2020

Lean Six Sigma Workbook

HARRYBAKER TRAINING INSTITUTE

1 JIDE SAWYERR DRIVE, MARUWA, LEKKI LAGOS, NIGERIA

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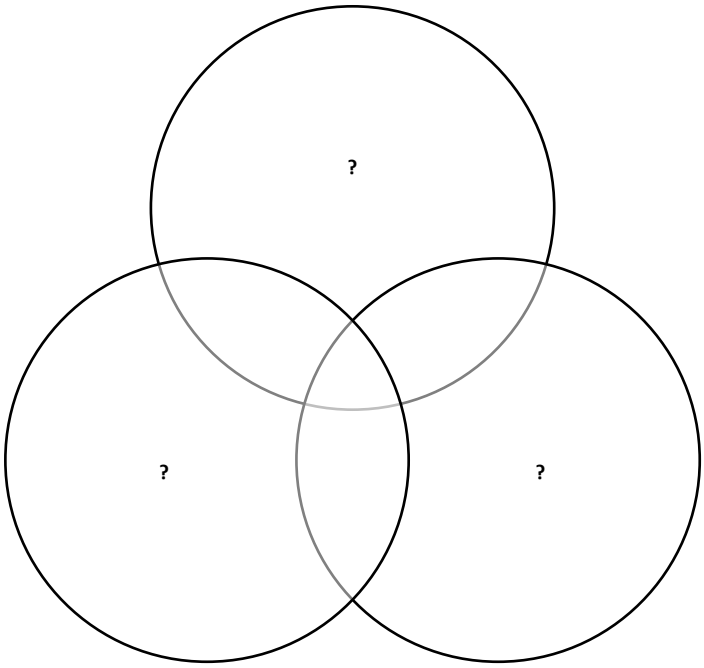
World Class Performance

1. What are competitive Strategies? Which do you feel is the focus of your organization and why?



My note:

Which is a competitive strategy that focuses on offering a superior and higher quality product?
a) Customer Intimacy
b) Operational Excellence
c) Product Leadership
d) Transaction Management

Which is a competitive strategy that focuses on offering a specialized service or product?
a) Customer Intimacy
b) Operational Excellence
c) Transaction Management
d) Product Leadership

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2. Organizations need processes to deliver products and services. These processes can be broadly be divided into physical processes and transactional processes. Can you provide examples in your organization?

3. What is Lean and Six Sigma?

4. What are lean Principles?

1. 2. 3. 4. 5.

5. What is the main principle (focus) of Six Sigma?

Which is the MOST likely objective for an organization to implement Lean Six Sigma?
a) Achieve no more than 3.4 defects per million opportunities
b) Reduce the risk of regulatory and legal breach
c) Reduce costs and improve employee morale
d) Deliver better quality quicker

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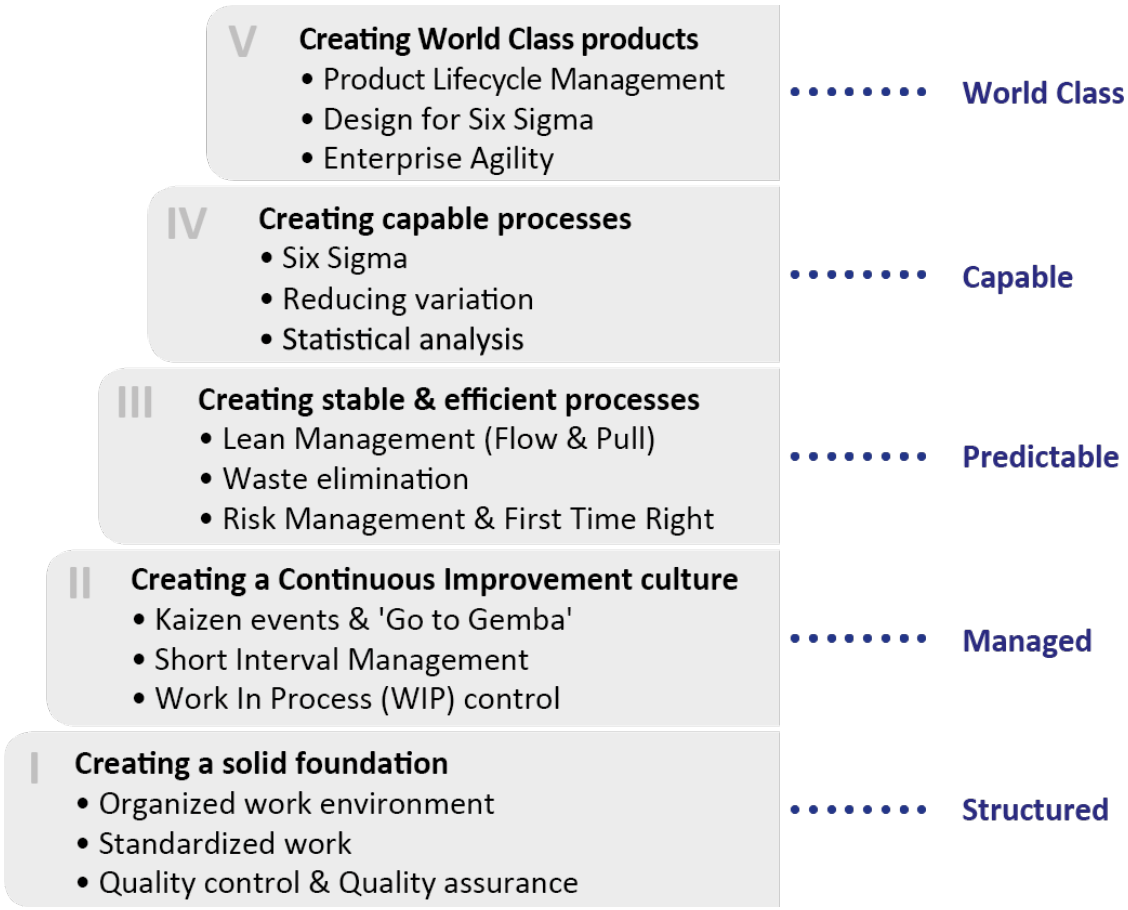
6. Process Improvement Planning:



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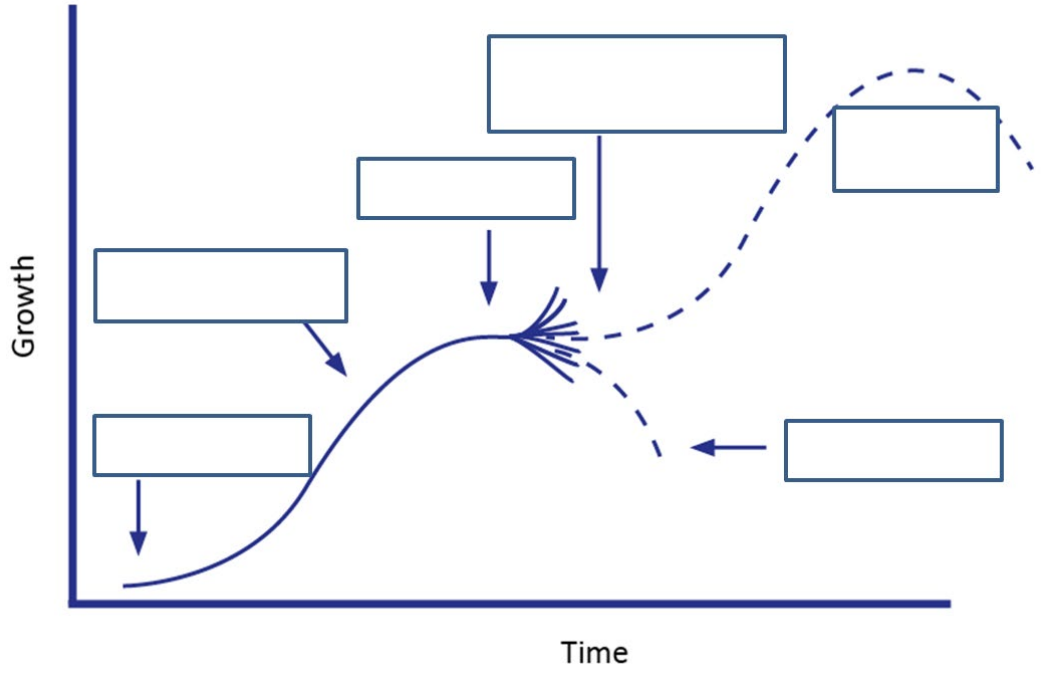
Chapter 2: Introduction to Organizational Change Management

As a Lean Six Sigma Green Belt holder, you will be managing process improvement projects. There is a need to understand Organizational Change Management in terms of:

- Culture:
  - Change Management S-curve
  - Commitment and Resistance
  - Emotional Cycle
- Organizational Approaches to Change Management
  - Kotter 8 Steps
  - Top-down and Bottom-up
- Stakeholder management
- Team Motivation, Coaching and situational Leadership
- Communication

1. Organizational Culture

Can you complete the diagrams below on the cultural aspects:



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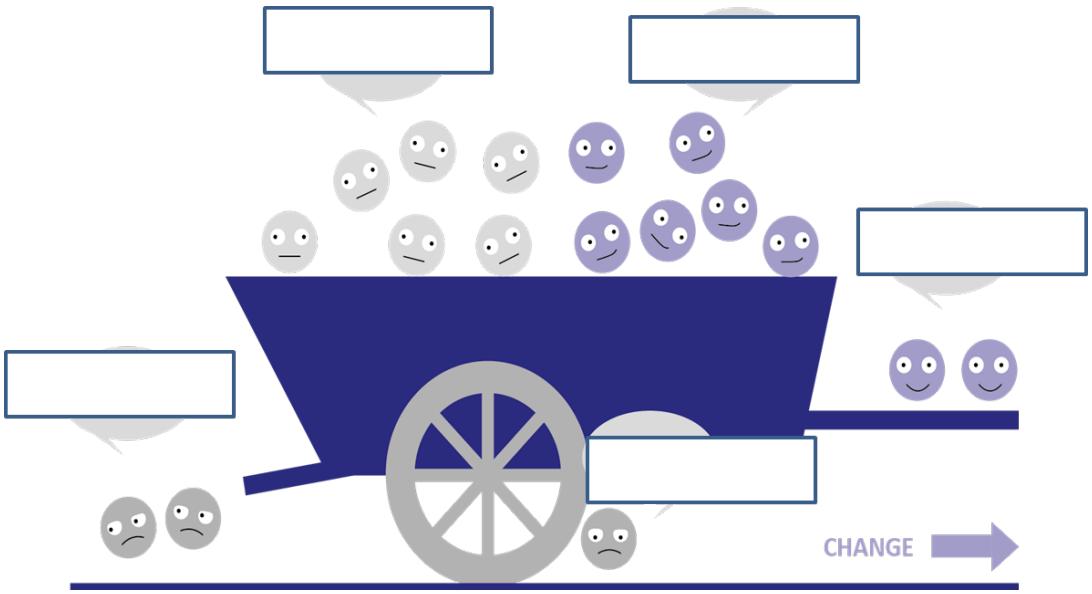

