumptions of a given hypothesis test; verify all are satisfied
  - For example, before performing a test for equal variance, first carry out normality tests on all samples
- Calculate test statistic and critical value with Minitab
- If Minitab is not used:
  - Calculate the appropriate test statistic. (e.g., t-value, F-value or Chi-Square value)
  - Determine the critical value for the test statistic. (e.g., based on sample size and α risk look up $t_{critical}$ in a t-table)

When statistical software is used to apply the hypothesis test

The sample data for the call centre example:

- **The x** – Call centre location
- **Y** – Proportion of calls not answered in 30 seconds
- **The test selected** – Chi-Square
- **The sample data**:

↓	C1-T	C2	C3
		<30 secs	>30 secs
1	Glasgow	926	634
2	Edinburgh	744	946
3	Dundee	1771	2129
4	Aberdeen	951	1649
5	Inverness	1514	1736

Using statistical software to apply the hypothesis test

The p-value indicates a difference. But which call centre or centres are different?

Chi-Square Test: <30 secs, >30 secs

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

	<30 secs	>30 secs	Total
1	926	634	1560
	708.72	851.28	
	66.614	55.458	
2	744	946	1690
	767.78	922.22	
	0.737	0.613	
3	1771	2129	3900
	1771.80	2128.20	
	0.000	0.000	
4	951	1649	2600
	1181.20	1418.80	
	44.863	37.350	
5	1514	1736	3250
	1476.50	1773.50	
	0.952	0.793	
Total	5906	7094	13000

Chi-Sq = 207.381, DF = 4, P-Value = 0.000

Develop statistical conclusions, *continued*

If statistical software is not used, compare the test statistic to the appropriate value in a statistical table as follows:

- If test statistic > critical value, reject the null hypothesis
- If test statistic < critical value, fail to reject the null hypothesis

Develop statistical conclusions, *continued*

Examples:

- The p-value for the 2-sample t-test of average cycle time at distribution centres A and B was 0.01. Since $p < 0.05$, we reject the null hypothesis and conclude that average cycle times are different at the different distribution centres

- The p-value for the F-test of cycle time variance before and after a Black Belt project was completed was 0.78. Since $p > 0.05$, we fail to reject the null hypothesis and are unable to conclude that the Black Belt project had a significant impact

The concept of an actionable x

A

Your confirmed vital few inputs (x's) must be recorded at an actionable level of detail:

- Knowing that Glasgow appears to be better and Aberdeen appears to be worse than others is valuable but inadequate information to define a solution to the problem.
- Call centre location is not an **actionable input**.
  - Actionable x's are at a level of detail to define an appropriate control or solution for the x
- For the x to be actionable, you need to know:
  - What does Glasgow do (or not do) to influence their performance?
  - What does Aberdeen do (or not do) to influence their performance?

Summary of key learning points

A

- Every hypothesis test involves a comparison and conclusion to be drawn
- Null and alternative statements are used to create the hypothesis
- There are risks associated with statistical tests which need to be understood
- The selection of hypothesis test to be used requires a full understanding of the question to be answered and nature of data available
- An alpha risk of 0.05 and beta risk of 0.10 are normally used in hypothesis tests
- Statistical software is normally used to calculate the hypothesis test statistics

Recommended coach support points

A

- When reviewing your planned testing strategy
- Determining confidence level and appropriate sample size for the test
- Running the test using statistical software
- Confirming the statistical and business conclusion from your analysis

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IMPROVE

Lean Six Sigma

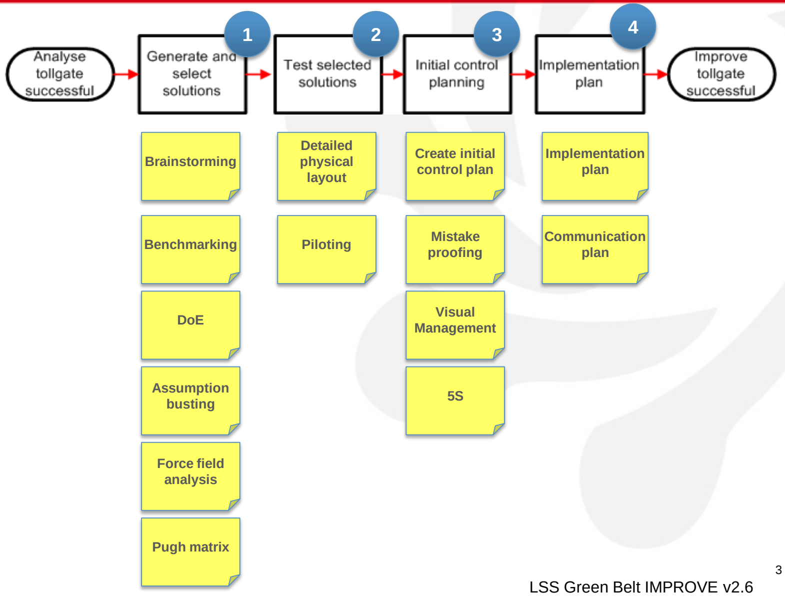
Green Belt

Objectives of this module

At the end of the module, you will be able to:

- Use techniques to generate solutions to business problems
- Test solutions
- Prepare an initial control plan
- Prepare the implementation and communication plans

4 step approach



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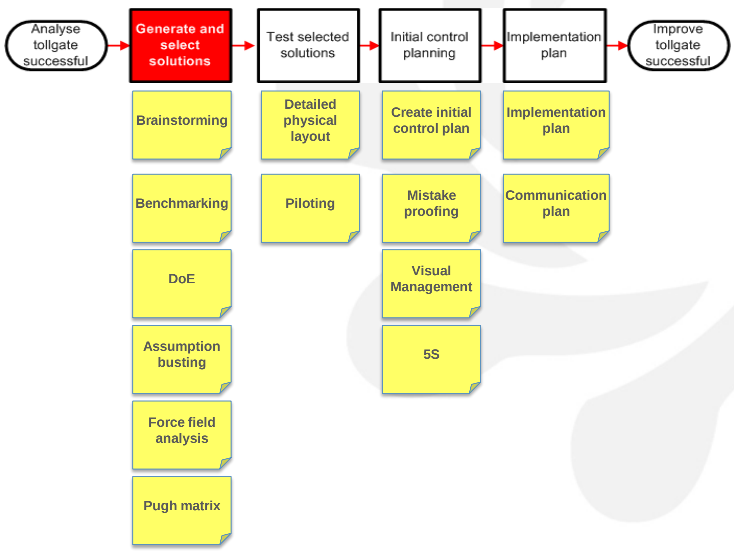
IMPROVE

Generate and select solutions

Generate and test solutions



Preview of the lesson

After completing this lesson, you will be able to:

- Explain how Brainstorming, Benchmarking, Famous Faces, Assumption Busting and Force Field analysis are used to generate solutions
- Select and apply the appropriate method to generate one or more potential solutions for your project
- Describe the three primary factors to evaluate the feasibility of a potential solution: Technical Impact, Cost and Organisational Acceptance
- Construct a Pugh Matrix to select the best solution to test

Solution generation begins with the right people

You've confirmed your root causes in the Analyse phase and are ready to identify potential solutions.

What people would you include in your solution-generation activities and why?

Be sure to:

1. Identify and include the appropriate SMEs for the high-level process
2. Avoid **psychological inertia** among the participants when generating solutions

Overview of Brainstorming

Brainstorming is a collaborative approach for generating a large number of potential solutions:

- **Benefits**
  - Allows open and creative thinking
  - Encourages team member participation
  - Generates solutions quickly
- **Requirements**
  - A skilled facilitator
  - Works best in groups of 8 to 12 people who have diverse perspectives

Brainstorming

Ask Question → Capture initial ideas → Loosely Affinitise → Clarify ideas → In scope/ out of scope

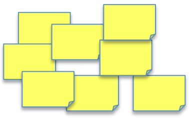
Ask Question

For Brainstorming to be effective – a frame of reference is needed. This can often be a simple question;

Eg. How can we grow existing revenues? How can we reduce staff costs?

Capture initial ideas

Let people have time to generate some ideas on their own. When it looks like things have slowed down, gather the ideas on a flip chart



Loosely Affinitise

Read out the ideas and start to make some form of grouping. You could let the team do this. Let any additional ideas be forthcoming

Clarify ideas

When it looks like there are no more ideas, read through the ideas and clarify – practice “appreciative enquiry” – do not give your own opinion – ask how it relates to the initial question

In scope/ out of scope

Finally the ideas need to be sorted into those that are to be taken forward or those that may be eliminated

Overview of Benchmarking

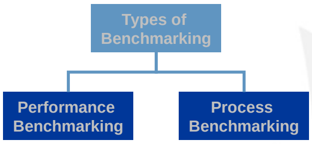
Benchmarking is a process for:

- **Identifying best-in-class practices/ standards**
  - Within or outside your organisation
- **Comparing your internal practices**
- **Improving the performance of a similar activity**

Overview of Benchmarking, *Continued*

The two types of benchmarking:

- **Performance Benchmarking**
  - A search to determine what are the "best performance results"
- **Process Benchmarking:**
  - A search to determine how "best practice" organisations provide their products and services



How Benchmarking works

Benchmarking occurs in three phases:

Preparing for the Study	Conducting the Study	Learning from the Study Findings
• Defining scope of the study • Planning your approach • Locating and securing partners	• Developing the interview guide • Collecting information using the interview guide	• Interpreting the information acquired • Applying what was learned into a solution

Famous faces

- Start with a clearly defined issue or problem to generate ideas against
- Provide any supporting facts and figures as necessary
- Write the problems statement on a flipchart
- Place some face cards facedown then ask the team to select one
- Ask how would "………" think about this problem?
- When ideas dry up move onto the next card
- Generate as many possible solutions as possible
- Have fun!

Assumption Busting

1. List assumptions - Look at the situation you are in.
   - Think about what assumptions you are making?
   - What seems obvious, so much so that you would not think about challenging it?
   - Think about cost & time, and identify where it is assumed impossible to do something because of these constraints
   - Think about where something works as a result of certain rules or conditions
   - Think about the things that people perceive, believe, think or need
   - Think about whether it is a need or a want

Assumption Busting, *Continued*

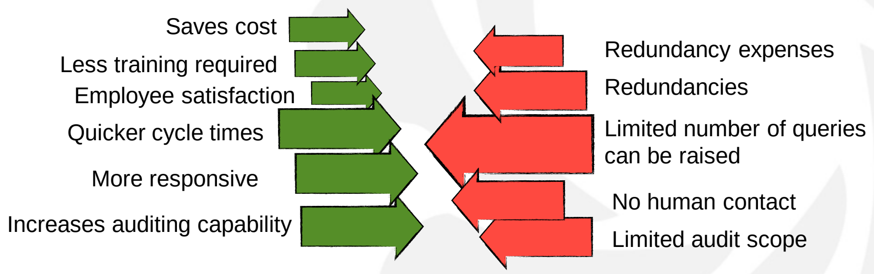
2. Challenge assumptions – take an approach where all assumptions can probably be challenged and overcome at some time.
   - Ask how could this be flipped so that it is no longer true or a constraint?
   - Ask what would it be like if we could do it significantly better – or if it took half the time?

3. Find ways of making the challenge the new reality
   - Take each assumption where it was identified that something could be done, and find ways to make it happen.

Force Field Analysis

List out the Forces for Change

List out the Forces against Change



1. First list out the Forces for Change on post its on the left hand side of a flip chart / white board / wall
2. List out all the Forces against Change
3. Align the For vs Against
4. Look for any gaps, especially where there is no “for” where an “against” exists and identify where what could be done to counter that force.
5. When communicating the results it can be useful to show the impact / strength of a force (for or against) by varying the size of the arrow. Relative positioning (horizontal) can also be used to show the probability of the force being realised.

What separates the best from the rest?

You've confirmed your x's in the Analyse phase and identified multiple solution alternatives so far in the Improve phase.

- What factors would you use to separate the "best" solutions from the others?

Factors to consider when evaluating solutions

The technical impact of a solution:

- **Defines the extent to which a solution produces a positive change in the project's metric(s):**

And therefore achieves the chartered goal for the metric(s)

Factors to consider when evaluating solutions

The cost of a solution:

- The true cost of a solution will include its:
  - Design costs
  - Development costs
  - Implementation costs
  - Operating/sustaining costs
  - Sun-setting costs

Factors to consider when evaluating solutions

The level of organisational acceptance for a solution:

- Describes the extent to which the project's key stakeholders will adopt or support the solution:
  - Focuses on the stakeholders who are identified in the Project Risk Assessment
  - Considers how the solution relates to other projects/initiatives

Overview of the Pugh Matrix

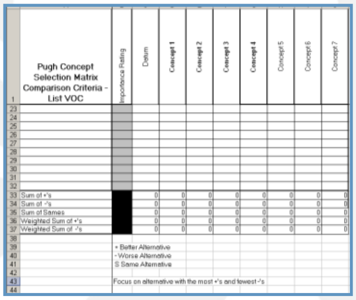
The Pugh matrix is a tool to identify which potential solutions are more important or “better” than others.

