LBSPartners

Problem Solver

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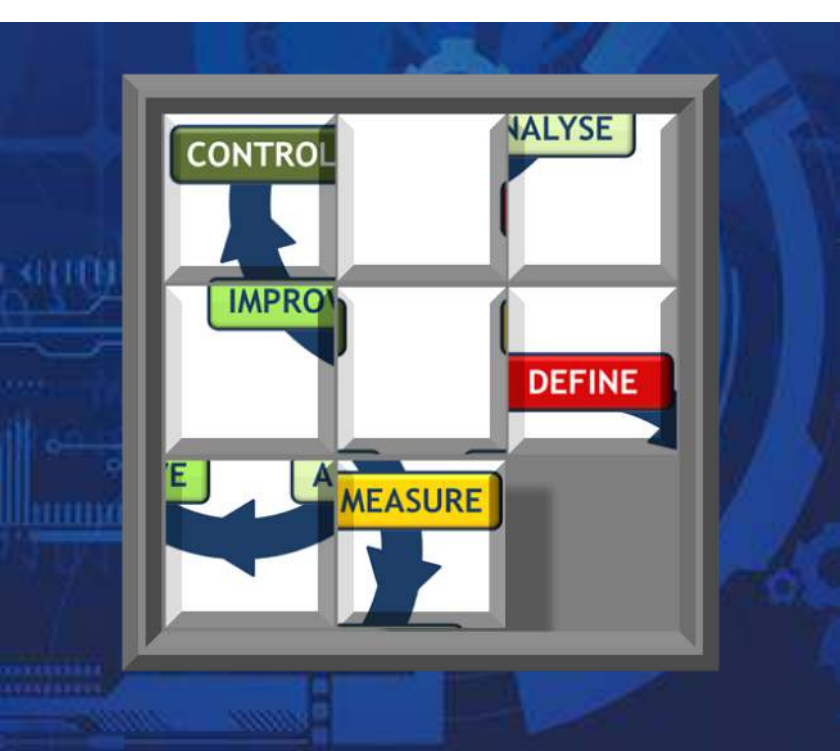

About LBSPartners

LBSPartners was founded in Limerick in 2002 to educate and assist companies in the development of operational excellence through Lean, Lean-Sigma & 6-Sigma.

We are a hands-on business improvement consulting firm with extensive Lean and management experience. Our customer base includes SMEs, Multinationals and Public sector clients in food, engineering, life sciences, services and software.

LBSPartners has a proven track record of delivering measurable and sustainable results to our clients through significant Lean transformations to hundreds of clients. Projects are typically delivering improvements in cost, cycle time, quality and customer service.

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Problem Solver

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Introduction

Problem Solving involves finding the root cause of an issue and implementing a corrective action or actions to effect a permanent fix for the issue.

A structured methodology is essential to successfully eliminate issues and ensure they do not recur. The aim is to depart from the “quick-fix” approach, and get to the point where the true cause of the issue is addressed to prevent its recurrence.

Lean Thinking is concerned with instilling a continuous improvement culture within an organisation, the use of a formal problem solving methodology is fundamental to this culture.

Problem Solver

The purpose of this book is to describe a basic problem solving model and the methodology (DMAIC) used in its implementation.

The chapter on “Lean Thinking” gives a brief summary of the five Lean Principles and the Eight Wastes as described by Lean. This brief summary is included here, as knowledge of these principles and wastes will contribute to the problem solving process .

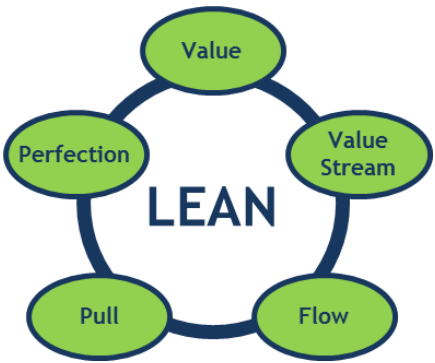
The “Problem Solving” chapter deals with problem solving at a high level and this is followed by a section on “Problem Solving Tools” which delves into problem solving in detail.

Establishing projects and working in teams is included because, generally project teams will be established to implement solutions to specific issues or work on continuous improvement initiatives.

This book is aimed at all levels in an organisation and is intended as a handy, portable reference guide to assist in the problem solving process.

Lean Thinking

Lean thinking focuses on each product/service and its value stream rather than management of individual assets. The objective of Lean is to enhance value and eliminate waste. The following Lean Principles define the steps which guide the implementation of Lean across an organisation.



Lean Thinking

Value

- Is the end customer willing to pay for it?
- Has the product been improved?
- Was it done right the first time?

Value Stream

- A Value Stream is the sum of all the activities necessary to create, order and produce a product or service.

Flow

- Each individual piece of work keeps moving i.e. being continuously worked on with no queues, waiting or rework.

Pull

- No one upstream should produce a Product or Service until the Customer downstream asks for it.

Perfection

- The ultimate objective is perfection - where every action and asset creates value for the end customer.

Lean Thinking

Lean thinking involves firstly identifying waste and then eliminating these wastes. It considers all activities carried on by an organisation, and sub-divides them into:

- Those which add value to the product or service (Value-adding).
- Those which don't add value but are necessary e.g. legal, certification etc. (Necessary Non-value adding).
- Those which don't add value (Waste).

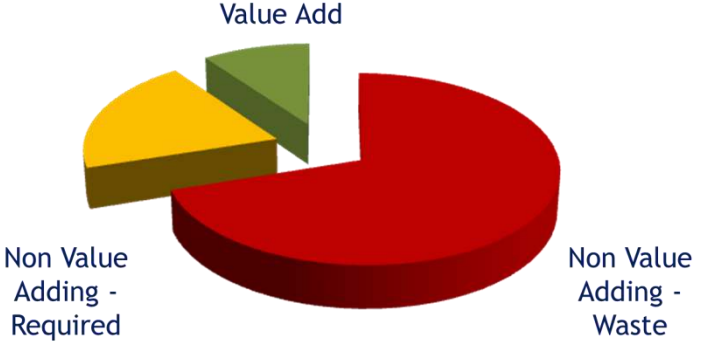


Figure 1 The Lean Concept

Lean Thinking

Lean thinking classifies waste under the following categories. To easily remember these wastes, the acronym TIM WOODS is used as a prompt.