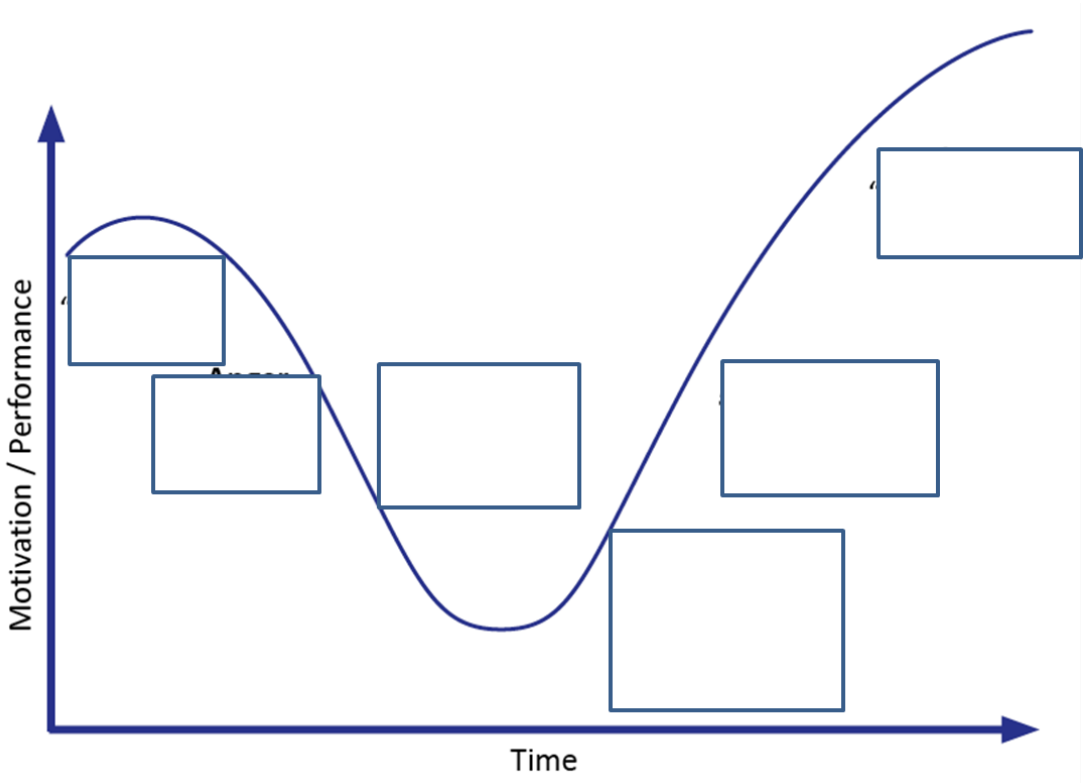

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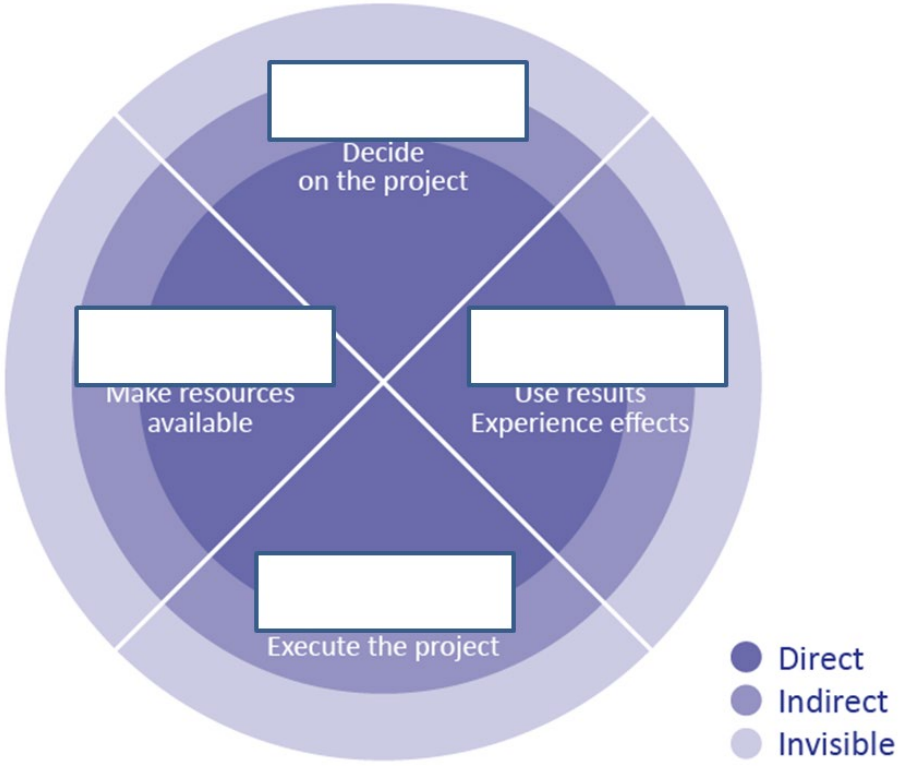
2. Change Management Approaches

Can you list the Kotter's 8-steps activities:
Step 1:
Step 2:
Step 3:
Step 4:
Step 5:
Step 6:
Step 7:
Step 8:

What is the point of top-down and bottom-up approach?

3. Stakeholder Management

It is very Important to identify the stakeholder and engage with them effectively. An important step after identification is to segment the stakeholders, which may flag whoever had been missed out. Can you complete the diagram below:



Which **BEST** describes a stakeholder?

a) Will have an interest in a project
b) Are likely to hinder the progress of a project
c) Have raised issues about the project
d) Are unaffected by the project

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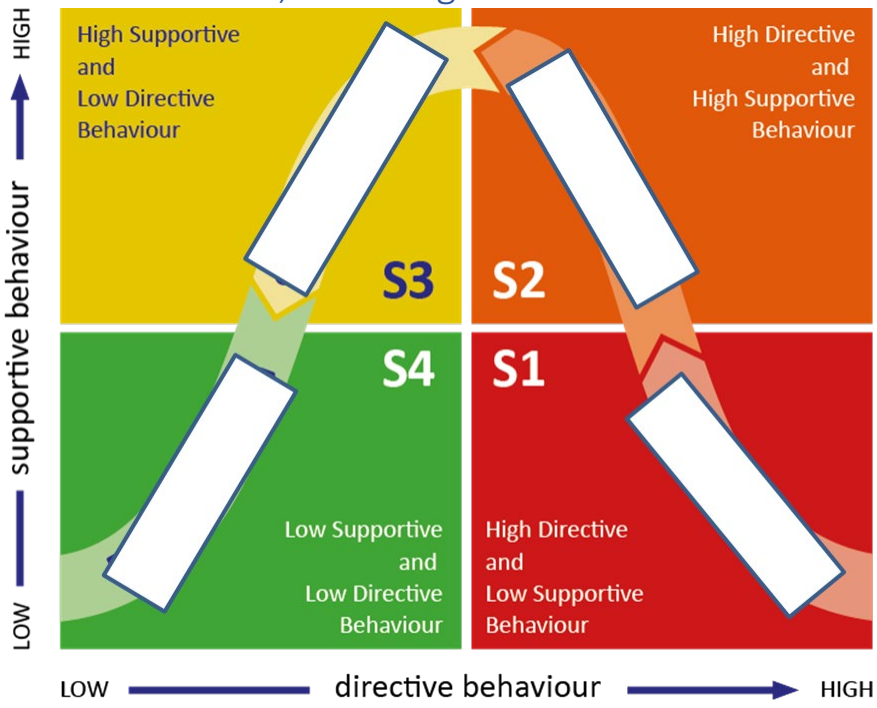
Which is a valid criteria used in project stakeholder analysis to describe the involvement of a key stakeholder?

a) Leads brainstorming sessions
b) Evaluates selected projects
c) Documents final project results
d) Authorizes project decisions

4. Leadership: Team Motivation, Coaching and situational Leadership



5. Motivation

Can you classify the factors on the screen to the following categories?

Hygiene Factors	Motivational Factors

6. Communication Model

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Chapter 3: Introduction to Project Management

As a Lean Six Sigma Breen Belt holder, you will be managing a number of Process Improvement projects. It very important to have a good understanding of Project Management Framework and Methodologies. We will cover a brief introduction to the subject here.

Organizational Roles and Responsibilities

Common Roadmaps Used in implementing improvement to organizational processes

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Project Charter

Business unit:
Department

Project Leader:
Name of project leader

Belt level / Method:
GB/BB & DMAIC/DMADV

Project title:
Short name of the project

Project Number:
Project number assigned

Problem Statement:
Short description of the problem / Reason for the project

Product / Service:
What is delivered?

Process:
Operational process

Customer:
Who receives the product?

Hard Benefits:
Direct bottom-line savings

☐ *Benefit Enabler*

☐ *Benefit Realisation*

Hard Benefits /yr:
Direct Monetary savings

Budget:
Estimated investment costs

Net Savings /yr:
Savings minus Costs

Soft Benefits:
Risk avoidance and Nonmonetary benefits

Interface with other projects:
Is the project part of another project? Will the project impact another device or customer?

Start Date:
Date the team will start

Target Completion Date:
Completion of Control / Verify

Actual Closure Date:
Release of team

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Project Initiation:

Project Planning:

Project Implementation:

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Project Closure:

As a Lean Six Sigma Green Belt holder, you are expected to understand at a high-level the Financial Measures used in justifying the selection of process improvement projects. Use the box below to summarize your thoughts on Cost of Poor Quality, Net Present Value, Return on Investment and Working Capital.

	Year 0	Year 1	Year 2
Cost of Team	€10,000	€0	€0
Time and Cost	€14,000	€0	€0
Reduction in Defects	€0	€13,000	€13,000
Resources Deployed	€0	€17,000	€17,000

The costs and benefits of an improvement project are summarized in the table below. Assuming an interest rate of 5%, which of the following conclusions can be drawn?

1. Return on Investment (ROI) at year 1 is 25%
2. Return on Investment (ROI) at year 2 is 150%

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3. Net Present Value (NPV) is €31,800
4. Working Capital (WC) is unchanged in year 0

a) 1, 2, 3
b) 1, 2, 4
c) 1, 3, 4
d) 2, 3, 4

7. As a Lean Six Sigma Green Belt holder, you must understand how process improvement projects are selected or decided upon in your organization. Here is an example:

	Urgent	*Impact*	*Strategy*	*Benefits*	*Effort*	*Ability*	*Change*	*Score*
Weighting	*5*	*3*	*3*	*5*	*3*	*3*	*1*	
Project 1	1	1	1	1	9	3	1	53
Project 2	1	3	3	9	3	9	3	73
Project 3	3	1	3	1	1	9	9	135
Project 4	9	9	9	3	9	9	9	237
Project 5	3	1	9	3	1	9	9	297
Project 6	1	1	9	1	9	3	9	205
…..								

Which quadrant of a Project priority diagram would contain 'low hanging fruit'?

a) Low impact, low effort
b) Low impact, high effort
c) High impact, low effort
d) High impact, high effort

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Which is a purpose of documenting lessons learned?

a) Evaluate the performance of the team

b) Do it better next time

c) Assess the performance of individuals

d) Establish next year's pay increase

Which is a responsibility of a Green Belt in an organization?
a) Teaching the principles of Lean Six Sigma
b) Supporting projects as team members
c) Execution of improvement projects
d) Allocation of resources and budgets

The management of a super market chain is seeking to improve customer and employee satisfaction. The approach they have chosen is to change the layout and appearance of the stores. The management has hired an external contractor to manage the project. What is the **BEST** measure to take to ensure a successful project?

a) Ensure the employees are well informed of the planned changes
b) Allow the employees to have an input to the outcome of the planned changes
c) Involve the store managers in the change process
d) Involve the customer and employees in planning the project outcome

An improvement project is expected to make the following benefits.