How it works:

- Compares all identified solutions to the weighted criteria to identify the best solution

Benefits:

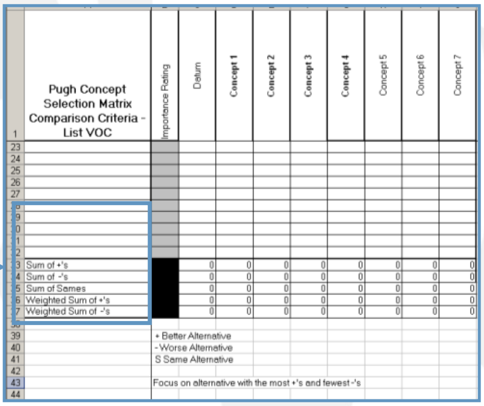
- Facilitates the comparison of multiple solutions
- Helps you arrive at an optimum solution that could be a hybrid of the other solutions



How to construct the Pugh Matrix

Step 1: Confirm the evaluation criteria to use for the solutions.

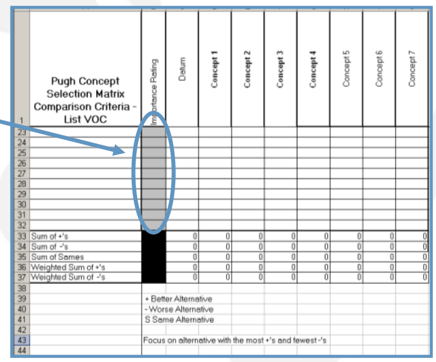
- At a minimum, use Technical Impact, Cost and Organisational Acceptance.
- Add other criteria, if necessary.
- Record the evaluation criteria in the first column of each row.



How to construct the Pugh Matrix

- Step 2: Assign an “Importance Rating” to each criterion.

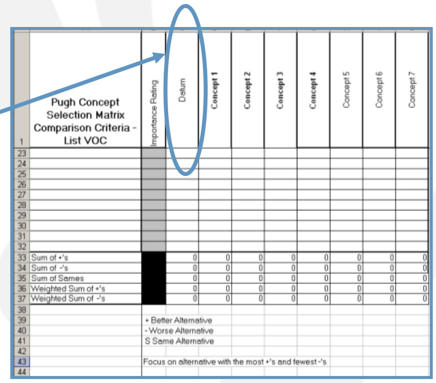
  - Rate the importance of each criterion using a scale from 1 to 5, with 5 having the greatest importance



How to construct the Pugh Matrix

- Step 3: Select the initial “best solution” as the datum.

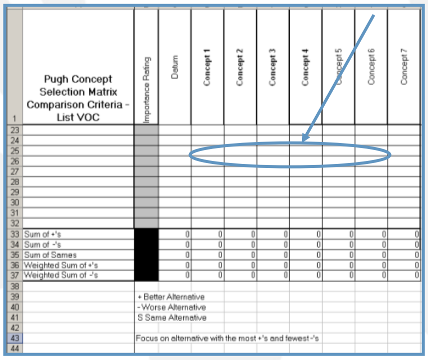
  - Record a description in the “datum” column



How to construct the Pugh Matrix

Step 4: Use the evaluation criteria to compare each solution against the datum. Assign the appropriate comparison rating.

- Record the alternative solutions in the first row of the remaining columns
- Compare each solution against the datum using the evaluation criteria.
- Rate the solution as:
  - Better than (+) the datum
  - The same (S) as the datum
  - Worse than (-) the datum
- Rate the datum with an (S) for each criterion.

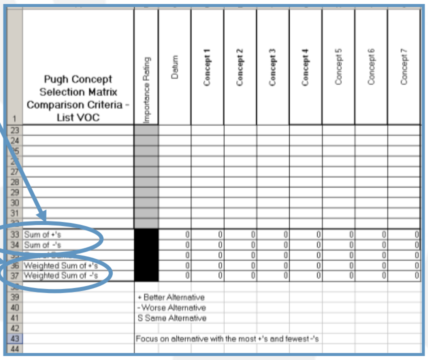


How to construct the Pugh Matrix

Step 5: Score each solution.

The Pugh Matrix template will automatically score the solutions based on your input

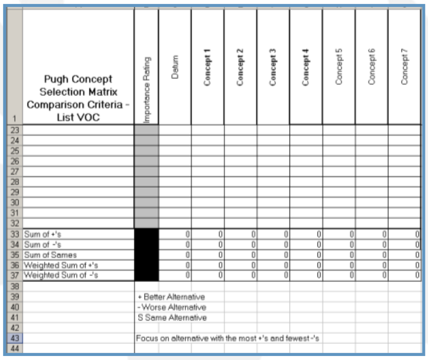
- Calculate the "Sum of" ratings
  - Record the number of (+) ratings for in the "Sum of +'s" row
  - Record the number of (-) ratings in the "Sum of –'s" row
  - Record the number of (S) ratings in the "Sum of Sames" Row
- Calculate the "Weighted Sum of" ratings
  - Add the "importance ratings" for all (+) ratings assigned to the solution.
  - Add the "importance ratings" for all (-) ratings assigned to the solution.



How to construct the Pugh Matrix

Step 6: Select the best solution.

- The “best” solution from the Pugh matrix is the one with:
  - The most pluses and the least minuses
  - The highest weighted sum of pluses and the lowest weighted sum of minuses

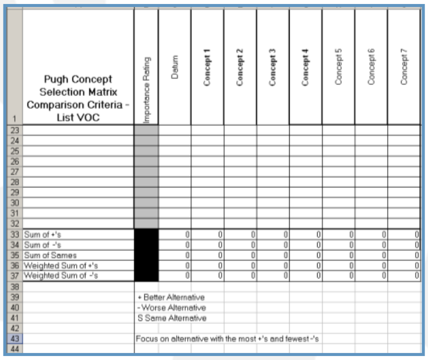


	Pugh Concept Selection Matrix Comparison Criteria - List VOC	Importance Rating	Datum	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6	Concept 7
1										
23										
24										
25										
26										
27										
28										
29										
30										
31										
32										
33	Sum of +'s		0	0	0	0	0	0	0	0
34	Sum of -'s		0	0	0	0	0	0	0	0
35	Sum of Sames		0	0	0	0	0	0	0	0
36	Weighted Sum of +'s		0	0	0	0	0	0	0	0
37	Weighted Sum of -'s		0	0	0	0	0	0	0	0
38										
39		+ Better Alternative								
40		- Worse Alternative								
41		S Same Alternative								
42										
43		Focus on alternative with the most +'s and fewest -'s								
44										

How to construct the Pugh Matrix

Step 7: Improve the best solution by incorporating the superior features or characteristics of the remaining solutions.

- Your "best" solution may have (-) ratings for some criterion.
  - (-) ratings indicate the potential to make the "best" solution even better.
- Examine other solutions in the matrix with (+) ratings for these criterion
- Review the features of these solutions that led to its (+) rating
- Synthesising these features with your best solution.



	Pugh Concept Selection Matrix Comparison Criteria - List VOC	Importance Rating	Datum	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6	Concept 7
1										
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34	Sum of -'s		0	0	0	0	0	0	0	0
35	Sum of Sames		0	0	0	0	0	0	0	0
36	Weighted Sum of +'s		0	0	0	0	0	0	0	0
37	Weighted Sum of -'s		0	0	0	0	0	0	0	0
38										
39		+ Better Alternative								
40		- Worse Alternative								
41		S Same Alternative								
42										
43		Focus on alternative with the most +'s and fewest -'s								
44										

An example of the Pugh Matrix

- Evaluating potential solutions for a family holiday

Pugh Concept Selection Matrix Comparison Criteria	Importance Rating	Drive to Edinburgh	Stay at home	Visit family in Glasgow	Drive to France	Disneyland	Visit friends in Australia
Fun for entire family	5	S	-	S	S	+	+
Educational for kids	4	S	-	-	S	-	-
Travel time	2	S	+	+	-	-	-
Cost	4	S	+	+	S	-	-
Family acceptance	5	S	-	-	S	+	+
Required planning	3	S	+	+	-	-	-
Sum of +'s		0	3	3	0	2	2
Sum of -'s		0	3	2	2	4	4
Sum of Sames		6	0	1	4	0	0
Weighted Sum of +'s		0	9	9	0	10	10
Weighted Sum of -'s		0	14	9	5	13	13

Constructing a Pugh Matrix

Pugh Matrix

Objective: To practise use of the Pugh matrix in selecting solutions

As a table team, use the Pugh Matrix to identify the best solution to deliver Lean Six Sigma training to Green Belt candidates

- Use the potential solutions and evaluation criteria below as a starting point
- Feel free to add other criteria as needed
- Be prepared to discuss your results

Time - 20 minutes

You have identified the following potential solutions:
- Web-based training
- Printed, self-instructional materials
- Instructor-led training using Web meeting
- Videotaped sessions

Your team also has identified the following criteria to evaluate the solutions:
- The cost of the training
- The time to complete the training
- Each participant's ability to apply the training content to his or her project
- Each participant's ability to apply successfully the content to his or her daily work activities
- Each participant's ability to ask questions

Summary of key learning points

- There are multiple different ways to generate solutions, the key is to generate as many as possible and throw the bad ones away
- A Pugh matrix can be used to choose between alternative options

Recommended coach support points

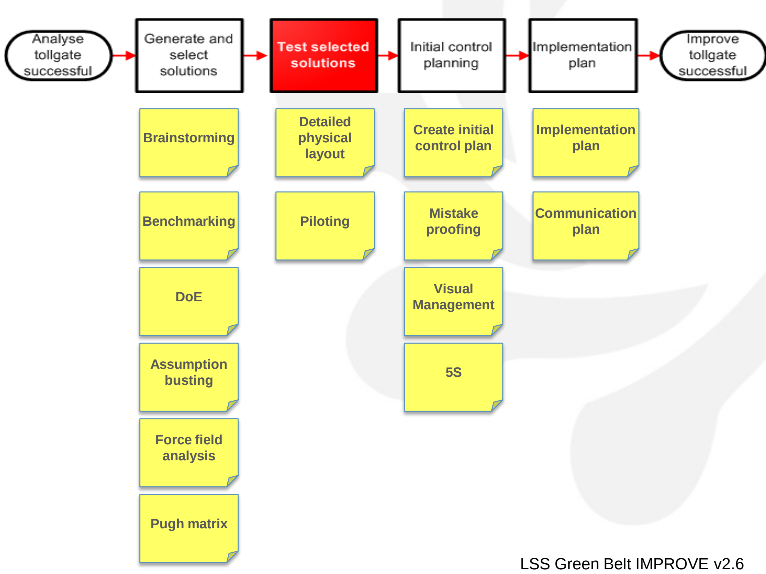
Be sure to engage your coach when

- Planning any type idea generation session
- Analysing the results of a Pugh Matrix

IMPROVE

Test selected solutions

Test selected solutions



Preview of the lesson

At the end of this lesson you will be able to:

- Find sources of help to prepare a detailed physical layout of a process
- Construct a detailed layout for any process steps where the product flows physically
- Evaluate your detailed physical layout
- Identify the stakeholders to review your detailed physical layout
- Conduct a stakeholder review of your detailed physical layout
- Pilot and validate the new solutions as part of the physical layout

Importance of the lesson

- A well-designed, detailed physical layout of the process is necessary for two reasons:
  - The layout impacts the flow of the product and the amount of waste in a process.
  - The detailed layout provides the information to transition to the new layout for the pilot test.

When the step is performed

A detailed physical layout is necessary when:

Your future-state process design:		**Your conceptual layout from the Analyse phase:**
Requires a change in the physical arrangement of staff, equipment or materials at one or more process steps.	and	Lacks the information or detail to guide the appropriate staff in deploying the change.

- The layout can be limited to the process steps where changes are required.

The key inputs to begin the step

- Any site drawings or blueprints for the facility or work area
- Any governmental regulations/requirements that must be considered in developing the layout

The software to use when preparing the layout

Several software applications are available to speed the process of a generating a detailed layout.

- Microsoft Visio
- Computer-Aided Design (CAD) software such as AutoCAD
- Microsoft PowerPoint or Excel

The indicators of a good physical layout

- A well-designed, physical layout will:
  - Promote a continuous product flow
  - Promote the visual management systems
  - Minimise waste
  - Protect the health and safety of staff
  - Maintain the security of information used
  - Optimise the use of the workspace
  - Be flexible to address changing demand levels and product/process changes
  - Accommodate the processing of rework without impacting the flow of the product
  - Incorporate the principles of 5S

The indicators of a good physical layout, *continued*

The 5S Audit Worksheet lists a series of assessment criteria of each of the 5S categories.