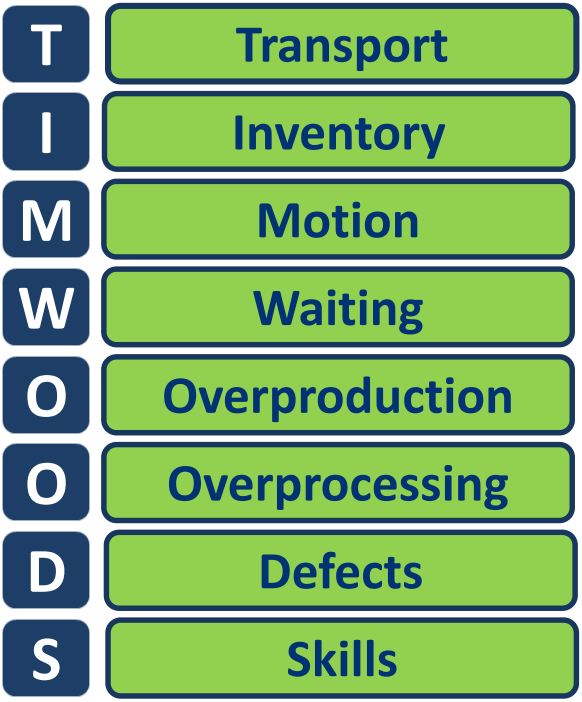


Figure 2 The Lean Wastes

Problem Solving

All continuous improvement activity involves problem solving in some form. The objective of this book is to describe the processes and tools typically used in a structured problem solving process.

Structured problem solving involves a variation on the basic model defined below in Figure 3.

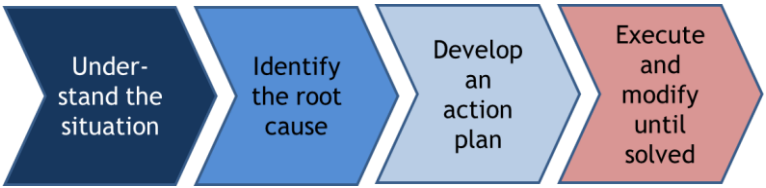


Figure 3 Basic problem solving model

DMAIC

These steps have been formalised into a structured methodology referred to as DMAIC, an acronym which stands for:

DEFINE the challenge or improvement opportunity.

MEASURE current process performance – *describe the issue with data.*

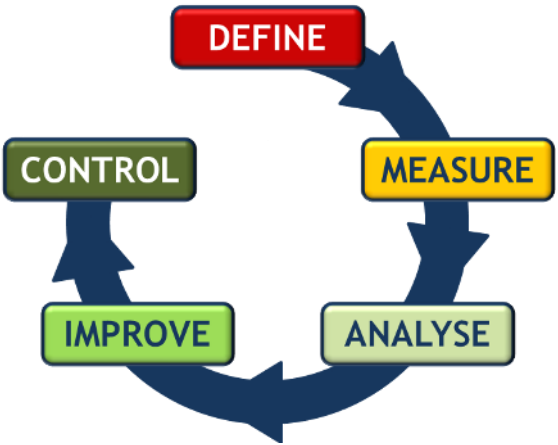
ANALYSE the process to determine the root cause of poor performance. Determine whether the current process can be improved or redesigned.

IMPROVE the process by attacking the root causes.

CONTROL the improved process to hold the gains.

What is DMAIC?

- It is a structured methodology which is used to understand and improve processes.
- It is an approach which is used to produce demonstrable improvements and financially validated benefits.
- It employs a set of tools and applications to support data based decision making (e.g. statistical process control).



DMAIC

The individual steps in the DMAIC methodology are summarised below.

DEFINE

- Form the team.
- Define the Customer, the problem or opportunity, and the Core Business Process involved.
- Understand the process to be improved by mapping the process flow.
- Define project boundaries - the start and end of the process.

MEASURE

- Describe the problem/opportunity with data.
- Measure the performance of the Core Business Process involved.
- Develop a data collection plan for the process.
- Ensure you have a balanced set of metrics.
- Complete the cost benefit analysis.

ANALYSE

- Analyse the data and process map to identify root causes of defects.
- Highlight gaps between current and goal performance.
- Prioritise opportunities to improve.
- Identify sources of variation.

IMPROVE

- Determine a range of solutions or countermeasures.
- Choose the best solution/set of countermeasures.
- Conduct risk analysis.
- Implement process change.

CONTROL

- Control the improvements to keep the process on the new course & demonstrate sustainability to prevent reverting back to the "old way“.
- Institutionalise the improvements through the modification of systems and structures.
- Calculate actual financial benefit.

DMAIC

How is DMAIC applied?

Listed below is a series of sample questions suggested for use in the various steps of the DMAIC process. Asking these questions will help in the implementation of a problem solving process.

DMAIC STEP	KEY QUESTIONS
DEFINE	• What exactly is the problem, how is the business being affected? • Have you involved other people? • Has the problem been clearly defined?
MEASURE	• What information do you have? • Have you gone to Gemba* • What's the difference between the current performance and planned future performance?

***Gemba** is a Japanese term for the location of the source of the problem. i.e. where the work is done or where value is added.

DMAIC STEP	KEY QUESTIONS
ANALYSE	• Have the process experts been consulted? • Has the true root cause for the issue been identified? • Have all practical actions to fix the issue been considered? • Have you selected the appropriate action or countermeasure to ensure a permanent fix is implemented?
IMPROVE and CONTROL	• Are the implementation plan and follow up plan in place? • Have the actions taken fixed the problem? • Can you quantify the benefit gained by implementing the fix? • Is a monitoring process in place to ensure that the issue is fixed?