Efficiency Improvement	From 10 to 9 employees
Reduced Cycle Time	From 5 to 4 minutes
Improved Yield	From 80% to 90%
Reduced Downtime	From 14% to 9%
Improved Employee Morale	From 3.4 to 3.7
Improved Customer Satisfaction (NPI%)	From 40% to 50%
Reduction In Reportable Incidents (RI)	From 28 to 11 p.a.
Reduced Risk p.a. of Regulatory Breach	0.9% to 0.75%
Cost per Employee p.a.	€50,000
Cost per RI (est.)	€3,000
Cost per Breach (est.)	€10,000,000

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What is the **BEST** statement of soft benefits?
a) €0,000 plus improved customer satisfaction and employee morale
b) €15,000 plus improved customer satisfaction and employee morale
c) €51,000 plus improved customer satisfaction and employee morale
d) €66,000 plus improved customer satisfaction and employee morale

The costs and benefits of an improvement project are summarized in the table below

	Year 0	Year 1
Cost of team	£8,000	£0
Capital Cost	£10,000	£0
Reduction in Defects	£18,000	£36,000
Resources Redeployed	£0	£17,000

What are the hard benefits of this project for the first year?
a) £53,000
b) £36,000
c) £71,000
d) £54,000

A project has been initiated due to repeated failures to meet a key performance measure in a process. The project team members have identified a key benefit which has been brought to the attention of the Champion. The key benefit has been identified as an improvement in the effectiveness of the process, and a significant reduction in the amount of work in progress. How would these benefits be categorized?

a) Loss avoidance benefits

b) Direct hard benefits

c) Soft benefits

d) Indirect hard benefits

Which is a benefit of using the Kano model?

a) Aids understanding of customer requirements

b) Helps to identify and group defect causes

c) Provides a set of questions to ask

d) Provides a description of an improvement opportunity

A car sales person has a regular customer who exchanges their used car for the latest model every two years. The customer has placed their order for the vehicle with the sales person several months in advance and has provided clear details of their requirements including the make, model, engine size, type of fuel, color, air conditioning system, a high quality audio system, and leather seats. The sales person values the customer's business, so has made use of the Kano model as a tool to assist in understanding the Voice of the Customer (VOC).

The customer arrives to take possession of the vehicle and the sales person demonstrates a number of upgrades that have been included free of charge: heated leather seats, a dual zone air conditioning system, an audio system with higher quality speakers than specified, a DVD player and a built in satellite navigation system with a reversing camera. Which of the following requirements would be classed as a 'Delighter' according to the Kano model?

1. DVD player
2. Reversing camera
3. Heated seats
4. Audio system

a) 1, 2, 3
b) 1, 2, 4
c) 1, 3, 4
d) 2, 3, 4

Which of the following tasks is the responsibility of a Champion?

1. Select the project
2. Select the project manager
3. Manage complex projects
4. Monitor project progress

a) 1, 2, 3
b) 1, 2, 4
c) 1, 3, 4
d) 2, 3, 4

Which is a responsibility of a Green Belt in an organization?
a) Teaching the principles of Lean Six Sigma
b) Supporting projects as team members
c) Execution of improvement projects
d) Allocation of resources and budgets

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Chapter 4: CIMM Level 1 – Creating a Solid Foundation

Before organizations can really work on process improvement programs like Lean and Six Sigma, it is required that a proper foundation is put in place. The first level of any Continuous Improvement scenario starts with the objectives of a professional and safe work environment, standardized Work and a solid quality management system. These elements will guarantee a stable foundation for further improvement initiatives.

In this session, we will cover:

- Organized Work Environment – 5S
- Standardized Work – Standard Operating Procedures (SOP)
- Quality Management – Quality Planning, Quality Assurance and Quality Control

Organized Work Environment – 5S:

The workplace is the mirror of the organization. If the surrounding are not organized, it reflects poorly on the organization and represents the way it regards its customers and its products or services. A tidy workplace leads to quality and therefore the starting point for every improvement!

1.

2.

3.

4.

5.

5S Transactional Assessment

Work Area: Manager's Office

Key: Use sheet to rate work area 5 times (note each date) 1 = "non-existent", - 3 = "average" and 5 = "excellent"

5S Phase	Definition	Standards To Be Met	Ratings					Next Steps
		Date of Assessment	4/10	5/12	6/9			
Sort (Seiri)	The right materials are available and anything unnecessary is removed	- No unused items are stored	1	3	5			Need to get rid of non-working files on the shared drive
		- No unneeded materials, forms or supplies	1	2	4			
		- There are no out-of-date posters on the wall	1	3	4			
		- Excess supplies are reallocated	1	4	5			
Set in Order (Seiton)	There is place for everything and everything is in its place	- It's clear where working vs archive files belong	1	4	5			Need to establish document naming conventions long with "Working Files" and "Archive" folders
		- The shared drive is easy to navigate	1	1	4			
		- Signage & naming conventions are clear	1	2	3			
		- Equipment and supply areas are clearly labeled	1	2	2			
Shine (Seiso)	Everything is clean and in working order	- IT conducts regular maintenance	1	1	4			Need to assess license status and who needs access
		- Licenses are renewed and updated on schedule	1	3	5			
		- Systems suffer minimal downtime	1	2	3			
		- Employees have access to the right applications	1	4	5			
Standardize (Seiketsu)	Guidelines and practices are established to maintain first three steps	- 5S activities and locations are clearly outlined	1	2	4			Put 5S responsibility RACI on Shared Drive - arrange for automatic emails
		- Audit forms and checklists exist	1	4	5			
		- There is a 5S schedule & responsibilities are clear	1	4	5			
		- Quantities and limits are clearly marked	1	3	3			
Sustain (Shitsuke)	5S is a habit that people incorporate into their daily practice	- Leadership enforces 5S habits	1	4	5			Put 5S Progress Tracker on the Shared Drive
		- There is accountability for ongoing 5S practices	1	3	5			
		- 5S results are prominently displayed	1	2	5			
		- Employees are recognized for 5S practice	1	2	4			
		Total Score	20	55	85	0	0	

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Standardized Work – Standard Operating Procedures (SOP)

Without a standard there is no logical basis for making a decision or taking action. The SOP describes what items or tools are required and the sequence of the process activities. The SOP also clearly describes what final product should look like and what quality checks need to be performed on the product. The SOP mentions the cycle time for the process step, which means that it defines how long the employee is expected to work at their operation step before the product is passed on to the next operation step. If applicable, it also includes how much raw materials or components should be on hand at the operational step and how often component levels must be replenished.
For service organizations, SOP includes how information should be documented and archived at the server. It also includes what standard documents, templates and revision numbers should be used.

Who Creates? How Often should SOP be reviewed or changed?

Quality Management – Quality Planning, Quality Assurance and Quality Control

It is essential for organizations to effectively manage customer satisfaction by meeting the needs and expectations of its clients and applicable legal requirements. Each organization should be able to manage its business processes properly. The quality procedures should be made known to all employees and they should work according to the agreed procedures. The Quality Management System – QMS is a set of policies, processes and procedures required for planning and execution (product/development/service) in the core business areas of an organization, such as areas that can impact the organization's ability to meet customer requirements.

What is Quality Planning (How to fulfil)?

What is Quality Control (detection)?

What is Quality Assurance (prevention)?

A project team is tasked with documenting the way in which a process should be operated. The team have been empowered by the Champion to define the various steps in the form of a Standard Operating Procedure (SOP).

Which step should **NOT** be taken by the project team to ensure the SOP is correctly described?

a) The employees working at the Gemba define how each step will operate
b) The operating step Cycle Times are calculated and recorded
c) The final product and required quality checks are defined
d) The SOP will remain unchanged until the next scheduled change point

When applying the 5S technique, Employee 'A' has left a note on an old filing cabinet, stating that it is empty and should be removed. Employee 'B' has added a comment to the note suggesting that the cabinet should be moved to another area of the office where it is much needed.

In which step of the 5S technique will the decision be made whether to remove or retain the cabinet?

a) Sort
b) Straighten
c) Shine
d) Standardize

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Paper Plane Activity

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Chapter 5: Level 2 – Creating a Continuous Improvement Culture

The second level is about creating a culture of proactive problem solving and Continuous Improvement activities. At this level we adhere to the Kaizen philosophy of Masaaki Imai. This is about creating a bottom-up approach with the objective that many small improvements will be executed by employees at the 'Gemba', rather than by top-down breakthrough improvement projects and change projects guided by project managers or management.

The idea behind this is that, by realizing a large number of small improvements, a big improvement has actually been made. This can be achieved by implementing short daily stand-up meetings with all people involved to discuss the daily output, issues and agreement on the actions that need to be taken.

The most commonly applied approach for problem solving at this level is the PDCA cycle, which stands for Plan-Do-Check-Act.

This session will cover:

- Kaizen and other useful tools
- Basic management tools

Kaizen

Kaizen focuses on Continuous Improvement. A Kaizen event is typically about a small improvement project, like Waste elimination and Cycle time reduction. Kaizen is about team work and empowerment. It is carried out at the place where it happens: 'the Gemba'. When problems occur you should 'Go to the Gemba' rather than looking for soloutions behind a desk or in a meeting room.

Examples of Kaizen are:

- Improving equipment set up and tooling change
- Improving ergonomics and safety
- Improving quality
- Reduction of cost
- Designing bins and racks for storage of raw components and finished goods
- Designing forms, templates and inspection criteria
- Waste identification and elimination
- Problem solving activities to prevent quality issues

What are the principles of Kaizen and discuss?

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A typical Kaizen event is the Kaizen Blitz. It is the most well known and most effective way of achieving immediate and obvious gains within any environment (service or manufacturing). The Kaizen Blitz event takes from a few days to a week and is led by a facilitator (e.g. Lean Facilitator, supervisor or external consultant). The team focuses on one specific area. Typically a Kaizen Blitz concentrates on the removal of the eight types of "waste". The strength of any Kaizen approach is gaining the result within a short period of time.