The indicators of a good physical layout, *continued*

The 5S Audit Worksheet lists a series of assessment criteria of each of the 5S categories.

- The worksheet is used primarily in an audit context for an existing physical workspace.
- The criteria can be used to evaluate and improve your layout.
- Review each criteria. Ask:
  - Does the layout align to this criteria?
  - How can the layout align to the criteria?

The indicators of a good physical layout

The 5S Audit Worksheet for a Physical Environment

FIREBRAND 5S Audit Worksheet - Physical Environment

Project Name			Project Type	
Completed By:			Scores:	
Location:			Sorting	0
Date:			Storing	0
	Scoring:	0 = Not started; zero effort 1 = Activity started; slight effort 2 = Widespread activity, however many opportunities for improvement exist 3 = Initial improvement sustained for 3 months; continuing to improve 4 = Initial improvement sustained for 6 months; culture of continuous improveme	Shining	0
			Standardizing	0
			Sustaining	0
			Grand Total (Highest score 20)	0

Category		Description	Score	Comments
Sorting		**Should it stay or should it go?**	4,3,2,1,0	
	Office supplies	Only the required levels of office supplies are kept in the area. There are no excess forms, paper, pens. Visual system for replenishment.		
	Office furniture	Only the necessary items to perform the work are located in the area. There are no unneeded tables, chairs, cabinets in the area.		
	Documents, files, folders	Only the documents used on a regular basis are stored in the area. Old and dated material is removed on a regular basis.		
	Bulletin boards	No outdated, torn or soiled announcements are displayed. All bulletins are arranged neatly.		
	Overall first impression	A procedure exists for the removal/disposal of unneeded items.		
Storing		**A place for everything and everything in it place**	4,3,2,1,0	
	Work stations	Desks, tables and files are arranged in a logical & neat fashion to promote a smooth flow of information through the work area.		
	Aisles and hallways	Hallways and walk areas are free from materials and obstructions. Nothing leans against walls, and exits are clearly marked.		
	Documentation and visual signals	Only current labeled documents and binders necessary to do the work are found at designated locations. Documents and binders are stored in a neat and orderly manner.		
	Tables, shelves and cabinets	Tables, shelves and cabinets are free of surface clutter. No papers or objects are sitting on top of cabinets waiting to be filed.		
	Closets and storage	Closets and storage areas are clean and well lit with clearly designated storage locations for all items. It is easy to find what is needed and return it.		

The indicators of a good physical layout, *continued*

Shining		**Always Clean, Always Cleaning**	4,3,2,1,0	
	Condition of workspace	All floors are clean. White boards in common locations are clean and ready for the next users. Routines are in place to care for maintenance items uncovered by cleaning.		
	Equipment and furniture	Desks, computer screens, and office equipment is clean and free from dust or soil. All office equipment is in excellent working order.		
	Walls and cubicles	All walls, cubical dividers and common areas are kept clean on a regular basis. Unsuitable conditions are promptly addressed.		
	Electrical equipment	All electrical connections and wires are restrained out of sight so as not to interfere with cleaning or pose a tripping hazard. There are no potential overloads or safety hazards.		
	Supplies	All cleaning equipment–including trash and recycling cans–are stored in a neat manner. It is obvious where things belong, and cleaning supplies are available when needed.		
Standardising		**Are We Doing it across the board?**	4,3,2,1,0	
	Methods	Methods for Sorted, Stored, and Shone are reviewed on a regular basis, and as new methods are developed, they are quickly documented. Associates are trained on new methods.		
	Work standardization	Associates understand current work methods and execute consistently		
	Visual display	The 5S performance and standards are prominently displayed (i.e. radar chart).		
	Visual control	Visual techniques are deployed as applicable to highlight out of control conditions		
	Audits	5S audits are performed in each work area at predetermined intervals, results are shared with all associates. Action items are developed.		
Sustaining		**Stick to it, It's worth it**	4,3,2,1,0	
	Maintenance	Associates are designated within each area to keep common use items in good working order and contact information is prominently posted and updated.		
	Document control	All documents are labeled clearly as to contents. Responsibility for control and revision is clear. Nothing is unlabeled or unclear as to its origin/source.		
	Responsibility	Each area falls under the responsibility of a manager with 5S auditing and assignment authority.		
	Visibility	Responsible manager visits each work area on a regular basis and provides feedback on 5S efforts and results.		
	5S improvements	Disciplined controls to assure each of above items is maintained. There is a sense of responsibility by all associates to maintain and continuously improve 5S processes, based on audits and other input.		

Secure stakeholder feedback on the proposed layout.

- Changes to the physical work environment are often resisted by staff because:
  - They represents a change to the status quo.
  - They directly impact their personal needs.

- Resistance increases when employees have no opportunity to provide feedback on the change prior to its implementation.
  - Good ideas can be rejected, not because they lack value, but as a means of retaliation.

Validating selected solutions

Pilot Testing

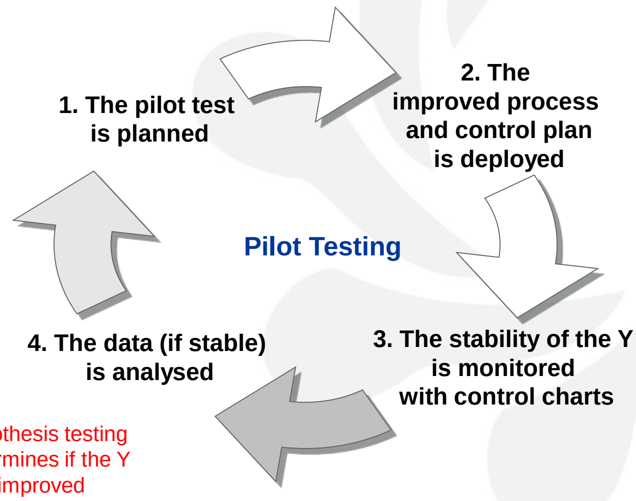
What is a pilot test?

- A limited-scale, live, controlled deployment of your selected solution to validate the impact on the project's metric(s)

Key points to remember:

- You are piloting the **improved process** and **initial control plan**
- The objective is to:
  - Acquire statistical proof of an improvement to the Y with the new process
  - Verify the effectiveness of the initial control plan

How pilot tests are conducted

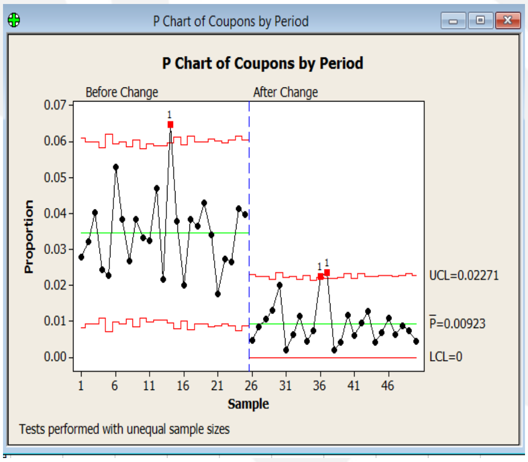


- Hypothesis testing determines if the Y was improved
- Sigma Levels define the capability of the Y

How control charts are used

Control charts are used to assess the stability of the Y during the pilot:

- Data on the Y is collected
- The data is plotted on the control chart (you can add to the initial control charts for your project metrics created in the Measure phase)
- The control chart helps determine whether the improved process (during the pilot run) performs in a stable manner



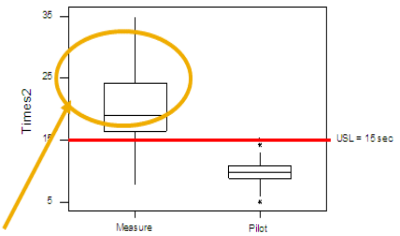
How hypothesis testing is used

Hypothesis tests can determine whether improvement has occurred with the Y:	
Has the goal for the project metric been achieved? H_0: $Y_{Improved}$ = Goal H_A: $Y_{Improved}$ < Goal	**Is the Y for the improved process different from its baseline measure?** H_0: $Y_{Improved} = Y_{Old}$ H_A: $Y_{Improved} < Y_{Old}$

Why a sigma level is calculated for the Y

The sigma level defines the **capability** of the new process to meet the requirement for the Y over time:

- The Sigma Level for the Y will estimate the number/percentage of defectives for the Y.
- Use the customer specification to calculate the Sigma Level.



Beyond Specification Limits

The duration of pilot test

The duration of the test is driven by the data requirements to:

- Assess the stability of the Y
- Conduct the appropriate hypothesis test
- Calculate the Sigma Level

Pilot tests require careful planning

Careful planning of your pilot test is critical when:

- Your solution may present significant risk to the business
- The scope of the project may be large
- The cost of the solution (acquisition and deployment) may be high
- The solution might have long term effects and consequences

The elements of the pilot test plan

Elements of a good pilot plan:

- The validation methods to be used
- How the test will be conducted
- The project risk management approach (including stakeholders)
- The measurement systems used
- The data collection plan
- The evaluation criteria and strategies for the pilot

Tips for planning the pilot test

Improve the value of your pilot test by:

- Applying the principle of “stress testing”
- Collecting data on other factors (process or external) that are likely to influence the results
- Observing as much of the pilot test as possible

Other benefits of pilot testing

In addition to validating the effectiveness of your solution, the pilot test:

- Evaluates the effectiveness of your initial control plan
- Reveals tips and traps for the full deployment
- Simplifies the effort to estimate the cost savings for the solution
- Minimises long-term resistance to the solution among stakeholders

The importance of checking your measurement systems

Consider the quality of the measurement systems before conducting the pilot.

- Review the key measurement systems (defined in the control plan) that will be used during the pilot test.
- Determine if there are likely precision and accuracy issues for:
  - *The measurement of the project metrics*
  - *The measurement of the vital few inputs (x's)*

Do not start the pilot until you have a high level of confidence in your measurement systems.

The importance of educating impacted staff

Staff involved/impacted in the pilot test need to understand:

- The purpose and duration of the pilot test
- The requirements to operate the process using the control plan
- Any additional data collection requirements for the pilot (not specified in the control plan)

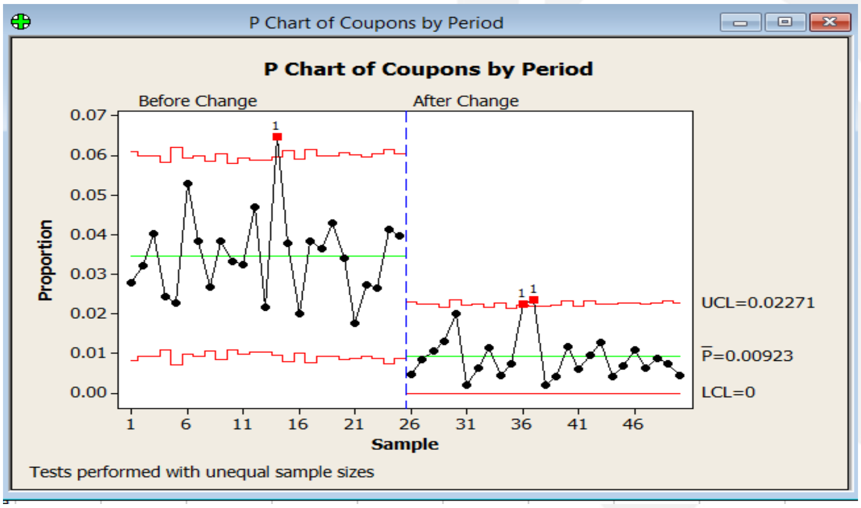
Team roles during the pilot

Clarify and communicate what the team should look out for during the test:

What is observed (and learned) by team members can be applied when:

- Conducting any follow-on pilot tests if the improved process shows minimal or no improvement to the Y
- Developing the full-scale implementation plan for the solutions (if the goal for the Y is achieved).
- Developing the final control plan for any affected process steps

Evaluate the results of the pilot tests - graphically



Evaluate the results of the pilot tests - numerically

Calculating Sigma Level for Discrete Data	
Enter Number of Items Evaluated	16,000
Enter Number of Defective Items	8,902
This is your Sigma Level	**1.36**
This is your Yield	44.36%
This is your DPM	**556,375**

Calculating Sigma Level for Discrete Data	
Enter Number of Items Evaluated	1,500
Enter Number of Defective Items	460
This is your Sigma Level	**2.01**
This is your Yield	69.33%
This is your DPM	**306,667**

Determine the appropriate follow-up actions

Outcome	Action
The pilot results are acceptable	• Develop a plan for the full-scale implementation of the process • Finalise control plan
Improvement occurs with the project metric (but not to the goal level**)**	• Determine if the test was conducted properly. • Verify the vital few inputs (x's) • Review solution to determine if changes are necessary • Modify solution and the control plan as necessary • Repeat the pilot test
No change or improvement occurs with the project metric	• Determine if the test was conducted properly • Verify the vital few inputs (x's) • Repeat the solution generation and selection activity • Update the control plan for the new solutions • Repeat the pilot testing process