Reference

"Managing to Learn" – John Shook

The table below maps the steps in the DMAIC process to the problem solving tools most commonly used to implement them.

The main tools listed are described in detail in the next section of this book.

Step	Commonly used tools
DEFINE	Team charter SIPOC (Supplier, Inputs, Process, Outputs, Customer) Process maps Is/Is not
MEASURE	Check sheets Process maps Control charts (Voice of the Process) Measurement System Analysis (MSA)
ANALYSE	Tools listed above Pareto & Histograms 5 Why's Cause & Effect diagram Design of experiments (DOE)
IMPROVE	Tools listed above Brainstorming
CONTROL	Failure Mode & Effects Analysis Control Charts (Voice of the Process) Control Plans (ISO/TS)

Table 1 Problem solving tools

Problem Solving Tools

The following section describes each of the standard problem solving tools in detail:

- SIPOC
- Process mapping
- Check sheets
- Pareto diagrams
- Run and Trend charts
- Brainstorming
- Cause & effect diagram (Ishikawa diagram)
- 5 Why's/Root Cause Analysis
- Scatter diagrams
- Histograms
- Control charts

SIPOC

What is it?

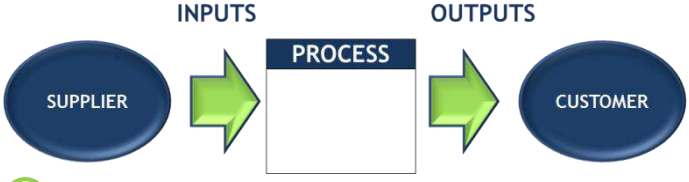
•A process is a series of steps or operations through which a product is produced or a service is provided. Problem solving in the Lean context will generally involve the study of a process to obtain improvements to that process.

•SIPOC is used to begin to understand the process under consideration.

•SIPOC is an acronym for Suppliers, Inputs, Process, Outputs and Customers.

•The first step is to understand the boundaries of the process to be studied in terms of:

- Exactly where it starts and finishes
- What the inputs to and the outputs from the process are



Who will use it?

Team members, Team Manager and Team leaders

When/where should it be applied?

•SIPOC is used at the start of the problem solving process to clearly define the extents or scope of the process to be improved.

How is it applied?

The form shown overleaf is used to record the elements identified through the application of SIPOC.

The process of completing SIPOC results in the collection of the following information:

- The name of the process and its purpose
- The owner of the process
- Clear definition of where the process starts and ends
- Clear definition of the Supplier to the process and the Customer who receives the output from the process
- Clearly defined inputs to the process
- Clearly defined outputs from the process

SIPOC

Process Definition	
Process name and Purpose Clearly name the process and identify what it does	**Process Owner** Name the owner e.g. Production Manager's name
Starts with For example raw material	**Ends with** Completed product or service

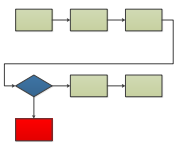
S	I	P	O	C
Supplier	**Input**	**Process**	**Output**	**Customer**
Suppliers name(s)	Raw material		Completed product or service	End-Customer

The process box will illustrate the current or “as-is” process. The level of detail included in the SIPOC form will depend on the process under consideration. In most cases is will be sufficient to study the “top-level” process. However it may also be necessary to analyse each individual sub-process.

Example

A more detailed example is illustrated below for reference.

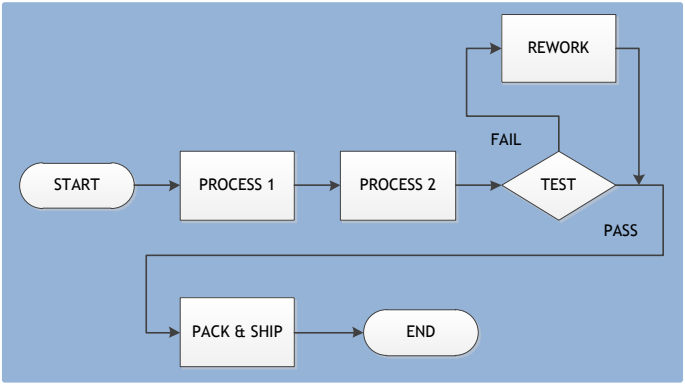
Process Definition	
Process name and <u>Purpose</u> Fabrication	**Process Owner** Joe Bloggs
Starts with Receipt of raw material	**Ends with** Fabricated parts

S	I	P	O	C
Supplier	**Input**	**Process**	**Output**	**Customer**
PS Supplies VOB Products Eire Products	Sheet metal Powder paint Cartons		Fabricated (Cut, bent and welded) parts	EON Products

Process maps

What is it?

- A process map is a visual representation of the steps required to produce a product or provide a service to a customer.



- The process map is generally read from left to right and from top to bottom. It should provide information on both the physical steps of the process and the information flow which supports the process.

Process Maps

Who will use it?

Team Members, Team Manager and Team Leaders

When/where should it be applied?

- When you need to identify the actual or ideal path that any product or service follows
- To identify critical steps for control
- To suggest areas for further improvement
- To help explain and solve problems

How is it applied?

1. Select a team of people with expert knowledge of the process
2. Describe each process step as defined by SIPOC
3. In the process of brainstorming the process steps, ensure that all steps are covered
4. In some steps there could be a pass/fail outcome. These need to be documented and each loop described i.e. what happens if a part passes a test and also what happens if it fails

Process Maps

General notes:

•The process mapping exercise should be carried out using a flipchart and some post-it notes.

•The process steps don't necessarily need to be listed in order at the start, the important point is to include all the tasks or activities that are involved. These can then be re-sequenced later in the exercise.

•Ensure that where steps have a pass/fail, go/no-go output that all eventualities are documented.

Once the individual process steps have been defined, a draft process map is created using the standard symbol convention described on the next page.