Methods and Tools that can be used for Kaizen Events

Scrum, Short Interval Meetings, Visual Workplace:

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Root Cause Analysis

Brainstorming Techniques:

- Affinity diagram
- 5 Whys method
- Cause & effect diagram (Ishikawa)

Example of 5 Whys:

1. Why did the machine stop during production?
   - The drive chain is broken
2. Why is the drive chain broken?
   ➔ The bearings have been broken
3. Why are the bearings broken?
   ➔ The bearings have run dry
4. Why are the bearings run dry?
   ➔ The lubricating oil pipe to the bearings is broken
5. Why is the lubricating oil pipe broken?
   ➔ A pallet truck has hit the lubricating oil pipe
6. Why did the pallet truck hit the lubricating oil pipe?
   ➔ The oil pipeline runs unprotected outside the machine

Solution: Move the lubricating oil pipe or place a guardrail

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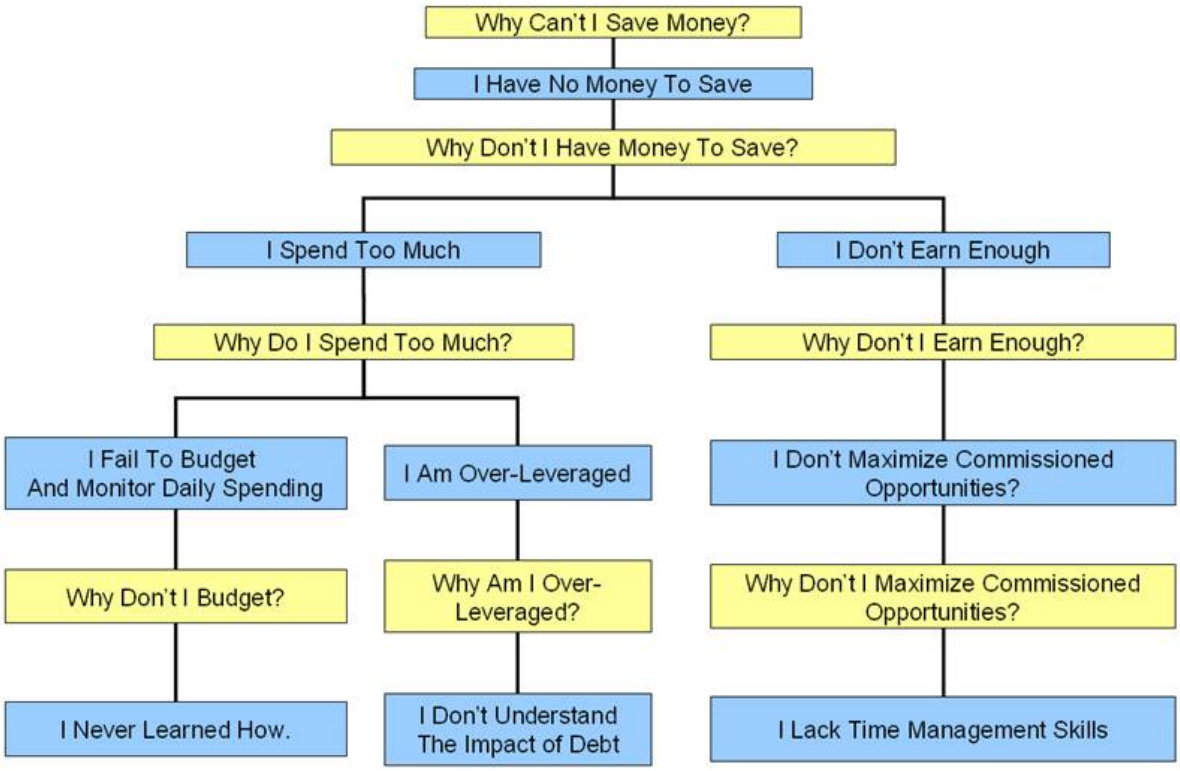
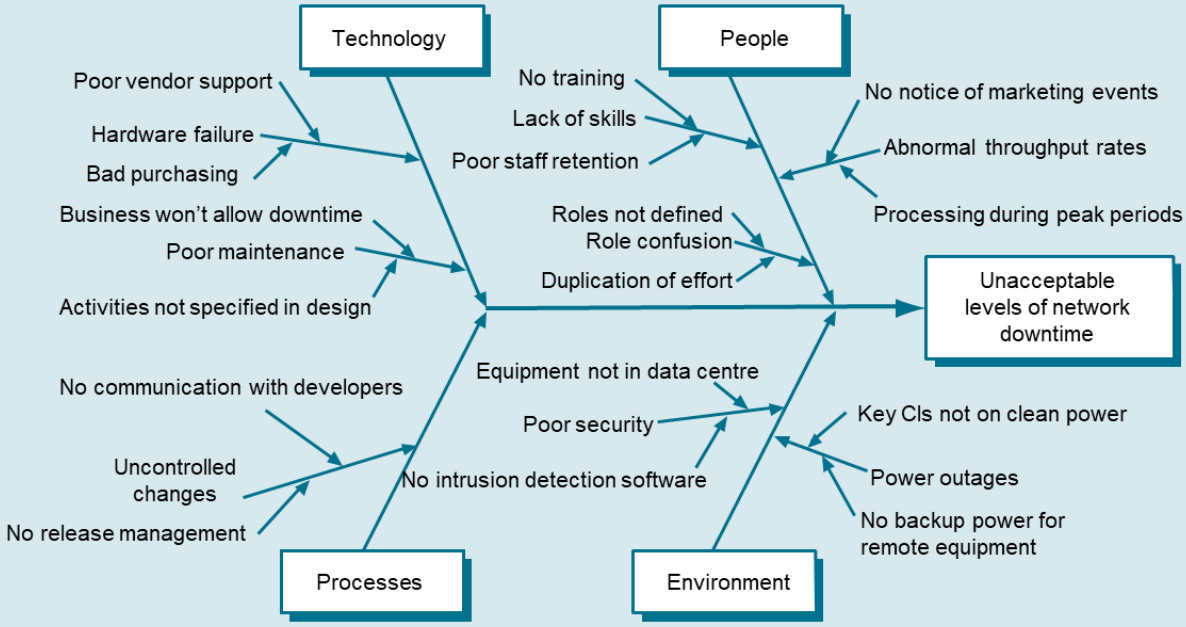


Ishikawa diagram showing possible causes



Prompt List can be used here such as:

- Manufacturing – technology or equipment related causes
- Method – process related causes
- Materials – raw material or information
- Man – causes related to people or employees
- Measurement – causes related to measurement tools or inspection methods
- Mother nature – environmental causes

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Decision making

The 'Cause and Effect Matrix' (C & E Matrix) is a powerful tool in the decision making process. It shows the strength and relationship between the factors of influence (causes) and responses (results or effects). It is not a process mapping tool, but it connects the process input variables to the process output variables. The process steps are listed in the left side of the matrix.

Step 1: Enter the output variables or effects (Key Process Output variables – KPOV)
Step 2: Enter the specifications of the outputs or requirements (from the CTQ – Tree)
Step 3: Indicate the importance of each output for the customer or for the organization (1 – 10)
Step 4: Enter the factors of influence or causes (Key Process Input variable – KPIV)
Step 5: Define the correlation between the inputs and outputs
Step 6: Calculate the total score for each KPIV

		Rating Customer Importance:	10	9	6	7	9		3			
			1	2	3	4	5	6	7	8	9	10	
		KPOV: Key Process Output Variables (Customer requirements)	Clean clothes	Clothes smell good	Wrinkle free	No shrinkage	No dye run			1			Total
	Proces Stap	KPIV: Key Process Input Variables											
1	Man	Laundry sorted	9			9	9						234
2	Man	Operator			3								18
3	Method	Stains pre-treited	3				3						57
4	Method	Load size	3		9								84
5	Measurement	Cycle used	3		3	9	9			5			192
6	Measurement	Wash temperature	9			9	9						234
7	Milieu	Water hardness	3										30
8	Material	Softner used	3	9	9								165
9	Material	Detergent	9	9	3		3						219
10	Machine	Washer type	9		3								108
Total:			510	162	162	210	297	0	0	0	0	0	
		Low Spec											
		Target								2			
		Upper spec											

Activities:

An employee has been tasked with facilitating a Kaizen Blitz event on the returns area in a retail outlet. What level of employees within the organization should, in any case, be invited to participate in this event?

a) Chief executive officer and senior management
b) Shop floor employees
c) Employees that are NOT from within the affected area
d) Middle management

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A brainstorm session has used a herringbone diagram to capture the potential reasons behind a persistent defect in the manufacture of a plastic bottle. Which of the following should be captured under the heading 'Material'?

1. The weighing scale used to measure component quantities is faulty
2. Different batch sizes from the component supplier vary each week
3. The chemical used to bind components is not strong enough
4. The recycled plastic chips are of inconsistent quality

a) 1, 2, 3
b) 1, 2, 4
c) 1, 3, 4
d) 2, 3, 4

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Chapter 6: CIMM Level 3 – Creating Stable and Efficient Processes

During the first two Continuous Improvement maturity levels the workplace has been organized, standards have been determined and a system has been put in place to solve problems and to continuously work on improving the operation. The third maturity level focuses on improving the logistical flow and making it stable, efficient and predictable. The main purpose of creating stable processes is intended to avoid incidents, stress, fire-fighting, downtime, unsafe situations, quality slips, mistakes, etc. In order words the creation of an environment where you can predict what will happen and what can be promised to the client.

The roadmap used in this level is the DMAIC roadmap. Although the origin of this roadmap is from Six Sigma, it can be followed in Lean projects as well.

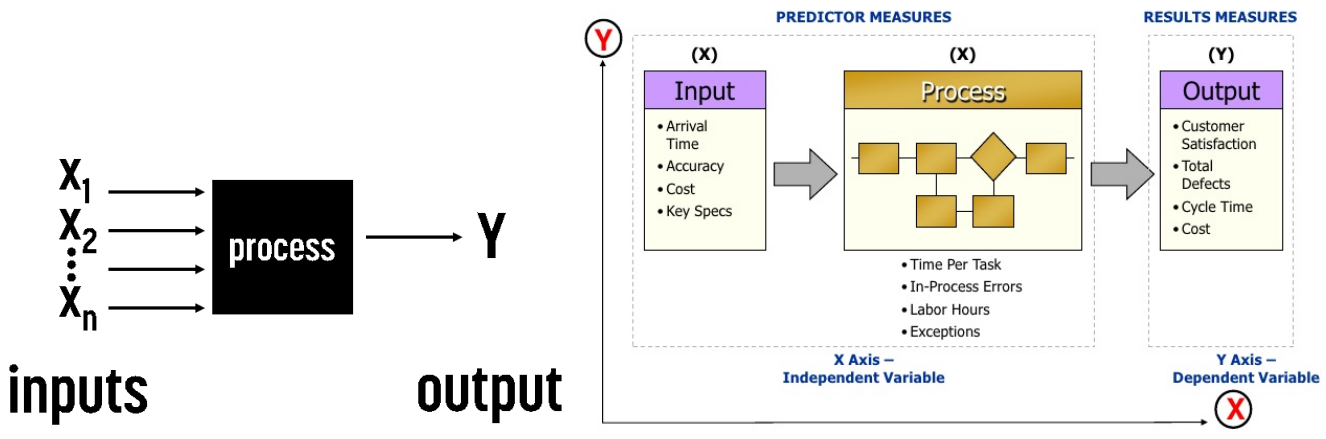
A number of tools that can be used at this CIMM-level are demonstrated here. Please be aware that the list is not exhaustive. Other tools can be used as well.

Define	Measure	Analyze	Improve	Control
Project Charter	Performance Metrics	VSM - Current State	VSM - Future State	Standardized Work
Voice of Customer	Time Series Plot	Graphical Tools	Kaizen improvements	5S
Costs of Poor Quality	OEE Analysis	Ishikawa	Reducing Muda (8 x Waste)	First Time Right, Poka Yoke
SIPOC		Brainstorm Techniques	Reducing Muri (Overburden)	Jidoka
Process Mapping		Affinity Diagram	Flow, Balancing, TOC	Visual Management
Swimlane			Reducing Mura (Unevenness)	Performance Management
Pareto			Pull, Kanban, FIFO, CONWIP	Short Interval Management
CTQ Flowdown			Levelling	FMEA, Control Plan
Stakeholder Analysis			SMED	Standard Operation Procedure
				Training (Skill development)
				Maintenance (TPM)
				Statistical Process Control
				Auditing

Define Phase

What is a process?

A process is a systematic series of activities that are required to to achieve a goal. The series of activities uses one or more types of input and creates outputs with added value for the customer. Charting the process in a visual representation will work like a map to guide the team.