Summary of key learning points

- Pilot the new process to refine the design
- Testing of selected solutions should include:
  - Layout of the workspace where the new process will be and
  - Testing of the new process itself
- Assess the pilot results for improvement in process performance and stability

Recommended coach support points

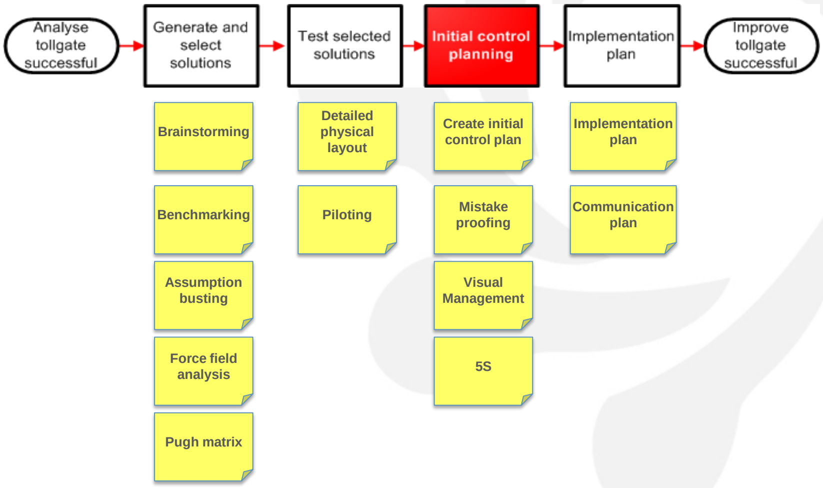
- Reviewing your detailed floor layout
- Determining how to engage stakeholders in a review of the proposed layout
- Reviewing your pilot test plan
- When developing the strategy to rollout the pilot test.
- When evaluating the pilot test results

FIREBRAND

IMPROVE

Initial control planning

Initial control planning



Preview of the lesson

At the end of this lesson, you will be able to:

- Describe the purpose, benefits, focus and structure of a control plan
- Explain where and how control plans are applied in the DMAIC methodology
- Construct an initial control plan for the vital few inputs (x's) with their solution in the improved process
- Select and apply the appropriate:
  - Method to determine the out-of-control conditions for your vital few inputs (x's)
  - Control method for the vital few inputs (x's)
- Construct a reaction plan to use when out-of-control conditions are detected

The purpose of a control plan

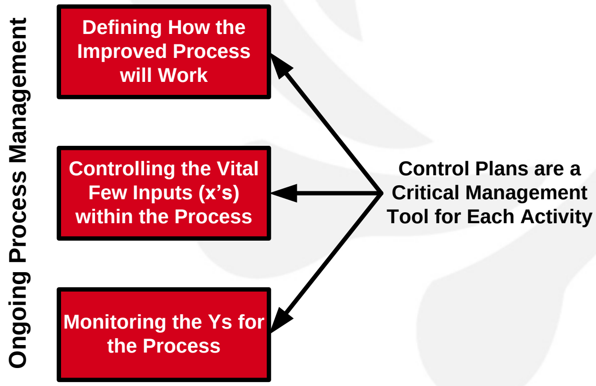
Control plans are based on the fundamental concept of Y=f(x):

If…	Then…
You can control the vital few inputs (x's) that affect your metric (Y)	You will have an improvement that lasts

The purpose of a control plan

Control plans are a key management tool to sustain your project improvements:

- Managing the process to assure its long-term performance involves:



The purpose of a control plan

What is a control plan?

- The blueprint for managing the improved process.
- It is a one-stop reference view of:
  - The vital contributors to the success of a process
  - The required data-driven actions to manage the process
- It includes documentation to effectively manage the process such as:
  - Detailed process maps
  - FMEAs for process steps
  - Standard Operating Procedures (SOPs)

Benefits of a control plan

A well-designed control plan offers significant benefits:

- Institutionalises the improvements
- Defines what needs to happen for the process to operate consistently on target with minimum variation
- Minimises process tampering (over-adjusting the process)
- Defines the key training needs for the daily operation and management of the process

Control plans must be reviewed and updated regularly

The focus of a control plan

Control plans are built for processes, not projects

- Control plans are not isolated, project-specific documents completed to pass a tollgate.
- Control plans are process management tools.
- The findings from your DMAIC project are incorporated into an existing control plan for the relevant business process.

If the process …	Then you …
Has an existing control plan	Update the existing control plan with the findings for your project.
Does not have an existing control plan	Populate a new control plan for the process with your project information.

The structure of a control plan

Control plan elements:

1. Detailed process maps
2. FMEA's for the process steps
3. SOPs
4. Customer Critical-to-Quality (CTQ) Requirements and Measures
5. Critical information technologies used
6. Reaction plans for the x's and Y's
7. Training requirements for the process
8. Review/maintenance schedule for the control plan
9. Capability studies for the process metrics
10. Measurement Systems Analysis (MSA) results for the vital few inputs (x's) and key metrics (Y's)
11. A control plan summary sheet

How control plans are used in DMAIC

Control plans are developed/updated at two points in the DMAIC process:

- **An initial control plan is developed in the Improve phase**.
  - Focuses on the vital few inputs (x's) to which the solution is applied.
  - Ensures that your solution is implemented properly for the pilot test
- **The final control plan is implemented in the Control phase**.
  - Updates the initial control plan based on the pilot test results
  - Incorporates all findings and lessons learned from the project to the process

Identifying out of control conditions

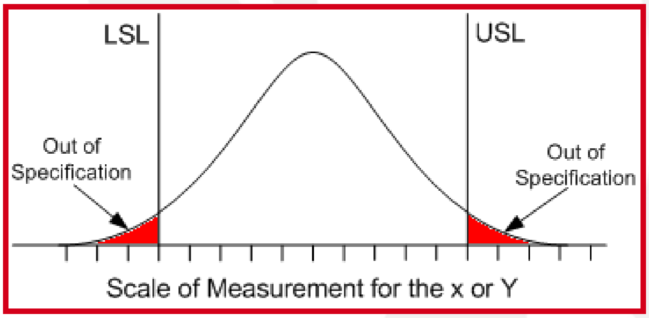
Before identifying these conditions, we need to have an updated process map to develop the initial control plan:

- Applying your solution for the vital few inputs (x's) will require changes to the process
  - New steps might be added
  - Existing steps might be removed
  - Requirements or standards might have changed for existing steps
- You should update the detailed process map from the Measure phase to reflect the process as it "should operate" with the solution

Methods to identify out-of-control conditions: *Specification Limits*

- The solutions for some x's might have been limited to establishing acceptable levels or settings for the x.
- For example:
  - The number of call centre staff available (20 to 25)

Values outside specification limits define an out-of-control condition:



An out-of-control condition for these x's occurs when a value for the x falls outside a specification limit.

Methods to identify out-of-control conditions: *FMEA for the Improved Process*

An FMEA of your improved process identifies out-of-control conditions:

#	Process Function (Step)	Potential Failure Modes (process defects)	Potential Failure Effects (Y's)	SEV	Potential Causes of Failure (X's)	OCC
1	Customer initiates telephone inquiry	-VRU drops call	Customer must redial	3	Phone system overload	2
7	Utilize resources to resolve inquiry	Wrong solution given	Customer leaves bank	5	Lack of experience with resources (computer sytems)	3
7	Utilize resources to resolve inquiry	Wrong solution given	Customer has to call back	3	Lack of experience with resources (computer sytems)	3
7	Utilize resources to resolve inquiry	Wrong solution given	Bank must absorb an additional cost	1	Lack of experience with resources (computer sytems)	3

Methods to identify out-of-control conditions: *FMEA for the Improved Process*

An FMEA of your improved process identifies out-of-control conditions:

- FMEA evaluates/prioritises the potential failures of a process to prevent them from occurring.
- The FMEA in the Improve phase differs from the Measure phase FMEA
  - The FMEA in the Measure phase focused on the existing process.
  - The FMEA in the Improve phase focuses on the improved process, which incorporates your solution.

Identifying out-of-control conditions from the FMEA

Out-of-control conditions are the causes (and their respective failure modes) with one or more of the following indicators:

1. A high risk-priority number (RPN) relative to all RPNs generated
2. High occurrence **and** high detection ratings (regardless of the Severity rating) -- customer nuisance
3. High occurrence and low detection ratings (hidden factory)
4. A high severity rating

Follow-up actions from the FMEA

The next steps for the out-of-control conditions identified by the FMEA:

- Determine if we can eliminate (or mistake-proof) the causes
- Determine how to identify these out-of-control causes or failure modes in the process
- Create reaction plans for these out-of-control conditions once they are identified

These should be documented on the FMEA as Recommended Actions.

Follow-up actions from the FMEA

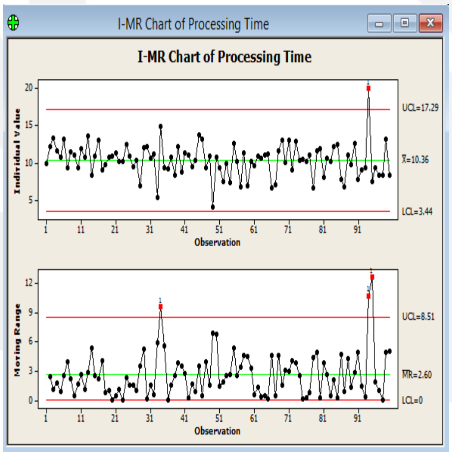
The next steps for the out-of-control conditions identified by the FMEA:

#	Process Function (Step)	Potential Failure Modes (process defects)	Potential Failure Effects (Y's)	SEV	Potential Causes of Failure (X's)	OCC	Current Process Controls	DET	RPN	Recommend Actions	Responsible Person & Target Date	Taken Actions	SEV	OCC	DET	RPN
1																
2																
3																
4																
5																

Methods to identify out-of-control conditions: *Control Charts*

Control charts can signal an out-of-control condition for your x's:

- Control limits on a control chart signal the presence of a special cause of variation within the process.
- We should consider control charting the vital few inputs, especially the controllable and noise variables

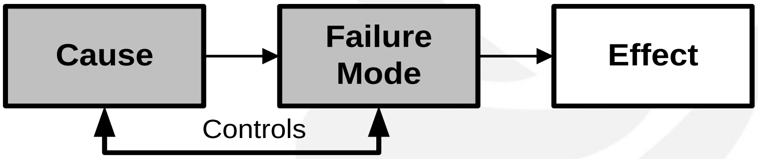


The two types of control methods

Control methods can have a prevention or detection orientation:

Prevention-Oriented Control Methods

- Prevent the cause



Detection-Oriented Control Methods

- Detect the cause
- Detect the failure mode

Mistake-proofing as a control method

Mistake-proofing is an action taken to:

- Remove the opportunity for an error in a process, or
- Make the error so obvious that it cannot reach the customer
- Also called **Poka-Yoke**, a Japanese term that means to avoid (yokeru) inadvertent errors (poka)

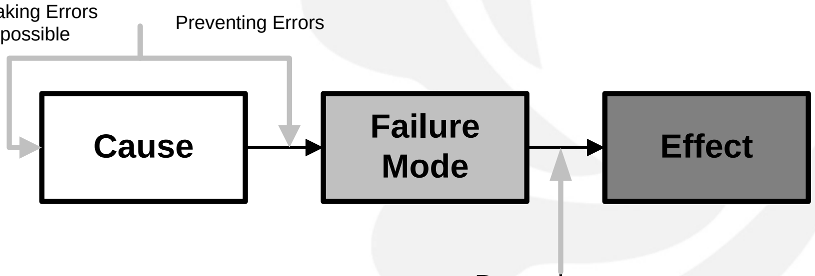
Mistake-proofing as a control method

Prevention

Mistake proofing activities at focus on:

Making Errors Impossible

Preventing Errors



Detection

Mistake proofing activities at this point focus on:

- Detecting errors
- Making sure errors do not turn into defects

The three mistake-proofing techniques

Mistake-proofing prevents or detects errors through three techniques:

Technique	Prevention	Detection
Shutdown	When a mistake is about to be made	When a mistake or defect has been made
Control	Errors are impossible	Defective items can't move on to the next step
Warning	That something is about to go wrong	Immediately when something does go wrong

Table exercise: Mistake proofing

There are many ways to mistake-proof a process. Review each of the following examples and determine:

- What is the defect to be prevented?
- Will the method described prevent or detect the defect?

Time 10 mins

1: Some cameras will not function when there isn't enough light to take a picture.
2: Some clothes dryers have a device that shuts them down when overheating is detected.
3: A fruit orchard takes great pride in the size of its apples. All of its apples must pass through a sizer. The small apples are sent to a discount outlet. The large apples are sent to customers.
4. Smoke detectors provide a warning that smoke has been detected and that there's a possible fire.