"As-is" process maps :

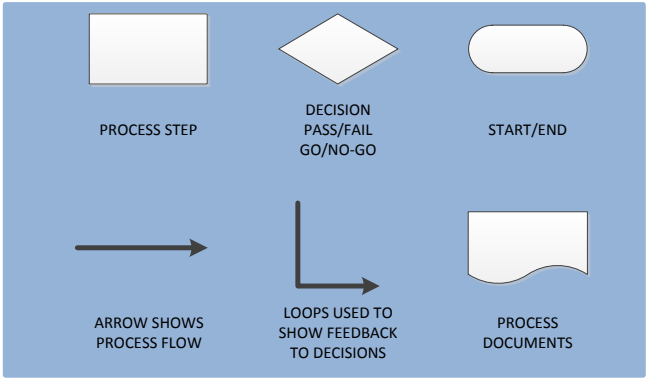
An "as-is" process map describes the process steps currently operated to produce the product or service. i.e. the current state – it is used to identify the process steps and decision points.

- It shows how the process works today
  - Does not show how the process should work
  - Does not show how the process could work

- On the process map identify
  - Documents associated with the processes
  - Standard operating procedures
  - Specification associated with the inputs and outputs
  - Visualise the process, actions, hand-offs between operations etc.

Conventions:

A general convention for the symbols used in process mapping is illustrated below.



Process map analysis

In Lean terms, the purpose of completing the process mapping exercise is to examine each process step to determine whether they are “Value-adding” or “Non-value adding” steps i.e. to clearly understand whether or not each step adds value for the customer.

For each step in the process map identify if it is:

- Value added i.e. Value is added to the product from the viewpoint of the customer
- Non-value added: There is no value being added to the product or service by completing this step
- Need to identify if non value add steps are necessary or not

Once the value-add/non-value-add step has been completed, look at the critical step on your process map.

The critical step represents where the most pain comes from and where most benefit would be gained by establishing a project to improve or remove (if possible) this step.

The process mapping exercise therefore helps identify possible areas for improvement of the current process.

Determining a critical step additionally narrows the scope of any improvement project (narrowing your scope to only the critical steps will focus the team and increase the probability of success).

To identify the critical step in the process, consider the following questions:

- Where do most of the problems seem to happen?
- Where are most of the defects occurring?
- What step costs the most money?
- What steps impact the product or service quality most?
- Which step takes the longest time to complete?

Completing the process map will help identify where improvement is required.

You can then consider establishing a project or projects to work on identifying and fixing the specific issues.

Examples:

Figure 4 displays a linear process map for a goods receipt/inspection process.

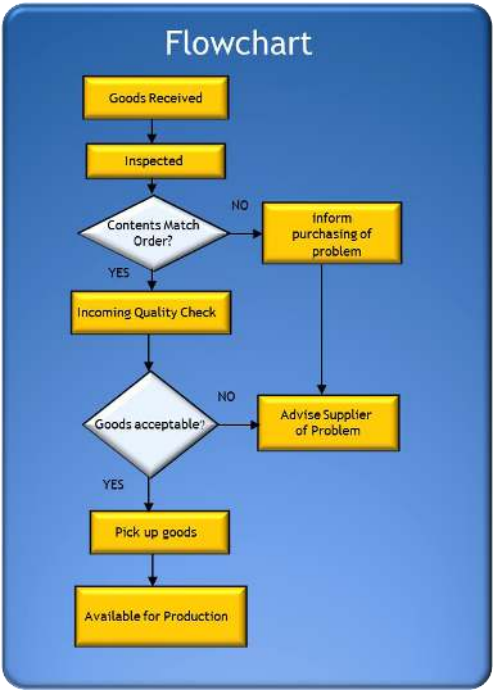


Figure 4 Linear process map

Figure 5 displays a cross-functional process map for the same process, however the process steps are spread across the departmental functions which perform them. This type of process map is also referred to as a “Swim-lane” process map.

This type of process map is useful when describing the handovers or interactions between functions.

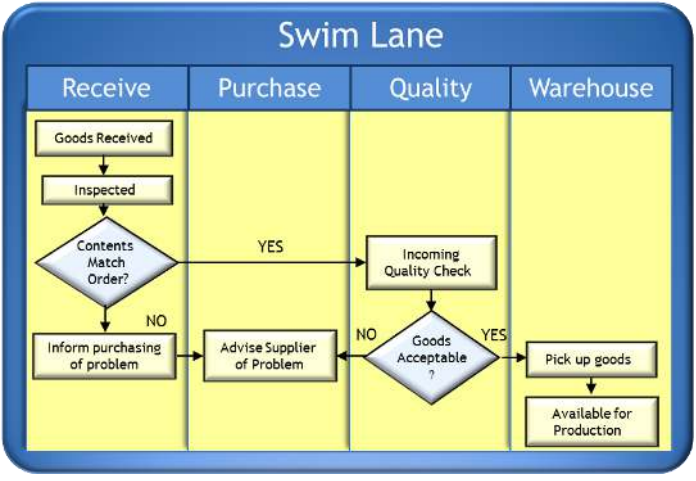


Figure 5 “Swim-lane” process map

Check sheets

What is it?

A check sheet is an efficient method for collecting data. It usually consists of a simple tally sheet designed around a specific event.

Check sheets are easy to understand forms which are used to answer the question:

"How Often are Certain Events Happening?"

Check sheets start the process of translating "Opinions" into "Facts." Once you have collected data using a check sheet, you can further analyse the data using other problem solving tools.

Who will use them?

Team Members, Team Manager and Team Leaders

When/where should they be applied?

A check sheet is used when you need to gather data based on sample observations in order to identify patterns. This is the logical starting point in most problem solving cycles.

How are they applied?

1. Decide upon a specific event to observe.
2. Define the item to be observed e.g. number of customer complaints.
3. Define the time period during which data will be collected, which could range from a couple of hours to a number of days.
4. Develop a clear, concise check sheet. It will need to include:
    - The data point
    - The number of times a measurement is observed
    - The total number of occurrences of each reading taken
5. Organize a consistent method for gathering data. Consider such factors as:
    a. Who will collect the data?
    b. Where will they collect it?
    c. When will they collect it. And for how long?
    d. How can you ensure consistency in data collection?