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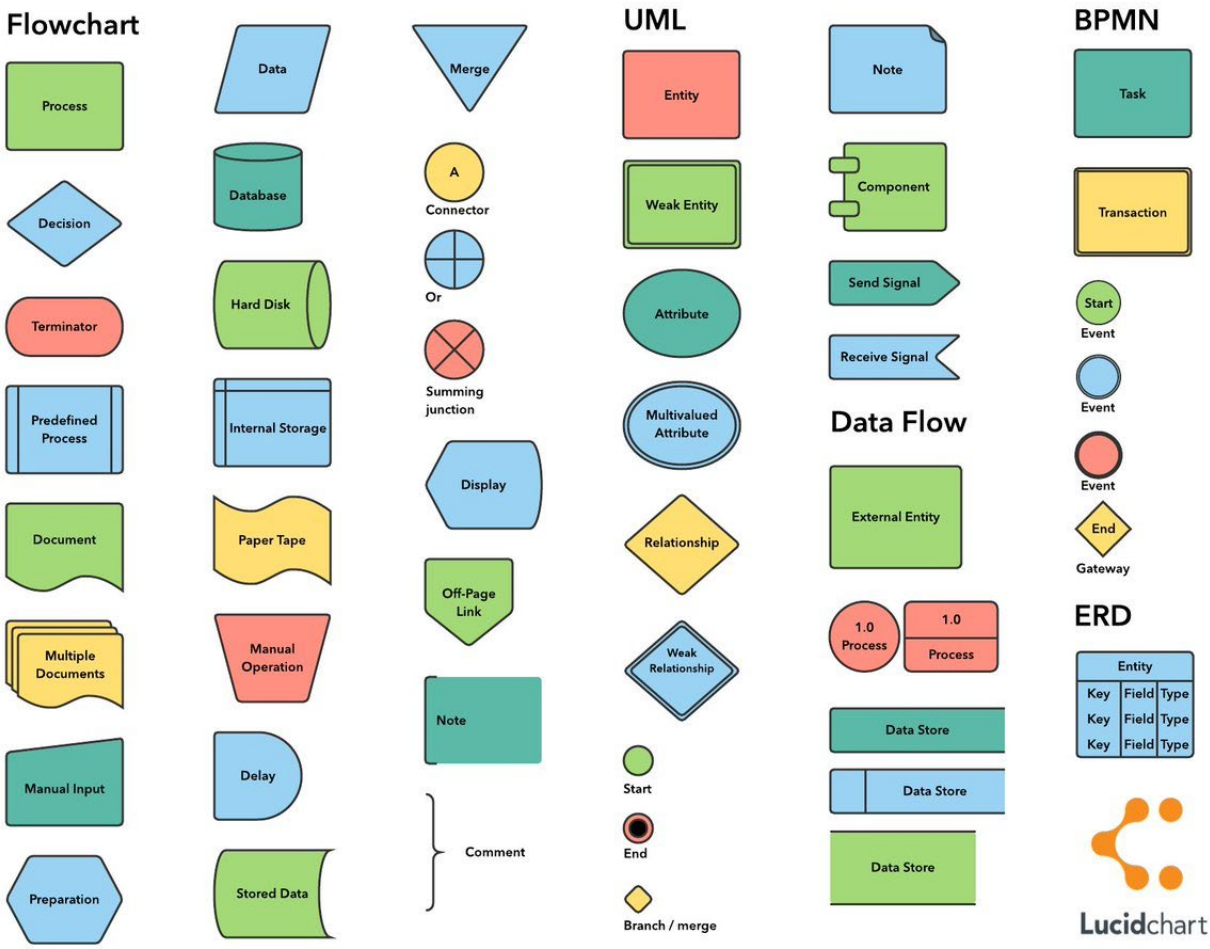
Create a Process Flow Diagram for Pizzeria Process what include these activities:

At High-level:

1. Deliver pizza
2. Take order
3. Package pizza
4. Make bill
5. Prepare pizza
6. Bake pizza

More detail from Pizza Chef perspective:

1. Prepare box
2. Remove from oven
3. Roll dough
4. Deliver
5. Take order
6. Pack pizza
7. Scrap
8. Test OK?
9. Add Cheese
10. Ingridients
11. Put in oven



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Process Flow Diagram

A Process Map or Flow Chart or Process Flow Chart Diagram (PFD) is a diagram commonly used to indicate the general flow of activities carried out on the product and decisions to be made. A process flow is also a graphical representation of the routing of the product. In 'Process thinking', it is important to understand what happens in the company and to understand how the work is done. Mapping the process is a way to indentify and reduce waste in the process. Process maps can be used:

- to communicate the process
- to define the scope of a project
- to describe and understand the processes
- to document and standardize the process
- to define responsibilities and competencies
- to analyze the processes / problems
- to identify improvement opportunities

Process Map

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Swimlane:

A Swimlane Flowchart is a visual representation of the process with the purpose to distinguish responsibilities for sub-processes within the overall process. Very often activities within a department or under the responsibility of a person are distinguished by the use of horizontal or vertical 'Lanes'.

By drawing business process in a Swimlane Flowchart, the opportunity for improvement becomes obvious.

Swimlane

High-level process description (SIPOC and Spaghetti Diagram)

SIPOC and Spaghetti diagrams are used for describing the process at a high-level. The Spaghetti diagram is often used in Lean projects, while the SIPOC is often used in Six Sigma projects.

SIPOC helps with:

- A high level process description (P)
- Identification of suppliers and customers (S/C)
- Identification of inputs and outputs (I/O)

Spaghetti Diagram:
An organized environment can still mean 'Chaos' in operation. A Spaghetti diagram can be helpful to track the routing on the shop floor. It visualizes movement and transportation of a product or document. Analyzing flows through systems can determine where time and energy is wasted and identify where streamlining would be beneficial.

SIPOC Diagram

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Measure Phase

Within the Measure phase the gap between the current performance and the required performance is defined. The purpose of the Measure phase is to make the project objectives tangible and measurable. Within Lean projects the target of the objective should be related to a high level KPI for Quality, Delivery or Costs like On Time Delivery (OTD); Net Promoter Score (NPS); Overall Equipment Effectiveness (OEE); Cost of Poor Quality (COPQ), etc.

Lean Performance Metrics

Metric	Definition

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Analyze Phase

Value Stream Analysis (Current State)

The objective of 'Value Stream Mapping' (VSM) is to reduce Lead Time and eliminate Waste. Value Stream Mapping is a technique that is used to analyse the series of activities to manufacture a product or to complete a service. It can be applied to nearly any value chain. Very often it is the first step of each Lean initiative or improvement initiative.

VSM was pioneered in the 1980s by Toyota chief engineer Taiichi Ohno and Sensei (teacher) Shigeo Shingo, with the intention to gain competitive advantage.

A value stream is defined as the series of all activities required to deliver a product service. Examples for a Value Stream are:

- From raw material to customer delivery
- From product concept to product launch
- From customer demand to delivered service

The purpose of VSM is to visualize the process and distinguish the Value Adding Activities (VA - customer willing to pay for it) from Non-Value Adding Activities (NVA – customer not willing to pay) and Necessary Activities (necessary for the process).

VA must meet the following criteria:

1. The customer is willing to pay for the activity
2. It Must be done correctly the first time (First Time Right)
3. The action must change the product or service in some way.

If one of the criteria is not met, it is classified as NVA and therefore as a waste, which should be eliminated.

Necessary activities are needed to keep the process running. These activities cannot be taken out of the process easily, but should be limited as much as possible. An example is inspection.

Group Activity

Our client is Stanbic IBTC bank ordering 200,000 cheque booklets per month.

There are 500 trays per pallet with 200 cheque booklets per tray.
The factory plant is producing in 3 shifts with an average of 20 days per month. The break time for each 8-hour shift is 20mins.

Volume of each process step is scheduled by the business system. We receive a 30, 60 and 90 days forecast from our client Stanbic IBTC. Orders by client are given every 2 weeks. A forecast to the supplier of printing paper is once every 8 weeks. Orders for printing paper are given to the supplier every 2 weeks.
Shipment of the finished goods to client by truck every two weeks. Delivery of printing paper is done once every four weeks by supplier.
The production process consists of the following five steps:

1. Component 1 – done by Operations
2. Component II – done by Finance
3. Component III – done by Assembly Line
4. Component IV – done by Assembly line
5. Testing & Packaging – done Distribution department

Process Steps	Cycle time	VACT	VNACT	Yield %	Distance	Inventory
Component I	6sec	2 sec	4sec	100%	50m	350000
Component II	10 sec	6sec	4sec	100%	3m	35000
Component III	9sec	3sec	6sec	100%	7m	17500
Component IV	7sec	4 sec	3sec	100%	5m	8500
Testing & Packaging	2sec	1sec	1 sec	95%	12m	22500
Shipping						180000

Can you create Current Value Stream Map for the process by following the steps provided on the screen?

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Value Stream Mapping Continues

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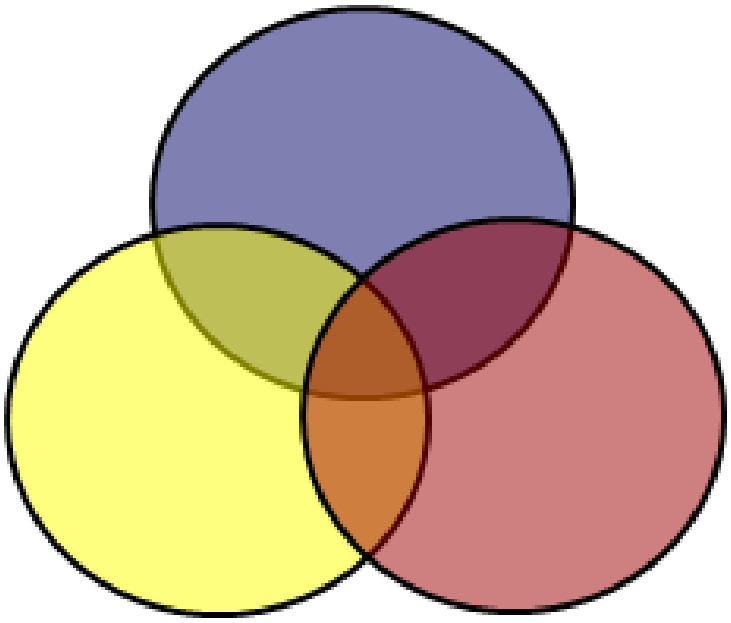
Improve Phase

Reducing the 3M's

Within the Toyota Production System the following three types of variation can be distinguished.
Muda: Waste uselessness, non-value added or idleness
Muri: Overburden, impossible, beyond one's power or excessiveness
Mura: Unevenness, irregularity or lack of uniformity

These are called the 3Ms of Lean. The reduction of these is fundamental within Toyota Production System to increase effectiveness and profitability.



Reducing Muda (Waste - TIMWOODS)

Waste	Explanation

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Waste in Transaction processes (Bicheno and Holweg, 2009)

Waste	Explanation

Reducing Muri (Overburden)

Reducing Muri can be achieved by producing according Takt Time and implementing 'Flow' and Standardized Work. Flow should be observable and every process step must be reduced to its simplest elements or components. Muri can only be avoided by not pushing equipment or employees to the edge of what they are capable of. Working overtime for a longer period, bad ergonomics and postponing preventive maintenance will increase Muri.

We will cover the following in this session:

- Flow
- Work Balancing
- TPM
- OEE
- Competency Management

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Total Productive Maintenance or Management (TPM)

TPM focuses on the effective and efficient use of equipment, by avoiding breakdowns, delays and machine-related rejections.