Visual management as a control method

What is Visual Management?

- A control method using visual tools that enables your process to talk or tell you:
  - When everything is OK
  - More importantly, when everything is not OK
- The visual tools enable "Management at a Glance":
  - You can easily recognise the difference between normal and abnormal conditions as they occur.
  - The abnormalities are made obvious to completion.

Technique	Prevention	Detection
Shutdown	When a mistake is about to be made	When a mistake or defect has been made
Control	Errors are impossible	Defective items can't move on to the next step
Warning	That something is about to go wrong	Immediately when something does go wrong

Visual displays and controls

Visual Displays:

Communicate important information, but <u>do not influence</u> or control what people or equipment do.

Visual Controls:

Communicate information so that activities are <u>performed</u> according to standard procedures.

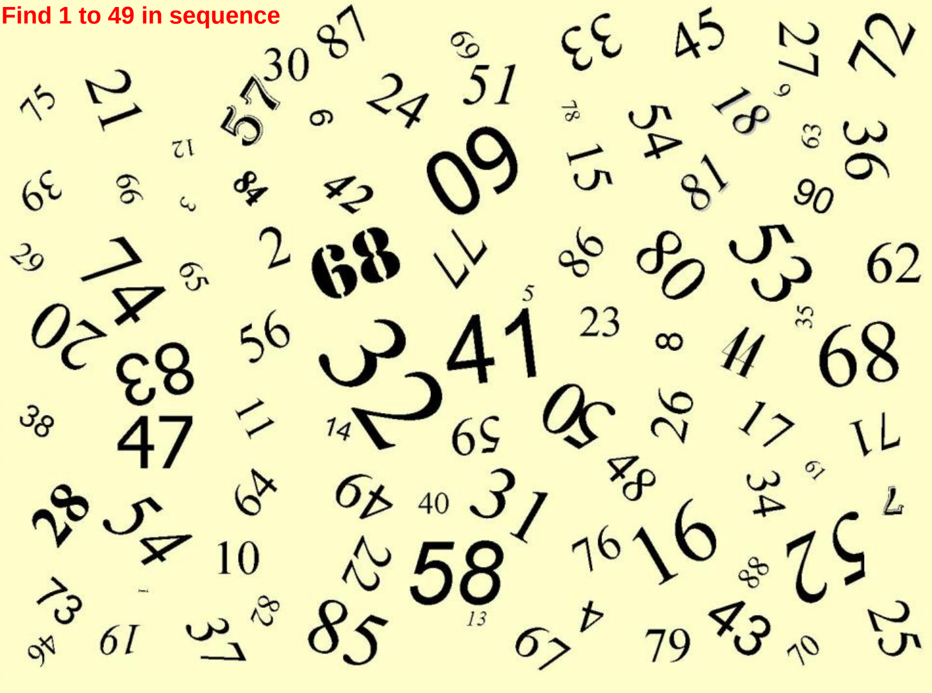
**Visual displays and controls
create a common visual language in the workplace.**

The foundation of visual management: The 5S Approach

- Methodology for creating and maintaining an organised, clean, high performance workplace
- Target areas:
  - People, materials, equipment methods and information

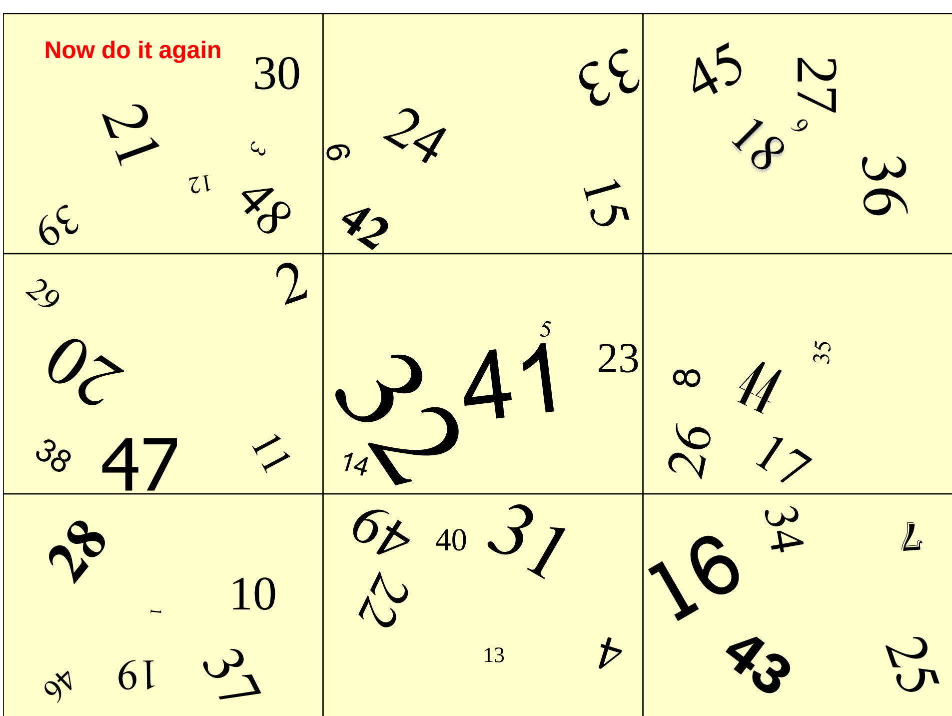
The 5S Approach	
Sort	• Get rid of what is not needed
Store	• Arrange and identify for ease of use
Shine	• Clean daily. Clean up what's left
Standardise	• Create standards and standard methods
Sustain	• Set discipline, plan and schedule

Find 1 to 49 in sequence



1. Sort – Decide on what is needed

Sort	
Definition	• To sort out necessary and unnecessary items • Clear Workplace and remove all un-needed items such as files, binders, electronics, and excess materials
Benefits	• Removes waste • Creates a safer work area • Increases available workspace • Simplifies the **visualisation** of the process
Tips	• Start in one area, then sort through everything • Discuss removal of items with all persons involved • Do it safely and recycle as appropriate



2. Store - arrangement of items needed

Store	
Definition	• To arrange all necessary items - have a designated place for everything and to put everything in its place
Benefits	• Visually shows what is required or is out of place • Reduces time to locate items/documents • **Saves time**, not having to search for items
Tips	• Things used together should be kept together • Use labels, tape, floor markings, and signs to label items • Keep items that are shared in a central location (eliminate excess, equal access)

Try it again!!

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43 44		45	46	47	48	49	

3. Shine - sweep and cleanliness

Shine	
Definition	• To keep areas clean on a continuing basis; while continuously raising the standards
Benefits	• A clean workplace is indicative of a quality product and process • A clean workplace helps to identify abnormal conditions and improve morale
Tips	• Storing "everything in its place" makes time available for cleaning • **Identify individual responsibilities** for cleaning

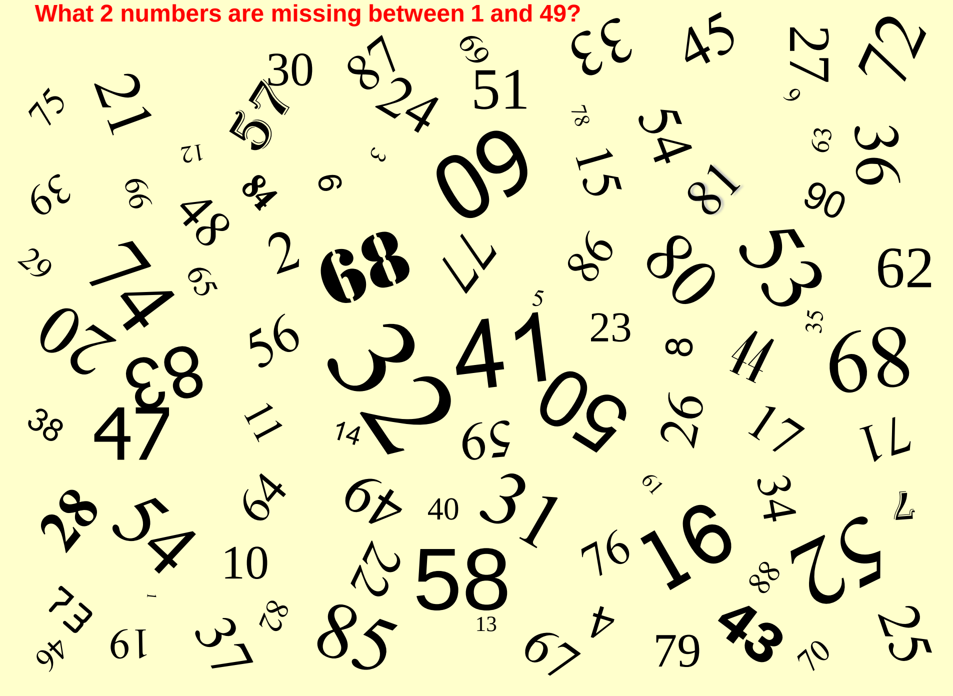
4. Standardise - create a common language

Standardise	
Definition	• To maintain the sorting, storage and shining activities into the workplace at a consistent level
Benefits	• Helps uncover problems and reveal their magnitude • Without standardisation of sorting, storage and shining, the **improvements from the first 3S's will disappear**
Tips	• Keep the work place neat and clean for visual identifiers to be effective in uncovering problems • Develop a system that will enable anyone in the workplace to see problems as they occur

5. Sustain – training & disciplined culture

Sustain	
Definition	• Practicing and repeating the 4S's regularly until they become a way of life in the workplace • Assessing the current practices and developing appropriate corrective actions
Benefits	• Sustain the 5S's into our everyday process as a habit. • Commitment and discipline toward housekeeping is essential in taking the first step in being World Class
Tips	• Develop schedules and checklists for the 4S actions

What 2 numbers are missing between 1 and 49?



So easy!!!!

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17		19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41		43	44	45	46	47	48	49	

Examples of Visual Management

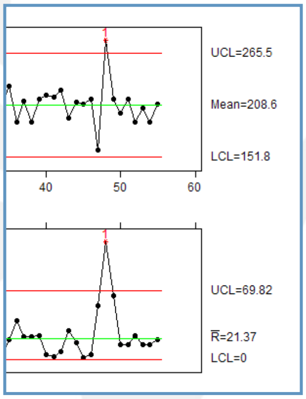
Dashboards are a common visual management tool:

- A dashboard is a collection of relevant visual displays and controls.
- Dashboards are readily visible.
- Other visual management tools include:
  - Pacing devices
  - Real-time visual / audible feedback (such things as counters, signals, color-coding, speakers, alarms and downtime clocks)

Control charts as a control method

Control charts can be applied to the vital few inputs (x's) to provide a statistical signal for an out-of-control condition

- Apply control charts to x's classified as noise (N) or controllable (C) variables on your detailed process flow.
- When using control charts:
  - Prepare instructions and incorporate them into the SOP.
  - Define and train appropriate employees.
  - Prepare a reaction plan for out-of-control signals.



Process performance measurement as a control method

Process performance measurement monitors the key Y's for the process:

- Designing, evaluating and monitoring the measurement systems for the Y's
- Applying statistical process capability and control methods to the Y's

Standard Operating Procedures as a control method

SOPs are an agreed-upon set of procedures for the new, improved process.

- Prepared to establish the best (and most reliable) sequence/methods for the process.
- Incorporated into the control plan.
- Benefits of Standard Work:
  - Defines a consistent, repeatable process
  - Defines a process to produce high-quality, low-cost products and services
  - Defines a process that minimises waste
  - Facilitates learning and consistent performance among employees

Tips and guidelines for applying standard work

Follow these guidelines when applying standard work:

- Specify requirements for inputs classified as "SOP" in your detailed process map.
- SOPs document how you will control the process. They are a mandatory deliverable for the improved process.
- Incorporate the use of job aids into the SOP
- Design steps that a typical employee can perform.
- Use a team approach:
  - Schedule regular and frequent idea meetings.
  - Revisit periodically. Standard work is not a one-time method.
- Make information readily available and easy to access for staff.
- Standard work must be **sold** to staff:
  - The importance of standardised jobs
  - Adhering to the SOPs and job aids

Steps to apply the standard work method

Steps to apply the standard work method.

Step	Action
1	**Lists the steps in the procedure in the order to be performed. Define the position that should complete the step.**
2	**Estimate the time to complete each step.**
3	**Document the expected outcome for each step as well as potential out-of-control conditions (what they are and how to identify them).**
4	**Specify reaction plans for these out-of-control conditions.**
5	**Document the process and its control checkpoints.**

Inspection as a control method

Inspection is the least effective of the control methods:

- Most inspection activities focus upon the Y's (the process metrics or outputs).
- Inspection can be used for your x's.
- It should not be the major (or only) control method for the process. Why not?
  - Inspection is not 100% effective.
  - Inspection is costly and time consuming.
  - Inspection, as the sole control, has a marginal impact on the detection rating.