Example

- In this example, a company decides to study the customer complaints received.
- It is decided to look at complaints under the headings displayed on the right.

COMPLAINT
Damaged
Late delivery
Other
Poor packaging
Wrong billing
Wrong item
Wrong quantity

- A series of observations is taken over four weeks in this case, as summarised below.

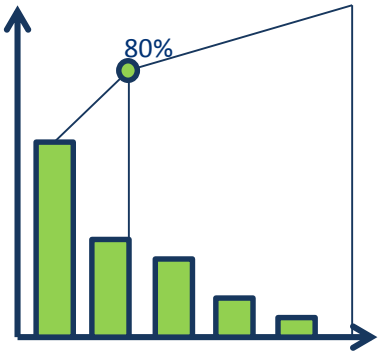
COMPLAINT	Week 1	Week 2	Week 3	Week 4	Total
Damaged	2	1	1	2	**6**
Late delivery	2	4	3	1	**10**
Poor packaging	0	1	0	0	**1**
Wrong billing	0	1	0	1	**2**
Wrong item	14	17	11	12	**54**
Wrong quantity	7	9	6	4	**26**
Other	0	1	0	0	**1**

- The process of turning opinions into facts has started. Already the company can see that they've had a total of 100 calls over 4 weeks and the table also details how many calls are related to each category.

Pareto Diagrams

What is it?

- The concept of the Pareto chart is based on the work of a 19th Century Italian economist named Vilfredo Pareto, originator of what has come to be known as the Pareto principle or 80/20 rule.
- In his studies, he found that 80% of the wealth was owned by 20% of the people.
- The use of this principle has been extended outside Economics. It is generally found that 80% of the costs associated with an issue are attributable to 20% of the causes.
- A Pareto Chart is a bar chart where the bars are arranged by height in descending order.
- The height of the bar reflects the importance or costs of the causes or categories associated with an issue.



Pareto Diagrams

Who will use them?

Team Members, Team Manager and Team Leaders

When/where should they be applied?

- To choose the starting point for problem solving
- To rank and prioritise problems
- To show how a few problems can cause the majority of rework and/or scrap

How are they applied?

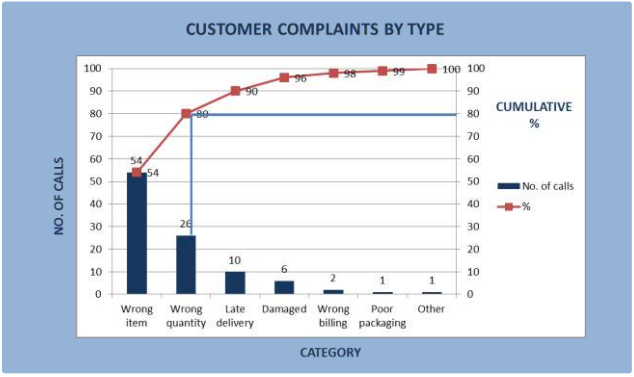
- Identify the characteristics you wish to study - For example, customer complaints.
- List the categories that contribute to that feature e.g. wrong part, wrong quantity, late delivery etc.
- Tabulate the frequency of the occurrence of each category.
- Construct the chart with quality characteristics (categories) plotted along the x-axis in descending order.
- Divide the right y-axis into units ranging from 0 to 100% and plot the cumulative frequency of each category.

Example

- Taking the example referenced under the Check sheets, sorting the table and adding the cumulative % gives the following data:

COMPLAINT	Total	%
Wrong item	54	54
Wrong quantity	26	80
Late delivery	10	90
Damaged	6	96
Wrong billing	2	98
Poor packaging	1	99
Other	1	100

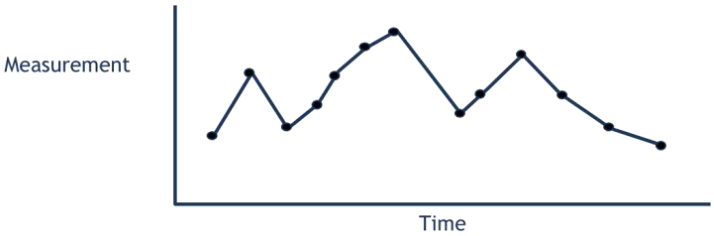
- Plotting this information as a Pareto chart indicates that the most benefit will be gained by tacking the "Wrong item" and "Wrong quantity" issues, addressing 80% of complaints.



Run and Trend Charts

What are they?

- A **Run Chart** is a chart which displays the changes in a process (represented by data) over time.
- A set of data is plotted on the y-axis versus time which is plotted on the x-axis.



Who will use them?

Team Members, Team Manager and Team Leaders

Run Charts

When/where should they be applied?

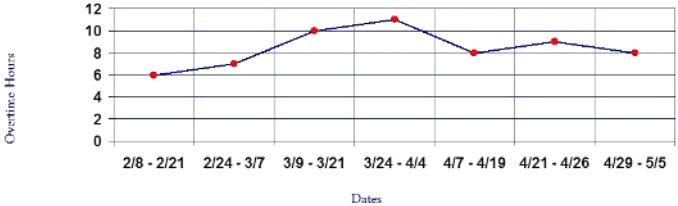
- Use a run chart when you need to do the simplest possible display of trends within observation points over a specified time period.

How are they applied?

- The y axis is the vertical side of the graph – represents the characteristic being measured.
- The x axis is the horizontal side of the graph – represents time.
- A marked point indicates the measurement or quantity observed or sampled at one point in time.
- Data points should be connected for easy use and interpretation.
- Time period covered and unit of measurement must be clearly marked.
- Collected data must be kept in the order that it was gathered. Since it is tracking a characteristic over time, the sequence of data points is critical.