TPM Areas	Definitions
	Applies manufacturing process to planning processes, resourcing, documentation or procedures
	Applies lessons learned about maintenance into new equipment development, design and implementation before they are installed in the plant.
	Periodic maintenance, inspection based maintenance, condition monitoring and corrective maintenance
	Focus is on Zero Waste, Zero Breakdowns, Zero Defects and Zero Accidents as objectives. Driven by OEE performance measure.
	Ensures that the approaches used to achieve manufacturing performance improvement are equally applied to Safety, Health and Environmental issues.
	Production system that is incapable of producing quality defects, e.g. using mistake proofing
	Addresses the knowledge gaps amongst the workforce and management
	Making operators responsible for their piece of equipment and tooling

Overall Equipment Effectiveness (OEE)

A piece of equipment has been scheduled to be available for 22.5 hours a day. It breaks down for 1 hours and the waiting time is 2 hours. The equipment was originally designed to produce 480 pieces per hour. After observing the equipment for one hour without idle time and breakdown, we count 428 pieces finished goods. We observed the quality of the equipment over a longer period and count the amount of good products and amount of products that were not First Time Right (Scrap and rework). Assume we count 4320 product in total (good and bad) and we count 3892 good products.

Calculate the following:

- Availability Rate
- Performance Rate
- Quality Rate
- OEE

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Reducing Mura (Unevenness)

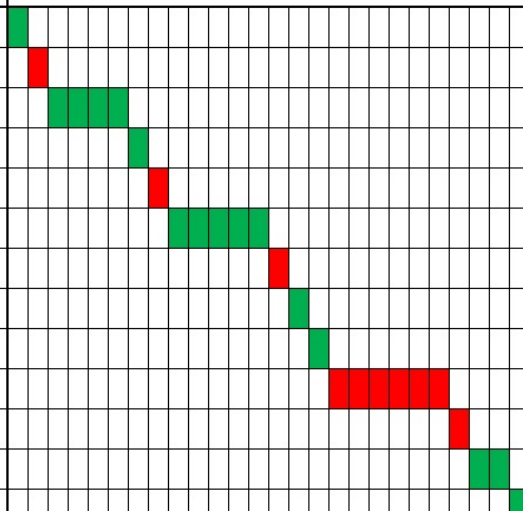
A common misunderstanding is that improving productivity is working faster. Lean however does not have the intention to treat every job as a sprint and to complete every task as soon as possible. Lean is not about increasing speed, but about reducing unevenness in speed in order to increase predictability. This will create a smooth and regular basis for further improvement initiatives.

"The slower but consistent tortoise causes less waste and is much more desirable than the speedy hare that that races ahead and then stops occasionally to doze. The TPS can be realized only when all workers become tortoise" Taiichi Ohno

Unevenness in production is called Mura. Reducing Mura can be achieved by:

- Pull vs Push
  - Kanban
  - Two-bin system
  - FIFO Lane
  - Scheduling the pacemaker
  - Theory of constraint
- Volume and Type Levelling
  - Heijunka
  - One-piece Flow
  - Lowering the water level
  - CONWIP
- SMED

Step No.	Description	Time	Cum.	I or E
1	Switch off power at board	1	1	I
2	Fetch allen keys from tool draw	1	2	E
3	Remoce 6 allen bolts from main guarding	4	6	I
4	Remove main guarding	1	7	I
5	Fetch 13mm wrench from tool draw	1	8	E
6	Remove 4 bolts holding main tool	5	13	I
7	Fetch screwdriver from tool draw	1	14	E
8	Revove air pipe from tool	1	15	I
9	Remove water pipe from tool	1	16	I
10	Fetch tool removal hoist	6	22	E
11	Find lifting eyes	1	23	E
12	Connect lifting eyes to tool	2	25	I



Value Stream Improvement

1. What sources of Waste can be identified?
2. Where can we implement continuous Flow
3. Where do we need pull systems (Kanban) to manage upstream production processes?
4. What is the pacemaker in our process?
5. How often do we release work at the pacemaker process?
6. How do we level the workload?
7. How do we level the production mix?
8. Which improvements do we need to become more Agile?
9. How can we prevent failures and deliver 'First Time Right'?

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Control Phase

Process Failure Mode and Effect Analysis (PFMEA)

FMEA is structure risk analysis method that is used to identify potential failure modes in processes, products or services and to plan actions so that the negative effects will be minimized.

Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	Sev	Potential Cause(s)/ Mechanism(s) of Failure	Prob	Current Design Controls	Det	RPN	Recommended Action(s)	Responsibility & Target Completion Date	Actions Taken	New Sev	New Occ	New Det	New RPN
Seals															
Coolant containment. Hose connection. Coolant fill. M															
Sensor mount. Seal	Compression set	Leak	8	Gasket material	7	Pressure cycle w/cold shock.	1	**56**	Use imported material						
Sensor mount. Seal	Loosen during sensor assembly/service	Leak. Fall inside tank	8	Fitting not held in place	2	Added rib.	1	**16**	Implement holding rib in design. New fitting design. Prototype validation.	J.P. Aguire 11/1/95					
Sensor mount. Seal	Damaged internal thread	Cannot install sensor	5	Damaged during installation or transportation	2		1	**10**							

AIAG Compelled Rating			
Rating	Severity of Effect	Likelihood of Occurrence	Ability to Detect
10	Hazardous without Warning	Very high; Failure is almost inevitable	Can not detect
9	Hazardous with Warning	Very high; Failure is almost inevitable	Very remote chances of detection
8	Lose of primary function	High; Repeated failures	Remote chances of detection
7	Reduced primary function performance	High; Repeated failures	Very low chances of detection
6	Lose of secondary function	Moderate; Occasional failures	Low chances of detection
5	Reduced secondary function performance	Moderate; Occasional failures	Moderate chances of detection
4	Minor defect noticed by most customers	Moderate; Occasional failures	Moderate high chances of detection
3	Minor defect noticed by some customers	Low; Relatively low failures	High chances of detection
2	Minor defect noticed by discriminating customers	Low; Relatively low failures	Very high chances of detection
1	No effect unlikely	Remote; Failure is unlikely	Almost certain

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Control Plan

Another important FTR Tool is the Control Plan which follows the steps of the process PFMEA. The PFMEA identifies what controls will be placed in the production process to catch any defects at various stages in the process. The control plan provides details on how the potential issues are checked. This can be applied to incoming quality, the assembly process and to end of line inspections of finished goods.

1			2				3					4
Part/ Process Number	Process Name/ Operation Description	Machine, Device, Jig, Tools, for Mfg.	Characteristic			Special Char Class	Methods					Reaction Plan
			No.	Product	Process		Product/ Process Specification/ Tolerance	Evaluation/ Measurement Technique	Size	Freq.	Control Method	

Jidoka and Poka Yoke

Poka Yoke is a Japanese term that means 'Mistake-proofing' designed to prevent human errors. It was originally called 'Fool-proofing' or idiot-proofing', but later on it was changed to be 'Mistake-proofing' to help focus on the process and maintain respect for the person.

Poka Yoke refers to any constraints designed into the process or product to prevent incorrect operation by the user. Its purpose is to eliminate product defects by preventing, correcting, or drawing attention to human errors as they occur.

Jidoka is the principle that every person is authorized to stop the line when a quality problem occurs. Actually, its each person's obligation to stop the line when he/she observes a problem.

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Chapter 7: CIMM Level 4 – Creating Capable Processes

The fourth level focuses on reducing variation in the stable process that is created in the first three levels. The objective is to increase the capability of the process performance. Rather than increasing quality with a step-by-step approach like Kaizen approach, Six Sigma focuses on quality breakthrough improvement projects. A six Sigma improvement project will take a few weeks or few months rather than few days. As a consequence, the Six Sigma approach is much more top-down driven than the Kaizen bottom-up approach.

At this level we will apply Six Sigma and Statistical tools, to analyze the performance of processes. In order to apply statistics, data will be needed. Therefore, at this stage, it is important to have a performance measurement system in place that is able to deliver process performance data at the level of the products or services that are produced.

Green and Black Belts are expected to analyze the data by using statistical softwares like Minitab or other software. We will use Minitab in this course. Yellow Belts are expected to understand and interpret many of these graphical outputs, but are not expected to generate them or analyze the data.

A number of tools can used at this CIMM level, here are some examples. Other earlier levels' tools can used as well. The list is not exhaustive.

Define	Measure	Analyze	Improve	Control
Project Charter	Performance Metrics	Graphical Tools	Design of Experiments	First Time Right, Poka Yoke
Voice of Customer	Time Series Plot	Ishikawa	Reducing variation CTQ	FMEA, Control Plan
Costs of Poor Quality	Measurement System Analysis	Brainstorm Techniques	Reducing Muda (8 x Waste)	Training (Skill development)
SIPOC	Attribute Agreement Analysis	Hypothesis testing	Reducing Muri (Overburden)	Statistical Process Control
Pareto		Process Capability Analysis	Reducing Mura (Unevenness)	Auditing
CTQ Flowdown		Exploratory Data Analysis	Design for Excellence (DfX)	
Stakeholder Analysis		Regression Analysis		

Define Phase

Critical to Quality (CTQ)

One of the first tools in the Define phase of a DMAIC project is that we have to compare a CTQ Flowdown based on the Voice of the Customer.

Critical Requirements

The Voice of Customer requirements are often expressed in an unclear manner. It is our task to interpret this into an unambiguous and measurable specification of the requirement. This metric is called the external Critical to Quality (CTQ_{ext})

VOC: Customer Requirements	CTQ_{ext}: Customer specification
On time Delivery	14 days between order and delivery
Accurate	Maximum tolerance +/- 2%
No damage	No scratches / Ra = 0.01
Good process	Yield > 98%

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CTQ Flowdown

After defining the critical requirements from the customer, it is necessary to translate the external CTQ to an internal CTQ.

The external CTQ is the metric that is related to the customers' requirement or complaint.

The internal CTQ is the metric that is related to what we measure in our product or process to verify the quality of the product or service.

Defining the proper CTQs is crucial for the Lean Six sigma project because the CTQ_{int} becomes the thread throughout the entire LSS project. Focusing on an incorrect CTQ_{int} will result in a lot of effort but not in improved customer satisfaction. A helpful tool for this is the CTQ Flowdown. A CTQ Flowdown represents the key measurable characteristics of a product or process whose performance standards or specification limits must be met in order to satisfy the customer requirements. The LSS project is focusing on a limited number of CTQ_{int}s, ideally even a single CTQ_{int}. and improvement effort or design effort should be aligned to these measurable customer requirements.

Define	The CTQ_{int} is measurable characteristic that is representing the customer's need
Measure	The CTQ_{int} should be measured properly and CTQ_{int} data should be available and reliable
Analyze	Potential factors of influence on the CTQ_{int} should be identified and investigated. The capability of the CTQ_{int} performance against the customer specifications should be analyzed.
Improve	The negative effect of factors that have a significant influence on poor CTQ_{int} performance should be eliminated or decreased
Control	The improved performance of the CTQ_{int} should be verified and controlled

The Flowdown consists of the following:

1. The characteristic of the product/service to be measured. The 'hard' (measurable) metric of the 'soft' CTQ description
2. The measurement procedure. Includes the instrument that is used and data collection procedure to follow.
3. The requirements on the $CTQ_{int.}$ The specification for the measure that determines (without discussion) if the VOC is met or not.