Control method summary

Method	Prevent Cause	Detect Cause	Detect Failure Mode	Notes
Mistake-Proofing	✓	✓	✓	Prevents controllable x's or compensates for noise x's
Visual Management		✓	✓	Helpful to identify out-of-control conditions
Control Charts		✓	✓	Apply control charts to all vital few inputs (x's) designated as controllable and noise
Process Performance Management			✓	Use to monitor the Y and ensure improvements are sustained. Identifies future improvements
SOPs	✓	✓	✓	Must have in all control plans
Inspection			✓	Should not be the only control method in the control plan

The concept of a Reaction Plan

Reaction plans should be prepared for each control method

- Define the probable causes and appropriate corrective actions whenever an out-of-control condition is detected by the control method
- Serve as a troubleshooting guide for staff

Components of a Reaction Plan

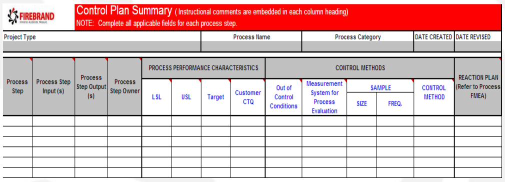
Reaction Plan components:

- A description of the out-of-control condition
- The probable causes for the condition and their corrective actions
- The actions to diagnose/confirm the probable causes
- Who is responsible for the diagnosis and action

Document the initial control plan

The Control Plan Summary template is a spreadsheet that:

- Profiles the key process steps (that is the step, its inputs, outputs and owner)



- Summarises:
  - The performance characteristics for the steps
  - The control methods for the steps
  - The reaction plan for the steps

The Control Plan Summary Template

The Elements of the Control Plan Summary :

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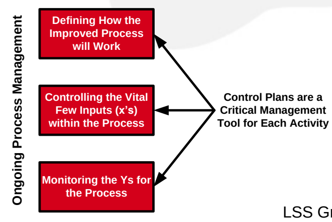
Control Plan Summary (Instructional comments are embedded in each column heading)
NOTE: Complete all applicable fields for each process step.

Project Type								Process Name		Process Category		DATE CREATED	DATE REVISED
Process Step	Process Step Input (s)	Process Step Output (s)	Process Step Owner	PROCESS PERFORMANCE CHARACTERISTICS				CONTROL METHODS					REACTION PLAN (Refer to Process FMEA)
				LSL	USL	Target	Customer CTQ	Out of Control Conditions	Measurement System for Process Evaluation	SAMPLE		CONTROL METHOD	
										SIZE	FREQ.		



The Control Plan Summary template

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				LSL	USL	Target	Customer CTQ	Out of Control Conditions	Measurement System for Process Evaluation	SAMPLE		CONTROL METHOD	
										SIZE	FREQ.		

Defining How the Improved Process will Work

Monitoring the Ys for the Process

Controlling the Vital Few Inputs (x's) within the Process

Summary of key learning points

- The initial draft of the control plan should be drafted and tested within the Improve phase
- There are preventative, detective and inspection methods to control the vital x's
- Have a reaction plan to deal with out of control conditions

Recommended coach support points

- Developing a FMEA for the new, improved process to identify out-of-control conditions
- Selecting and configuring the appropriate control methods for your vital few input(s)
- Reviewing the initial control plan in its entirety

Be sure to involve the Process Owner in the development of the Control Plan

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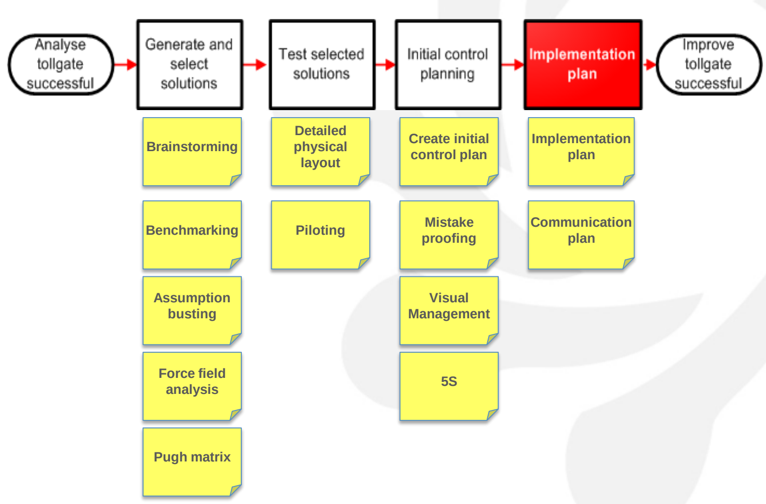
IMPROVE

Implementation Plan

Implementation plan



Preview of the lesson

At the end of this lesson, you will be able to:

- Describe how the Implementation Plan Checklist is used when preparing an Implementation Plan for your project
- Explain why stakeholders often resist change
- Develop a proactive Communication Plan for the implementation of your solution
- Determine the training requirements associated with the implementation and adoption of the new solution
- Identify and evaluate the key risk items that require mitigation strategies in your Implementation Plan
- Construct strategies to transfer the Control Plan to the Process Owner

Guidelines and tools for preparing an implementation plan

A good Implementation Plan will include activities to:

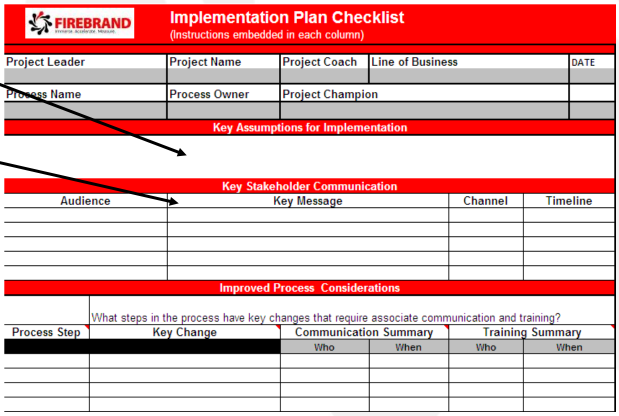
- Procure the solution, if appropriate
- Introduce the solution to:
  - The staff who will apply the solution
  - The managers who oversee the process where the solution is deployed
- Equip people with the knowledge and skills to introduce, use, and manage the solution
- Monitor and evaluate the success of the transition to the new solution

The content of the Implementation Plan will vary from solution to solution

Overview of the implementation plan checklist

The Implementation Plan checklist defines the critical elements to address in your Implementation Plan:

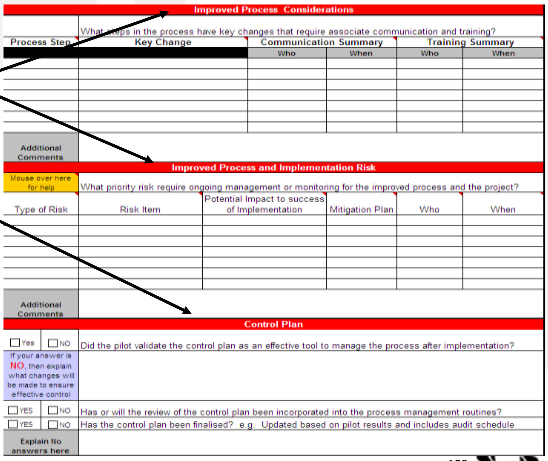
1. Key Assumptions for the Implementation
2. Process Change Considerations



Overview of the implementation plan checklist, *Continued*

The Implementation Plan Checklist defines the critical elements to address in your Implementation Plan:

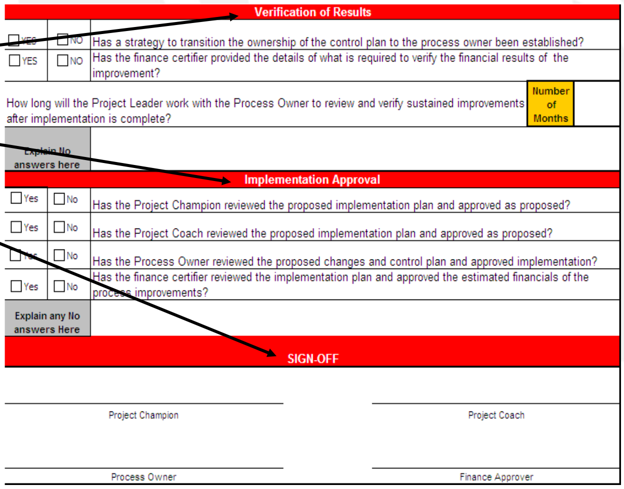
3. Improved Process and Implementation Risk
4. Control Plan



Overview of the implementation plan checklist, *Continued*

The Implementation Plan Checklist defines the critical elements to address in your Implementation Plan:

5. Verification of Results
6. Implementation Approval
7. Sign-Off



Verification of Results

☐ YES	☐ NO	Has a strategy to transition the ownership of the control plan to the process owner been established?
☐ YES	☐ NO	Has the finance certifier provided the details of what is required to verify the financial results of the improvement?

How long will the Project Leader work with the Process Owner to review and verify sustained improvements after implementation is complete? — Number of Months

Explain No answers here

Implementation Approval

☐ Yes	☐ No	Has the Project Champion reviewed the proposed implementation plan and approved as proposed?
☐ Yes	☐ No	Has the Project Coach reviewed the proposed implementation plan and approved as proposed?
☐ Yes	☐ No	Has the Process Owner reviewed the proposed changes and control plan and approved implementation?
☐ Yes	☐ No	Has the finance certifier reviewed the implementation plan and approved the estimated financials of the process improvements?

Explain any No answers Here

SIGN-OFF

Project Champion

Project Coach

Process Owner

Finance Approver

Document key implementation assumptions

Typical areas of assumptions

People	Staff or customers impacted by the solution, vendors, other stakeholders of the project or process
Operational Impacts	The upstream or downstream impact of the process improvement
Technology	Whether existing technology is capable of handling the impact of the change
Facilities/ Locations	Whether facilities, locations or workspace where the solution will be implemented are adequate and prepared
Communication	Assumptions regarding planned communication of the change
Training	Assumptions regarding the ability to deliver or receive training in the solution

Identify process change considerations

Use the Implementation Plan Checklist to document the improved process considerations.

Improved Process Considerations					
	What steps in the process have key changes that require associate communication and training?				
Process Step	Key Change	Communication Summary		Training Summary	
		Who	When	Who	When
Additional Comments					

Change Adoption - Why solutions are resisted

Reasons why your solution might be resisted:

- It is viewed as a threat to a personal or organisational need
- It is viewed as unnecessary
- It is perceived to do more harm than good
- The people introducing the solution are not respected
- No opportunities were given to provide feedback on the solution
- It is perceived as a personal criticism of the work performed
- It is perceived to add more work or effort than to keep the status quo
- Information on the change is heard secondhand

The importance of proactive communication

The minimum you can do to reduce resistance to change is proactive, effective communication.

- Communicate the right information to the key stakeholders:
  - The need for the project
  - The vital few inputs confirmed for the Y
  - The rationale and benefits of the solution
  - How the standard work process will change (or remain the same)
  - How the implementation will occur
  - Their roles in implementing/supporting the change
- Have the right people communicate the change:
  - Project Champion, Process Owner or both
- Solicit input from the stakeholders

Overview of a communication plan template

FIREBRAND **Communication Plan**
(Instructions embedded in Column headings)

Process Name	Project Name	Line of Business	Date Completed

Project Leader Name	Project Champion	Project Coach	Project Type

Purpose of Communication Plan

Audience	Key Message	Assumptions	Timeline	Channel	Recipient Response			Responsible	Contact Information
					Know	Feel	Do		

The implementation plan checklist summarises key communication activities

Use the Communication Summary section of the Implementation Plan Checklist to highlight the key communication activities.

Improved Process Considerations					
	What steps in the process have key changes that require associate communication and training?				
Process Step	Key Change	Communication Summary		Training Summary	
		Who	When	Who	When
Additional Comments					

The three types of training requirements for your solution

Training is required whenever people lack the knowledge or skills to:

- Roll out your solution to the targeted user community
  - Who: The people who will introduce the solution. Normally the Process Owner or Managers of the staff who are adopting the solution
- Adopt the solution
  - Who: The staff who will use/apply the solution on a daily basis in the process
- Monitor/manage the solution
  - Who: Managers of the staff who are adopting the solution

Common training methods

A range of training methods can be used to address the training requirements for your solution.

Consider …	When your training need …
Job aids or self-study materials	Is knowledge-based and does not require memorisation or quick access of information.
E-learning	Is knowledge-based and occurs regularly among a large and/or geographically dispersed audience.
Instructor-led, classroom-based training	Is lengthy and involves complex skills requiring practice and instructor feedback.
Telephone/Web-Based Conferences	Is short, involves simple skills requiring demonstrations and simple practices and occurs among a geographically dispersed audience.