Example

- The chart below displays overtime hours over successive weeks.
- Once you see the trend you can focus on the weeks where overtime was higher to determine the underlying cause(s).
- The Run chart is an entry point for analysis. Other problem solving tools may be used to allow you to drill down to root causes.



Brainstorming

What is it?

- Brainstorming is a technique used by groups or teams to solve a particular problem creatively.
- The process involves assembling a team and encouraging the team members to contribute ideas openly without being subject to criticism.
- The ideas generated in the initial phase are then critically assessed to arrive at a final solution.

Who will use it?

Team Members, Team Manager and Team Leaders

When/where should it be applied?

- Brainstorming is used when solving a problem which has proven to be particularly difficult to tackle.
- The brainstorming exercise encourages “lateral thinking” to generate as many alternatives for potential solutions as possible.

Brainstorming

How is it applied?

The process begins by the leader assembling a team, which can consist of between 6 and 12 members.

Ideally there should be at least 6 team members to ensure that a large number of ideas result from the process.

The leader drives the process of idea generation and records the suggestions as they are offered.

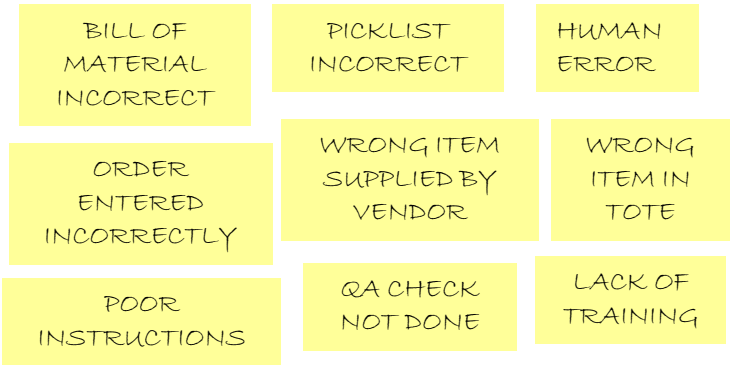
- One person at a time offers a suggestion
- If there is no response, the leader passes on to the next team member
- No idea is too obvious or stupid – the aim is to capture as many ideas as possible
- Ideas should not be enlarged upon - use as few words as possible to record the idea
- The leader leads the group and the process continues until ideas dry up – a time limit can also be set if desired
- Once it has been agreed that the ideas have been exhausted, the reduction process can begin

Brainstorming

- This is where the ideas generated in the initial stage are critically evaluated to arrive at the ultimate solution.
- Each idea is explained and expanded on by the originator.
- Ideas can be combined where deemed appropriate.

Example

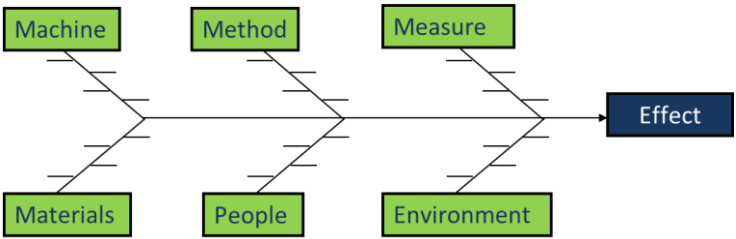
If the initial investigation has come up with an issue where a number of customer complaints have been received for “Wrong item shipped”. The result of a brainstorming session might be:



Cause and Effect Diagram

What is it?

- A Cause and Effect Diagram is a brainstorming tool that guides you in organizing your thoughts.
- You may also see it referred to as a Fishbone Diagram or an Ishikawa diagram.



Who will use it?

Team Members, Team Manager and Team Leaders

Cause & Effect Diagram

When/where should it be applied?

A cause-and-effect diagram is used when you need to identify, explore and display the possible causes of a specific problem or condition.

It is used to identify and explore all possible causes of a specific problem and to analyse the relationship between causes.

How is it applied?

An effect is identified as a starting point for the process, for example poor productivity on a production line. This is entered in the “Effect” box on the right hand side.

A brainstorming session is held with the relevant team members, team leaders, team managers etc. to list all the potential causes for the resulting effect.

After this session has been completed, the causes identified are grouped under the 4MEP categories (see overleaf).

While the 4MEP’s are the most common headings used, other more relevant headings can also be used.

Cause & Effect Diagram

- Completing this exercise will provide a clearer picture of the areas which need to be tackled to bring about an improvement to the effect under study.
- The team then selects the most appropriate projects that will address the causes, from which most benefit will be derived.

The main purpose of Cause and Effect Diagrams is to identify sources of variation and to drill down to root cause. Sources of Variation are conveniently grouped according to 4MEP (see Figure 6 below).

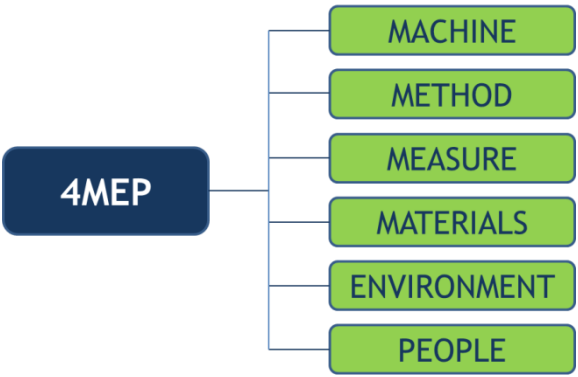


Figure 6 Definition of 4MEP

Cause & Effect Diagram

Example

Referring to the Pareto chart displayed on page 33, the issue which generates most complaints is the “Wrong item” problem.

Completing a brainstorming session results in the following possible causes. The 4MEP categories are used to assist the brainstorming process.