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Measure Phase

Six Sigma Performance Metrics

Defects and Defectives

1. PPM – Parts per Million
2. DPU – Defects per Unit
3. DPMO – Defects per Million Opportunities
4. Yield – Percentage of good products
5. Rolled throughput Yield – Probability a unit will pass a number of sequential process steps without any defect.

Process Step	Input	Scrap	Rework	Output
A	80	5	3	75
B	75	5	4	70
C	70	10	4	60
D	60	10	5	50

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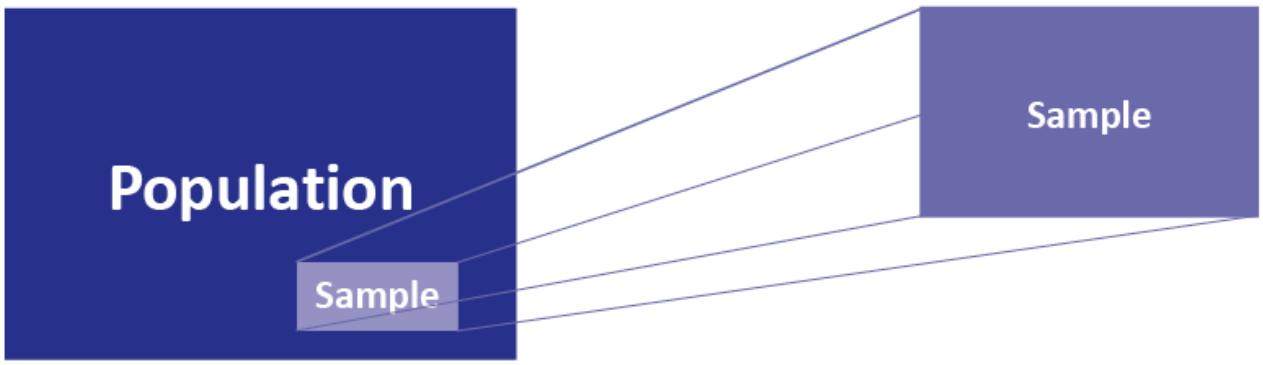
Statistics

Statistics is the stud of the collection, organization, analysis, interpretation and presentation of data. Statistics deals with all aspects of data including the planning and execution of experiments, the collection of data and analysis of the data.



Sampling Methods and Tools

DataType

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Measurement System Analysis

Visualization of Data

1. Check Sheet
2. Pareto Chart
3. Scatter Plot
4. Bar Chart
5. Pie Chart
6. Time Series Plot
7. Histogram
8. Box Plot

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Descriptive Data

Centre of Tendency

1. Mean
2. Median
3. Mode

Measure of Spread

1. Range
2. Interquartile Range
3. Variances
4. Standard Deviation

Distribution (Shapes)

1. Normal Distribution
2. Anderson Darling Test
3. Z-Transformation
4. Student T Distribution
5. Chi-square distribution
6. F-Distribution
7. Weibull Distribution
8. Lognormal Distribution
9. Exponential Distribution

Discrete Distribution

1. Bernoulli Distribution
2. Binomial Distribution
3. Hypergeometric
4. Poisson

Transformation

Central Limit Theorem
Data Transformation on non-normal data – Box cox and Johnson

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Analyze Phase
Hypothesis Testing and Confidence Intervals

Hypothesis testing

p-value – if p is low Ho must go

Confidence intervals and Significance Level

Sample size = $(1.96S/delta)^2$

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Test for Means, Variances, Proportions and Medians

In the following sections, we will review the most common hypothesis tests. There are many different tests to investigate the difference between population mean; difference in proportion; difference in count or difference in variances.

1. 1-Sample Z
2. 1-Sample t-test
3. 2 Proportion test
4. Test for equal variances
5. Chi-square test
6. Goodness of Fit test
7. Non-parametric tests

Hypothesis Tests	Explanation
1-Sample Z-test	The test is used to compare the average of the one sample against a specific target when the population standard deviation is known or very well estimated. **Example:** Measurements were made on the volume of bottles of Cola. We want to test whether the population's average volume is statistically different from 300ml. We know that the distribution of volume has historically been close to normal with σ = 3.0ml. Since σ is known, we will test using the 1 sample Z-test. H_o: $\mu_o = 300$ (Volume mean is 300ml) H_A: $\mu_o \neq 300$ (Volume mean is not 300ml)
1-Sample t-test	The 1 Sample t-test is used to compare the average of one sample against a specific target when σ is unknown. The only difference between the Z-test and t-test is that the t-statistics estimates standard error by using the sample standard deviation, while the Z-statistics utilizes the historical population's standard deviation. H_o: $\mu_o = 300$ (Volume mean is 300ml) H_A: $\mu_o \neq 300$ (Volume mean is not 300ml)
2 -Proportion test	A 2-proportion test is used to compare two Binomial proportions in order to answer whether the two proportions are equal or not. Two statistical test can be used. The first one is the 'Fisher exact test', the second test is using a normal approximation. The normal approximation can be used for large sample sizes and is used in the following example. Example: Two machines are minting Euros. A black Belt wants to know whether both minting machines produce an equal percentage of non-confirming coins. He selects from both machines 1000 coins. In one sample he finds 8-non-concorming coins and in the other sample he finds 20. The Black Belt performs a 2-proportion test on this result to verify if there is a difference between both minting machines H_o: $p_1 = p_2$ (there is no difference between both machines) H_A: $p_1 \neq p_2$ (there is difference between both machines)
Test for equal Variances	A 'Test for Equal Variance' is used to test if two populations' variances (or standard deviations) are equal or not.

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	For each test, the null hypothesis states that the two variances are equal. Sometimes, the null hypothesis for testing equal variance is written as: H_o: $\sigma_1^2/\sigma_2^2 = 1$, which is the same. Therefore this test is also called 'Ratio of Variances Example: A study is made to investigate the difference in recovery time after medical treatment between men and women. H_o: $\sigma_1^2/\sigma_2^2 = 1$ OR $\sigma_1^2 = \sigma_2^2$ H_A: $\sigma_1^2/\sigma_2^2 \neq 1$ OR $\sigma_1^2 \neq \sigma_2^2$ If your observed value of F is larger than the value in the F-table, then you can reject the null hypothesis with 95% confidence that the variance between your two population is not due to random chance (significant).
Chi-Square test	A "Contingency Table" also referred to as "Cross Tabulation", is a table that displays the frequency distribution of nominal or categorical variables. For example we can review a diet and health issues. The question we try to answer is whether there is a significant relationship between type of diet and certain diseases.
Goodness-of-fit test	The Chi-Square 'Goodness-of-fit' test whether a dataset follows a multinomial distribution with certain proportions by calculating the Chi-square contribution of each category. This test can also be applied to continuous data by dividing both the dataset and expected response into bins and then comparing the frequency of observed data with the expected frequency within each bin. Example: When continuously rolling dice, the outcome of a fair dice would follow a uniform distribution because all six outcomes have equal probability. The expected probability is 16.7% for each outcome. We like to test if the dice is fair. We will test this by rolling the dice 100 times and apply the 'Chi-square Goodness-of-fit test' to determine whether the results follow the expected distribution. H_o: $P_1 = P_2 = P_3 = P_4 = P_5 = P_6$ (the dice is fair: each outcome has the same probability) H_A: $P_i \neq P_j$ (the dice is unfair: at least one outcome has a different probability)
Non-Parametric Test	Non-parametric tests can be used when no assumption can be made about the distribution of the population. These tests are also known as distribution-free tests. For example, many tests rely on the assumption that the population follows a normal distribution with parameters σ and μ. Non-parametric tests do not make this assumption, so they are useful when your data are strongly non-normal and resistant to transformation. For example, salary data are heavily skewed to the right, with many people earning modest salaries and fewer people earning larger salaries. Non-parametric test are often based on testing the median instead of the mean. The hypotheses are defined as: H_o: $\eta_1 = \eta_2$ (population medians are the same) H_o: $\eta_1 \neq \eta_2$ (population medians are not the same)

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	The following three non-parametric tests are commonly used: **Mann-Whitney test** Also called Wilcoxon rank-sum test or Wilcoxon-Mann-Whitney test is a 2-sample rank test that can be used to test the equality of medians of two populations. It is nearly as efficient as the 2-sample t-test on normal distributions. All observations from both groups need to be independent of each other and the distributions of both groups need to be equally shaped. **Kruskal-Wallis test** Can be used to test the equality of medians from two or more populations. An assumption for this test is that the samples are from the different populations are independent random samples from continuous distributions, with the distributions having the same shape. The Kruskal-Wallis test is more powerful than Mood's median for data from many distributions, including data from the normal distribution, but is less robust against outliers. **Mood's Median Test** Can be used to test the equality of medians from two or more populations. An assumption of Mood's median test is that the data from each population come from independent random samples and the population distributions have the same shape. Mood's median test is more robust against outliers and errors in data than the Kruskal-Wallis test.

Correlation and Regression

- Correlation coefficient
- Regression Analysis
- Non-linear regression

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ANOVA

A One-way ANOVA test is used to compare two or more sample means with each other. For comparing two means, the 2 sample t-test can be used as well as the ANOVA. The calculation method of the ANOVA technique is different, but the approach and interpretation of p-value is same.

One-Way ANOVA: hypothesis that the means of two or more populations are equal (1 factor)
Balanced ANOVA: when classification of treatments is by n factors

A good model has a R-sq greater than 70%. So we have to be careful when drawing conclusions if the figure is less than or equal to 70%.

Conditions applying ANOVA:

1. The sample must be randomly taken (all units in population have the same probability of being selected)
2. The samples must be mutually independent. If sample parameters are not dependent on parameters of other samples, then the samples are mutually independent.
3. Variances of all factor-level combinations have to be equal.
4. The residuals must be normally distributed.

Kruskal Wallis analysis can be used when the above conditions for ANOVA have not been met.

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Process Capability and Performance

Before undertaking a process capability study, it is essential that the process is stable. Additionally, we must know whether the process is producing normally distributed data.
We perform three analyses:

1. Stability: the first test is to identify if any special causes are acting on the process. Is the process stable? This is undertaken with a 'Run Chart'.
2. Normality: The second test is to identify whether the process is producing normal data. Is the process normal? This is completed with normality test.
3. Capability: Finally it is then possible to determine if the process is capable. Is the process capable of meeting customer or business requirements? This is completed with a process capability analysis.

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Improve Phase
Design of Experiment (DOE)

Terminologies	Explanations
OFAT	Some 'Classic Problem Solver' experts will tell you to change only one factor at a time. The traditional OFAT is inferior to DOE because OFAT experiments usually require more time consuming test runs and obtain only incomplete information regarding the process. OFAT does not reveal interactions between factors. This is still commonly used as an alternative to DOE.
Responses	'y' – outcome
Factors	'x' – variables
Levels	Settings (low, med, high)
Main Effects	The effect of a Factor is called Main Effect, which is the average response at level +1 minus the average response at level -1.
Interaction Effects	As mentioned the big advantage of DOE above OFAT is the ability to determine the interaction effect. The interaction is the combined effect of A and B on the response Y, which is called the A x B interaction. The interaction effect can be calculated as half the difference in effect of A on both B levels.
Interaction Plots	Like Main Effects, the interactions can be plotted. An Interaction plot always shows two lines. If the two lines are parallel, there is no interaction present. If the slopes of both lines are different to each other, then there is interaction, A statistical analysis of the data should determine if this interaction is statistically significant.
3 Factors	Cube
Transfer Function	A 'Transfer Function' Y = f(X) is mathematical representation and describes inputs and outputs of the "Black Box" model. Once quantified through Design of Experiments, the Transfer Function can be used to define and optimize the process.
Planning Experiments	
Full Factorial Experiment	Full Factorial experiments are DOEs and the designs consist of two or more Factors. Each of these factors are discrete possible values or 'levels'. These levels can take all possible values but with 2^k Full Factorial designs, each factor has only two levels, low and high. This is the reason that we call these types of designs 2^k Full Factorials where k is the number of factors and 2^k the number of test runs.