The implementation plan checklist summarises your key training activities

Use the Training Summary section of the Implementation Plan Checklist to highlight your key training activities.

Improved Process Considerations					
	What steps in the process have key changes that require associate communication and training?				
Process Step	Key Change	Communication Summary		Training Summary	
		Who	When	Who	When
Additional Comments					

Identify and evaluate the risks associated with the deployment of the solution

Mitigation strategies should be incorporated into your Implementation Plan for the following risk items:

Risk Type	Description
Project Risks	"Red Status" risk items from the recent Project Risk Assessment that **do not** have a mitigation plan in place
Process Risks	Risk items from the FMEA of the improved process that have either: • A Risk Priority Number (RPN) greater than 30 • A Severity Rating of 5 and no mitigation plan in place
Other Risks	Risk items identified during the pilot test or when reviewing the process steps that will change for the solution.

The implementation plan checklist summarises the high-risk items for the deployment

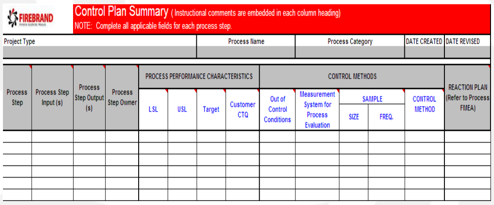
Record your high-risk items on the implementation plan checklist:

Improved Process and Implementation Risk					
Mouse over here for help	What priority risk require ongoing management or monitoring for the improved process and the project?				
Type of Risk	Risk Item	Potential Impact to success of Implementation	Mitigation Plan	Who	When
Additional Comments					

Your plan should include activities to update and transfer the control plan to the Process Owner

You will need to incorporate the following Control Plan activities into your overall Implementation Plan:

- Activities to update the initial Control Plan, if necessary, based on the pilot test results
- Activities to finalise the Control Plan
  - Develop and implement an audit schedule for the Control Plan.
  - Transition ownership of the newer Control Plan to the Process Owner.



Your plan should include activities to update and transfer the control plan to the Process Owner (cont'd)

The checklist includes questions to verify that you have planned adequately for the transfer of the Control Plan.

Control Plan		
☐ Yes	☐ NO	Did the pilot validate the control plan as an effective tool to manage the process after implementation?
If your answer is NO, then explain what changes will be made to ensure effective control		
☐ YES	☐ NO	Has or will the review of the control plan been incorporated into the process management routines?
☐ YES	☐ NO	Has the control plan been finalised? e.g. Updated based on pilot results and includes audit schedule
Explain No answers here		

Supporting the transition

The Project Lead:

- Assumes a consultative role, assisting the Process Owner in the activities to:
  - Control the vital few x's and monitor the Y
  - Verify sustainable improvement to the Y

The Implementation Plan Checklist identifies how long the Project Lead will work with the Process Owner:

Verification of Results			
☐ YES	☐ NO	Has a strategy to transition the ownership of the control plan to the process owner been established?	
☐ YES	☐ NO	Has the finance certifier provided the details of what is required to verify the financial results of the improvement?	
How long will the Project Leader work with the Process Owner to review and verify sustained improvements after implementation is complete?		Number of Months	
Explain No answers here			

Approving the transition

Include the signatures of the Project Champion, Coach, Process Owner and Finance Certifier on the Checklist:

Implementation Approval		
☐ Yes	☐ No	Has the Project Champion reviewed the proposed implementation plan and approved as proposed?
☐ Yes	☐ No	Has the Project Coach reviewed the proposed implementation plan and approved as proposed?
☐ Yes	☐ No	Has the Process Owner reviewed the proposed changes and control plan and approved implementation?
☐ Yes	☐ No	Has the finance certifier reviewed the implementation plan and approved the estimated financials of the process improvements?
Explain any No answers Here		

SIGN-OFF	
Project Champion	Project Coach
Process Owner	Finance Approver

Summary of key learning points

- A clear implementation plan will ensure that solutions are deployed in the most effective manner
- The plan should not only cover technical implementation activities but address some of the people issues associated with change
- Ensure that you have full approval on your plan before deploying your solution within your business

Recommended coach support points

There are recommended support points with your Coach, Project Champion or Process Owner.

Be sure to engage your Coach in a review of:

- Your Communication and Training Plans for the deployment
- The high risk items for the deployment and your risk mitigation strategies
- Your approach to transfer the Control Plan to the Process Owner

Be sure to engage your Project Champion and Process Owner in a review of:

- The overall Implementation Plan

Key points of the Improve phase

- Lean Six Sigma is all about implementing sustainable successful solutions for business.
- Generate high volumes of ideas through creative thinking techniques
- Use a Pugh matrix to select between and synthesise different solution options
- Assess solutions within the physical work environment and as part of a pilot
- Have a detailed plan to implement successfully addressing the people aspects of change

Lean Six Sigma simulation: Final Round

The coin simulation

Objective: Use the tools covered in this and the Analyse module to prepare:

- The future state value stream map
- Implement any changes you feel will improve performance
- NOTE THERE IS A NEW COMPETITOR IN THE MARKET

60 mins

FIREBRAND

CONTROL

Lean Six Sigma

Green Belt

Objectives of this module

C

At the end of this module, you will be able to:

- Use statistical process control
- Deploy your solutions successfully
- Close your Lean Six Sigma project

Control Phase Overview

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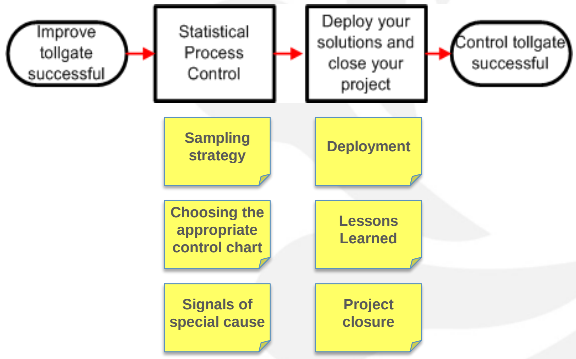

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CONTROL

Statistical Process Control

Statistical Process Control

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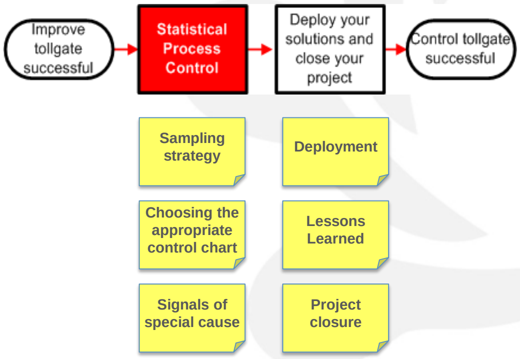

Preview of the lesson

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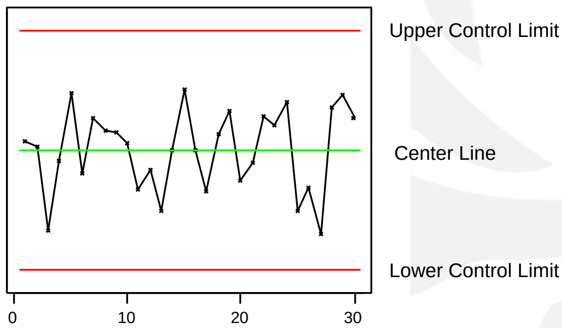
At the end of this lesson, you will be able to:

- Create the sampling strategy for the Control Chart and document it in the Control Plan
- Choose the appropriate Control Chart for the variables
- Identify signals of special cause when looking at a Control Chart

Review of Measure material

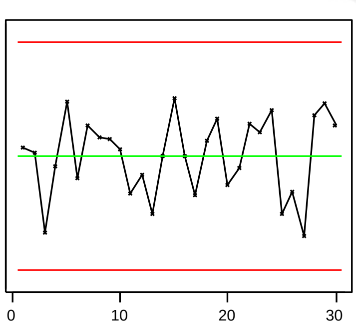
What are Control Charts?

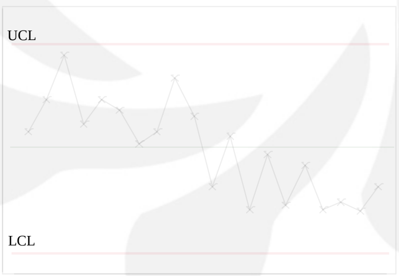


Use of Control Charts to identify type of variation

Two types of variation:

- Common cause variation
- Special cause variation





Error in control charting

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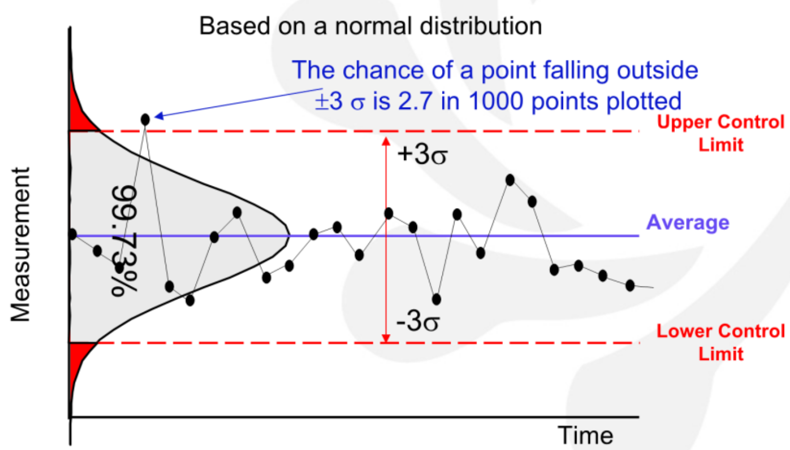

Signals of unusual variation

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Variation in call handle time:

- What are some examples of <u>common cause</u> variation in the handle time for a call?
- What are some examples of <u>special cause</u> variation in the handle time for a call?

Control Chart variables to evaluate

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Variables typically include:

- Project Y’s: monitor the primary and secondary metrics
- Vital Few Inputs (x’s): manage and control

Control chart sampling strategy

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The Control Plan will specify:

- Type of data
- Sampling strategy
- Designated control method

Process Step	Process Step Input (s)	Process Step Output (s)	Process Step Owner	PROCESS PERFORMANCE CHARACTERISTICS				CONTROL METHODS					REACTION PLAN (Refer to Process FMEA)
				LSL	USL	Target	Customer CTQ	Out of Control Conditions	Measurement System for Process Evaluation	SAMPLE SIZE	SAMPLE FREQ.	CONTROL METHOD	
Call Center System	Call Type	Customer inquiry resolved		0.95		0.9	1st Call Resolution	1 point outside of control limits, trend	Q&P randomly records calls and reviews to ensure resolution	100	Weekly	np chart	Investigate out of control conditions

Control Plan example

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TERISTICS	CONTROL METHODS						REACTION PLAN (Refer to Process FMEA)
Customer CTQ	Out of Control Conditions	Measurement System for Process Evaluation	SAMPLE		CONTROL METHOD		
			SIZE	FREQ.			
1st Call Resolution	1 point outside of control limits, trend	Q&P randomly records calls and reviews to ensure resolution	100	Weekly	np chart		Investigate out of control conditions

What type of data are we collecting?

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TERISTICS	CONTROL METHODS						REACTION PLAN (Refer to Process FMEA)
Customer CTQ	Out of Control Conditions	Measurement System for Process Evaluation	SAMPLE		CONTROL METHOD		
			SIZE	FREQ.			
1st Call Resolution	1 point outside of control limits, trend	Q&P randomly records calls and reviews to ensure resolution	100	Weekly	np chart		Investigate out of control conditions

Our data for control charts can be:

- Continuous
- Discrete
  - Defects
  - Defectives

Sampling strategy

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Determining the sampling strategy:

- The four sampling strategies

	Sampling from a Population	Sampling from a Process
Random Sampling	X	
Stratified Random Sampling	X	
Systematic Sampling	X	X
Rational Subgrouping		X

- **The sampling strategy used by Control Charts is rational subgrouping.**

The challenge of Rational Subgrouping

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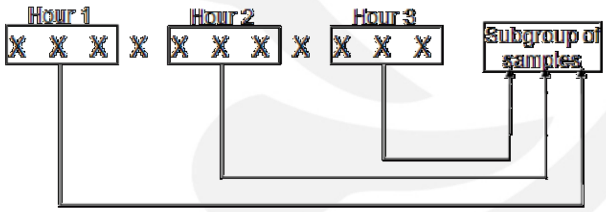
Challenge:

Construct a sampling plan that focuses on detecting between-subgroup variation by identifying subgroups that minimise within-subgroup variation.



Considerations:

- Size of the subgroup
- Frequency
- Composition of the samples for the subgroup

Minimising within subgroup variation

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Subgroup composition:

- The within-subgroup variation influences the control limits.
- The greater the within-subgroup variation, the wider will be the control limits.
- Wide control limits may mask special cause variation that occurs between subgroups.