BILL OF MATERIAL INCORRECT

PICKLIST INCORRECT

HUMAN ERROR

ORDER ENTERED INCORRECTLY

WRONG ITEM SUPPLIED BY VENDOR

WRONG ITEM IN TOTE

POOR INSTRUCTIONS

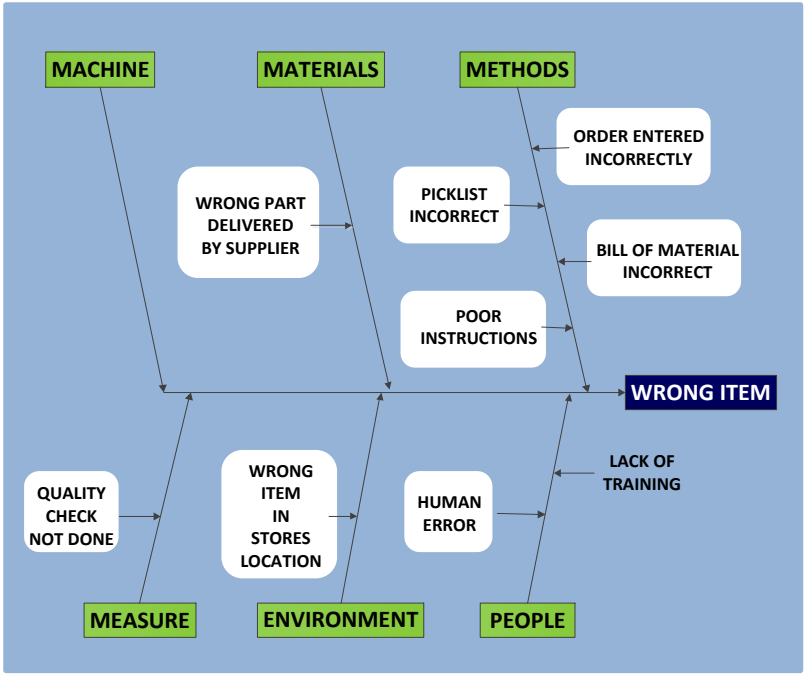
QA CHECK NOT DONE

LACK OF TRAINING

The resulting Cause & Effect diagram is displayed overleaf.

Cause & Effect Diagram

Example (Cont'd)



Cause & Effect: Cause screening

Once the likely causes for the sources of variation have been established and categorised, cause screening is a useful method for helping set the priorities. It can be used to set the priority for the improvement projects which will be established to tackle the issues.

In cause screening, the following questions are asked by the team:

- How likely is each cause to be a major source of variation?
    - V = Very likely
    - S = Somewhat likely
    - N = Not likely
- How easy would each be to fix or control?
    - V = Very easy
    - S = Somewhat easy
    - N = Not easy

Each item on the Cause and Effect diagram is rated under both questions.

Cause Screening

The ultimate aim of the process is to construct a matrix as shown below and from this matrix prioritise which causes will be addressed first.

Rating	Cause	Action	Owner	Estimated completion date
VV				
VN				
SV				
VS				

Figure 7 Cause screening matrix

A rating of “VV” means that the cause is very likely to occur but is also very easy to fix – these causes should be tackled first, as they are the “low hanging fruit”.

Conversely, a rating of “NN” means that the cause is not likely to occur and would also be very difficult to fix – these causes should not be tackled at all.

5 Whys/Root Cause Analysis (RCA)

What is it?

- Root Cause Analysis breaks down a complex problem into component causes.
- The causes are evaluated as problems themselves to ensure that the root cause has been identified.
- Once the root cause is corrected, the problem shouldn't reoccur.

Who will use it?

Team Members, Team Manager and Team Leaders

When/where should it be applied?

- It is used to:
    - Manage complex problems
    - Breakdown a problem into logical components
    - Solve the real problem instead of trying to solve superficial alarms

5 Whys

How is it applied?

- Clearly define the problem to be solved.
- Using either Brainstorming or a Cause and Effect Diagram, identify a list of possible causes.
- For each cause you've identified, ask: "Why is this a problem?" Continue to explore the causes until you get to the root. A general guideline is to ask "Why?" at least five times until you get to the root cause.
- Collect data to verify that you have identified the root cause.
- After implementing a solution, check back periodically to ensure that you stopped the problem at its root.

Example of use

To demonstrate root cause analysis, we'll look at the "picklist incorrect" cause from the Cause & Effect diagram on page 44.

Reference Figure 8 on the opposite page.

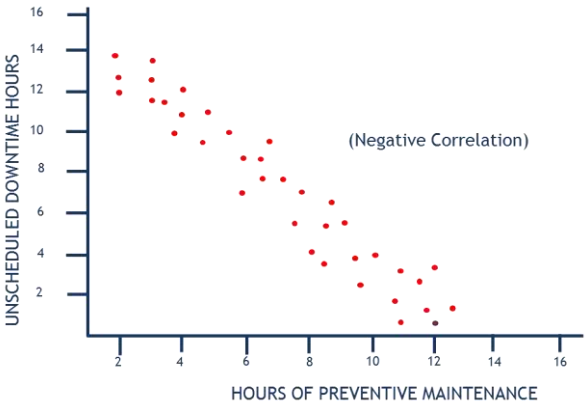
	Problem	Countermeasure
	Picklist is incorrect	Correct picklist
Why	Quantity entered incorrectly	Correct the quantity
Why	Product drawing/specification was incorrect	Correct the drawing
Why	There was an unofficial change to the drawing	Verify the changes should have been made
Why	The change was discussed but the change was not formally implemented	Review the change (and the cost implications)with the customer
Why	Change was requested by the customer but not accepted	Agree the change with all parties and update the document and picklist

Figure 8 Example of Root Cause Analysis

Scatter Diagrams

What are they?

- A Scatter diagram is one which shows how two variables are related and that a relationship exists. For example, downtime hours vs. preventative maintenance hours as shown below.
- They are used to test for cause and effect relationships.
- However one cannot necessarily prove that one variable causes the change to the other.



Scatter Diagrams

Who will use them?

Team Members, Team Manager and Team Leaders

When/where should they be applied?

Use a scatter diagram when you need to display what happens to one variable when another variable changes in order to test a theory that the two variables are related.