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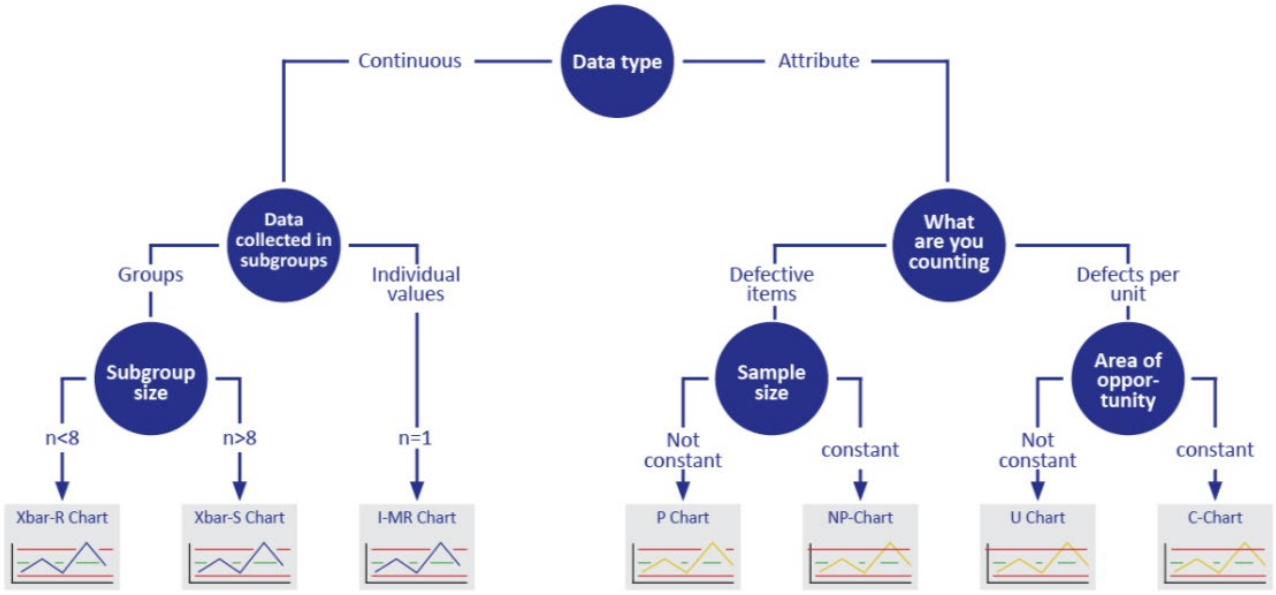
Control Phase

Statistical Process Control

The objective of the Control phase is that solutions that have been implemented to improve the process performance will be embedded in the process and organization, to assure that improvements will sustain after the project has been closed. This is a critical element to make a Six Sigma project successful.

The concept of Statistical Process Control (SPC) was introduced by Walter Shewhart in 1924 at Western Electric. Before that, products were tested and removed if defective. Shewhart used simple control charts for early detection of process variation. SPC helps to detect special cause variation. Special cause variation that cannot be explained by common causes alone.



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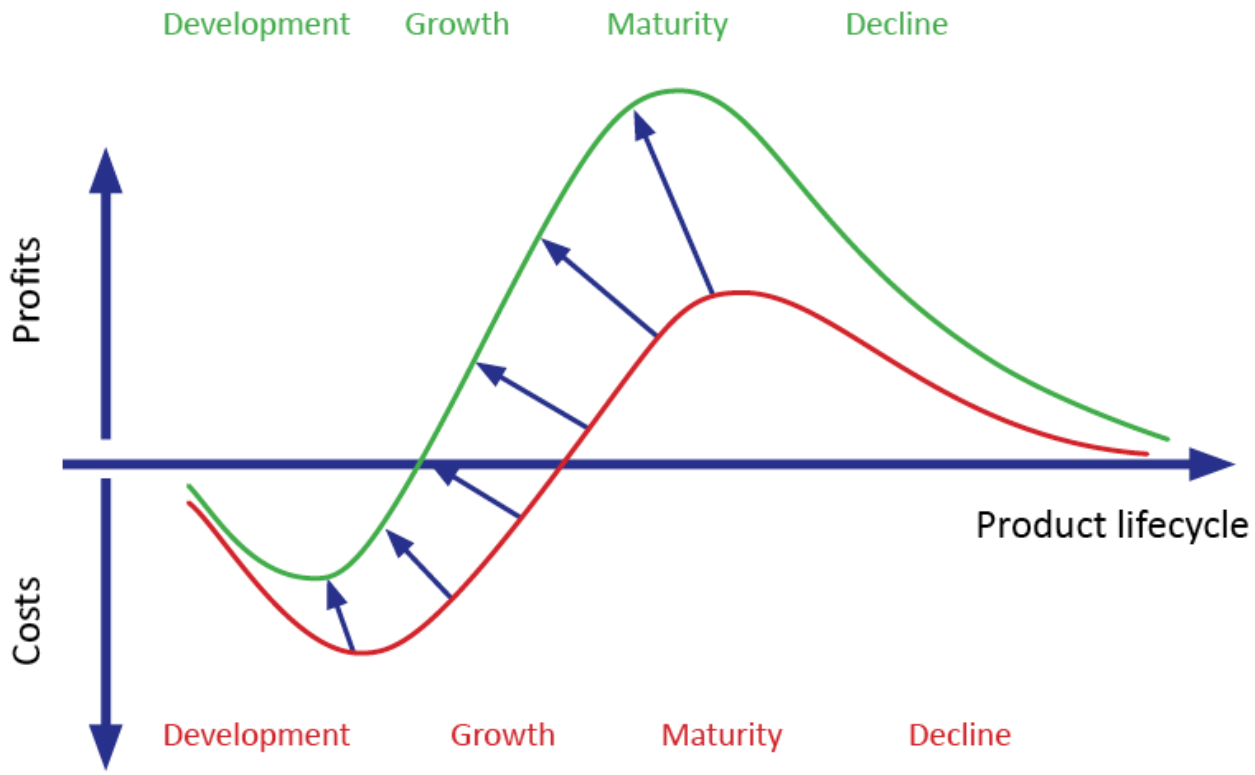
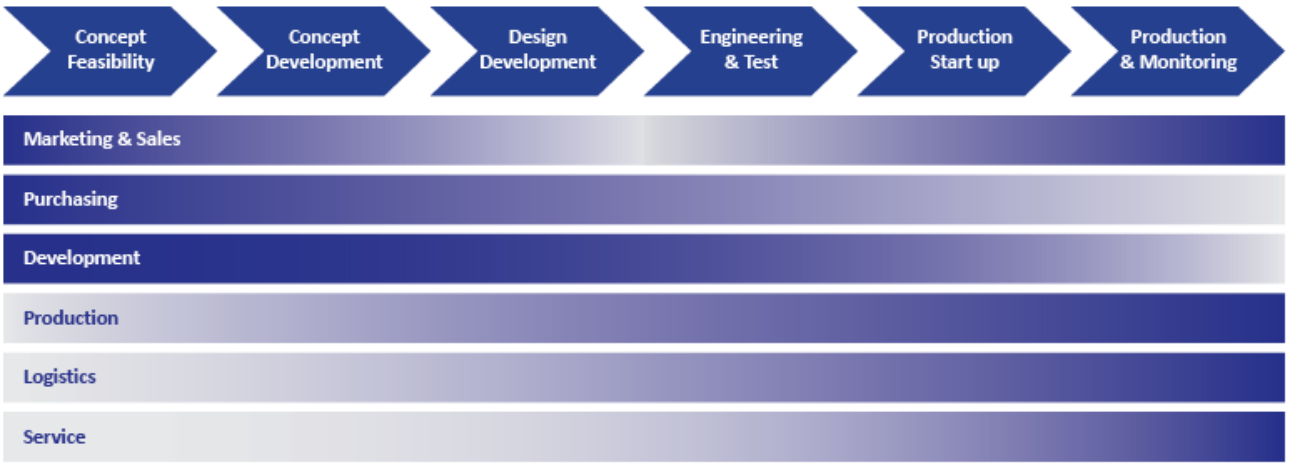
Chapter 8: CIMM Level 5 – Creating World Class Products

At the fifth level we will change from a reactive approach, where the focus was on improving the current situation to a proactive approach, where we will focus on developing products and services that will meet customer expectations and will have no problem in production and delivery. This is a combination of:

- Product Lifecycle Management (PLM)
- New Product Development (NPD)
- Design for Six Sigma (Dfss)





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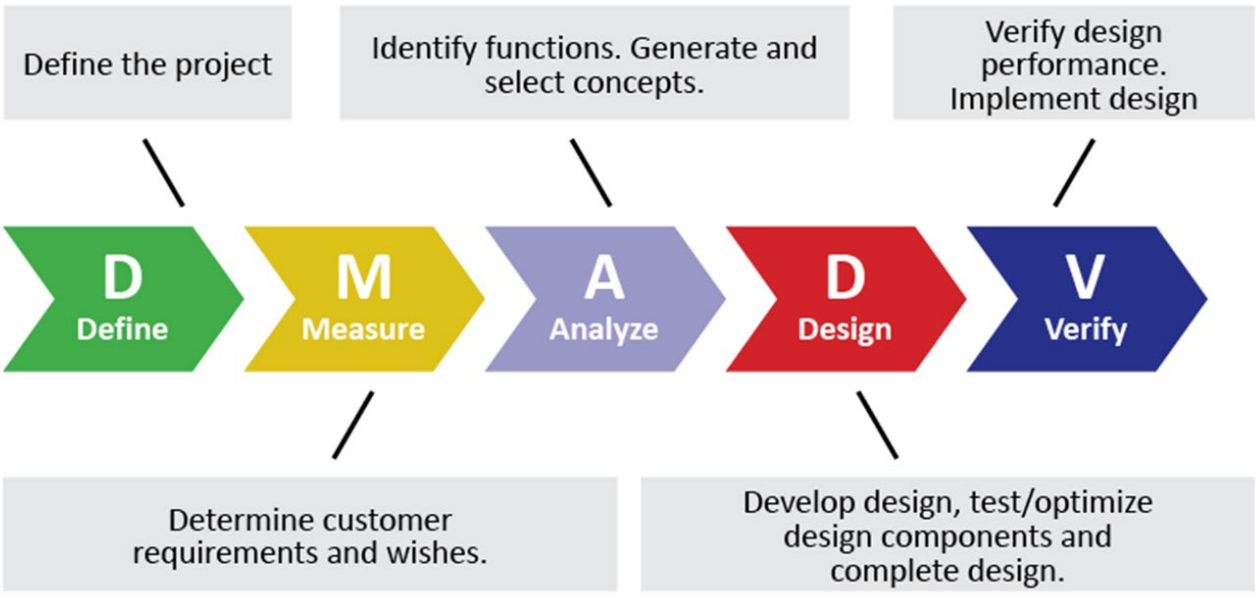

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