Determining sampling frequency

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Factors to consider when determining frequency:

- The sensitivity of the Control Chart refers to the ability of the Control Chart to detect special cause (or out-of-control conditions) between subgroups.
- The frequency of sampling should be often enough for special cause variation to be detected when it occurs.
- Try to maximize the variability between subgroups.

Selecting the correct control chart – Control Chart Decision Tree

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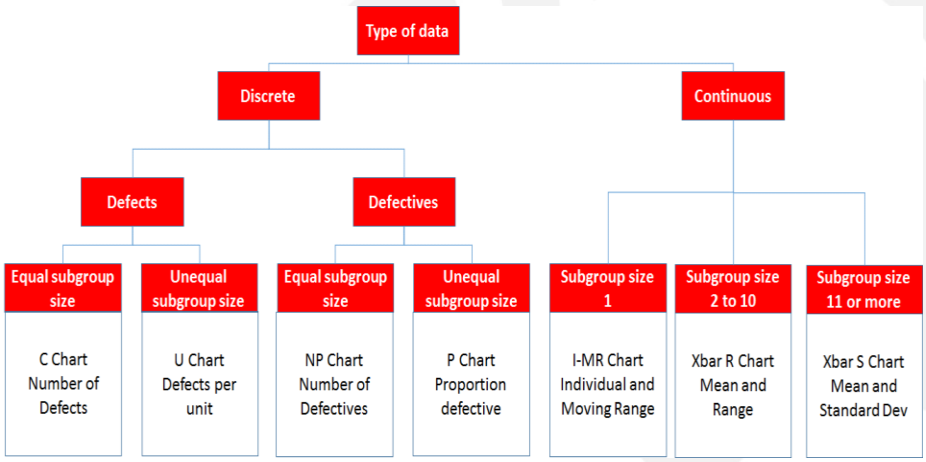
Question 1: What is the data type for the variable?



Question 2: What is the sampling strategy?

Subgroup sizes

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Sampling Strategy	Take this path when…
Equal subgroup sizes	You collect the same number of samples for each subgroup For example, you might collect, 150 forms per day, 100 calls per hour
Unequal subgroup sizes	You collect different numbers of samples for each subgroup. For example, you might collect all forms received in a day (this will change day-to-day), all calls in an hour

Table activity: selecting the appropriate control chart

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20 mins

Objective: Use of Control Charts

In your table team, read each scenario on the following slide and answer the questions below to determine which Control Chart is most appropriate:

- What variable is identified?
- Is this continuous or discrete? If discrete, is the data defects or defectives?
- How is data collected (as an individual value or in subgroups)?
- Is the same amount of data collected each time (fixed or variable subgroups)?
- How much data is collected each time (this is your subgroup size)?

Prepare to report your team's findings to the group

Table activity: selecting the appropriate control chart

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- The billing department in a gas supply company has found a relationship between customers receiving estimated bills and the number of credits issued by customer service. The department has started to monitor the number of bills that are based on actual meter readings. It will take a sample of 100 statements every day.
- Incorrectly lodged application forms are a problem for the company. Too many errors on each form cause major delays for new customers and drive significant additional cost into the business. The manager is monitoring the errors daily based on all the forms filed each day.
- The time to close mortgages is related to the time it takes to submit the application. The mortgage processing manager feels there may be a lot of variation in the time to submit the application and wants to start monitoring it. The manager plans to collect the time to complete every 50th mortgage application.

What are signals of special cause?

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Signals of special cause:

Signals of special cause are

- One point outside the control limits
- Non-random patterns in the data plotted over time that are unlikely to occur solely due to natural variation.

What is a non-random pattern?

Overview of non-random patterns

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There are four different categories of non-random patterns:

- Cycling Pattern
- Mixture Pattern
- Shift Pattern
- Trend Pattern

Cycling Pattern

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Cycling pattern example:

Possible causes:
- Seasonal or periodic influences

Mixture Pattern

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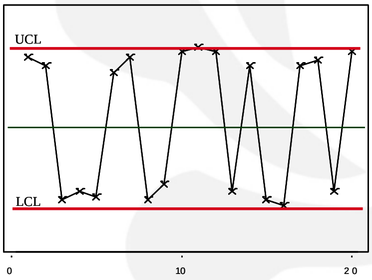
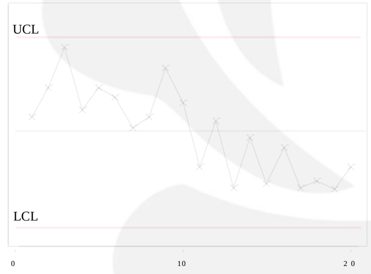
Mixture pattern example:



Possible causes:
- Two or more overlapping process output distributions
- Tampering

Shift in process level

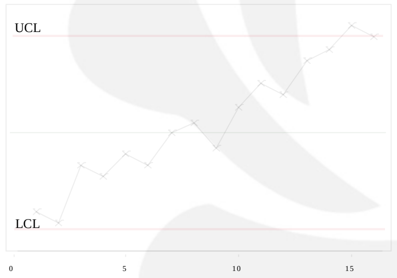
Shift in process example:



Possible causes:
- Introduction of new inputs
- A change in inspection methods or standards
- A process improvement

Trend pattern

Trend pattern example:



Possible causes:
- A cumulative effect over time, such as an increase in staff knowledge with more experience
- A gradual effect due to noise variables, such as an increase in the cycle time to process loans when volume increases

Control charts for continuous data

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Continuous

Subgroup size 1	Subgroup size 2 to 10	Subgroup size 11 or more
I-MR Chart Individual and Moving Range	Xbar R Chart Mean and Range	Xbar S Chart Mean and Standard Dev

Overview of XBar R Charts

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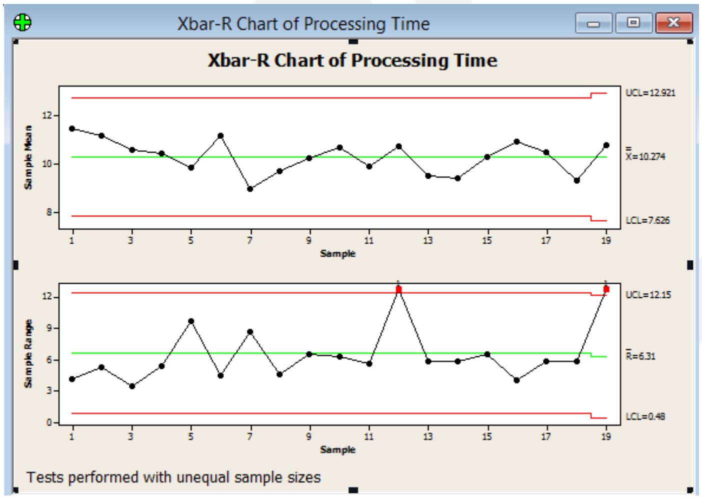
XBar R Chart example:



Control charts for discrete data

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- Discrete
  - Defects
    - Equal subgroup size: C Chart, Number of Defects
    - Unequal subgroup size: U Chart, Defects per unit
  - Defectives
    - Equal subgroup size: NP Chart, Number of Defectives
    - Unequal subgroup size: P Chart, Proportion defective

Characteristics of the U Chart

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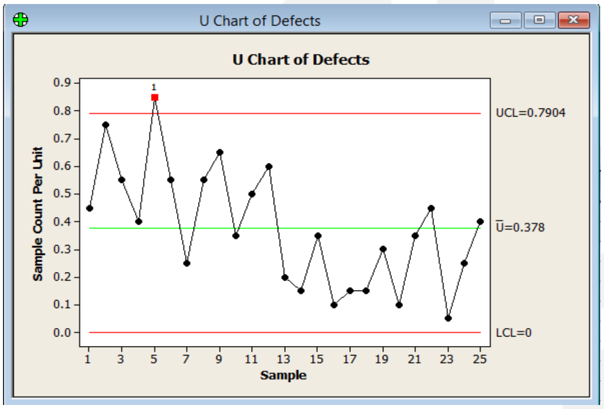
- Review the chart below:



- How would you interpret this?
- What do you notice about the control limits?

Characteristics of the P chart control limits

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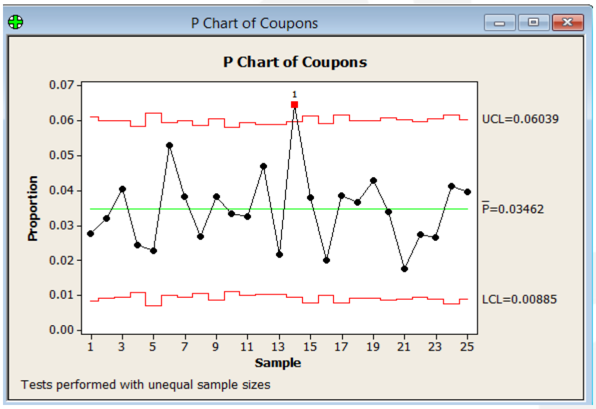
- Look at the chart below:



- What do you notice about the control limits?
- Why might this happen?

Summary of key learning points

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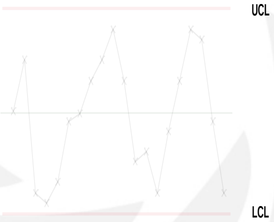
The key points to remember when using control charts to monitor and manage a process are:

- Identify the variables to monitor
- Establish the sampling strategy.
- Select the appropriate Control Chart.
- Create and analyse the Control Chart.



Recommended coach support points

C

- When identifying variables to monitor using Control Charts
- The Data Collection Plan for the Control Charts
  - For rational sub-grouping, the rationale for the subgroups, how your sampling plan will show less variation than expected between the subgroups

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CONTROL

Deploying the solutions and closing your project

Deploy your solutions and close your project

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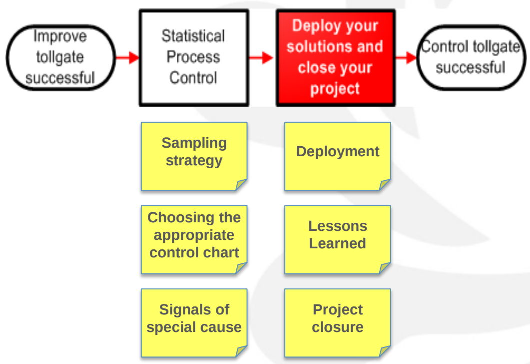

Preview of the lesson

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After completing this lesson, you will be able to:

- Describe the indicators of a successful deployment of your solution and control plan
- Deploy the solutions and Control plan on a full-scale basis
- Complete the required actions to close your Lean Six Sigma project
- Explain the responsibilities of the Coach and Finance Certifier in closing your project

Deploying the solution

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A successful deployment has three indicators:

- The Process Owner “owns” the solution and Control Plan
- Training for the solution and Control Plan is delivered
- The deployment of the solution is verified

Deploying the solution

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Most organisations have their own implementation methodologies and standards. At a minimum, after a successful period of systems, integration and user acceptance testing a detailed task schedule and/or Gantt chart will be prepared documenting:

- Detailed implementation task list
- Implementation task ownership
- Timing
- Task dependencies
- Escalation
- Notifications of task start/completion times

The task schedule may by controlled by the Project Manager or be managed centrally by a Control Room

Document the key lessons learned from your project

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What are lessons learned?

- Additional pieces of information discovered during a work effort. They can be:
  - Positive lessons (possible best practices)
  - Negative lessons
- Lessons learned and best practices are the basis for continuous improvement of your Lean Six Sigma program.
- Lessons learned are captured:
  - Informally throughout the project
  - Formally at the close of the project

Document the key lessons learned from your project

C

Sources of Lessons Learned:

- Lessons Learned can be identified from:
  - The results of the project
  - The process improved
  - The use of the DMAIC methodology

Other project closure activities

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Your Finance Certifier should:

- Approve the Predicted benefits for your project
- Agree how the benefits will be recognised
- Mandate reporting frequency and responsibility

The control phase tollgate must be completed

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A project must pass the Control Phase tollgate review to meet the criteria for closure.

- The Project Lead, Coach and Project Champion must agree that the chartered project goals were met.
- The Project Lead is responsible for completing the tollgate review.

Summary of key learning points

C

- Poor deployment can undermine all the good work completed on your project to date
- Ensure you have a detailed plan for implementation
- Document and share any lessons learned and best practise
- Agree project benefits and recognition approach
- Complete Control tollgate and gain formal approval to close your project

Recommended coach support points

C

- When deploying the solution/control plan
  - The final Control Plan
  - The strategy to transfer the Control Plan to the Process Owner.
  - The validation strategy for the Y after the solution/Control Plan has been deployed
- When closing your project
  - The information required to complete the Control phase tollgate review.
  - Your lessons learned from the project.