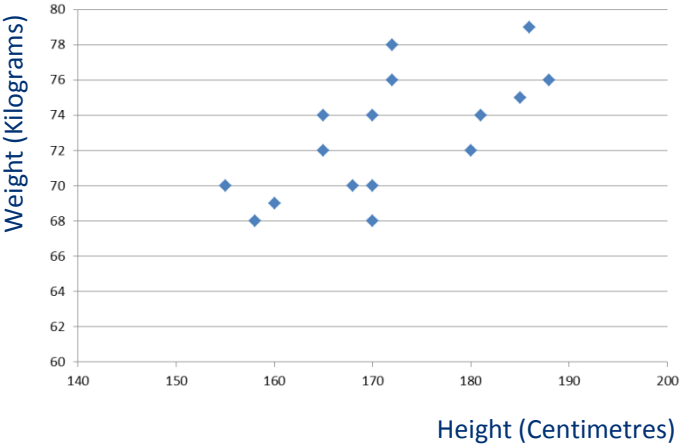
How are they applied?

The steps in the construction of a scatter diagram are:

- Select the 2 variables
- Collect the data (typically >50 points)
- Plot the “cause” or “independent” variable on the X axis
- Plot the “effect” or “dependent” variable on the Y axis
- Can usually see visually if a relationship exists

Scatter Diagrams

Example

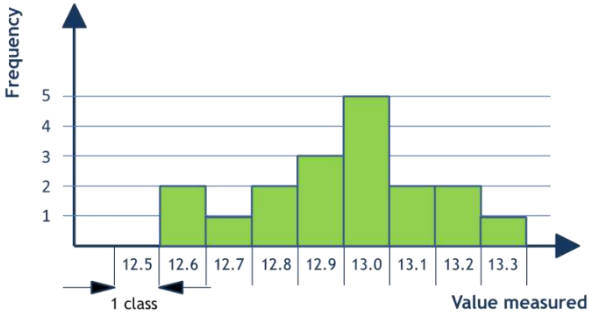


This scatter plot of a series of values of human height vs. human weight shows that generally there is a positive relationship between height and weight i.e. when one variable increases the other also increases.

Histograms

What are they?

- A Histogram is a graphic display of variation in a set of data - It is a bar chart for continuous, variable data which is grouped into classes.
- It enables one to see patterns not easily visible in a table of numbers.



Who will use them?

Team Members, Team Manager and Team Leaders

When/where should they be applied?

- To quickly illustrate the distribution of data
- To analyse patterns not easily apparent in numerical data

Histograms

How are they applied?

- Firstly collect process data - at least 30 data points
- Determine the number of categories or classes (increments into which the data will be divided)

No .of data points	Number of classes
Under 50	5-7
50-100	6-10
100-250	7-12
Over 250	10-20

- Determine the class width (H), the width of the increment

CLASS WIDTH (H)

$$H = \frac{R}{K}$$

R = Range (largest – smallest data value)

K = No. of classes

- Place the data on a frequency chart – work out how many points fall within each class
- Plot the histogram

Example

A company makes steel tubes. The spec for one tube is diameter 10mm +/- 0.2mm. 30 tubes are measured.

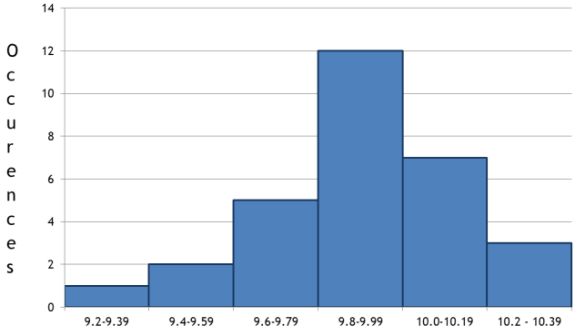
- For 30 data points, K is set at 6 (see table on page 54)
- The range is 10.4 – 9.2 = 1.2
- Therefore:

$$H = 1.2/6 = 0.2$$

- Plotting the data points which fall in each class gives this frequency chart

Class	Frequency
9.2 - 9.39	1
9.4 - 9.59	2
9.6 - 9.79	5
9.8 - 9.99	12
10.0 - 10.19	7
10.2 - 10.39	3

- The histogram is then plotted as illustrated below.

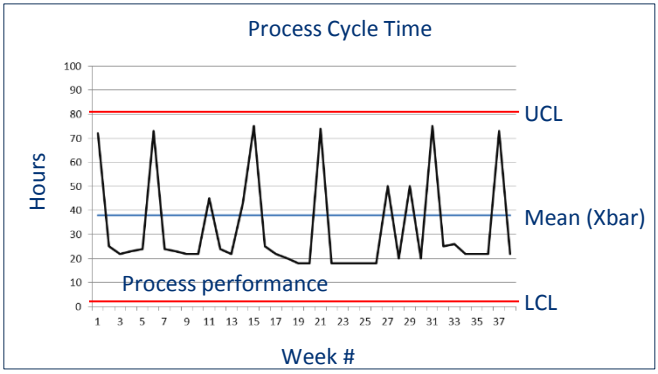


- The process is well centred around the specification, most parts will meet the spec. but many do not – corrective action is required.

Control Chart

What is it?

- A Run Chart is a graphic representation of the variation in process output over time.
- It reveals trends (or patterns) in your process.
- When Process Capability needs to be observed, the Run Chart can be expanded into a Control Chart.
- With a Control Chart, the control limits help to decide whether the process needs to be adjusted.
- Two control limits are used, the Upper (UCL) and Lower (LCL) Control limits.



Control Charts

Who will use them?

Team Manager and Team Leaders

When/where should they be applied?

- Control charts are used to analyse the outputs from a process to determine if it is in control statistically.
- If the process is not in control, appropriate actions must be taken to achieve and maintain a state of statistical control and to improve its capability.
- Control limits should be set within the specification limits for the process to ensure the spec. is met.

How are they applied?

- Decide on the process characteristic to be studied and record actual process data.
- Using statistical methods (standard formulas) calculate the mean (X bar) and standard deviation (**σ**) for the data set. Normally the formulas are:

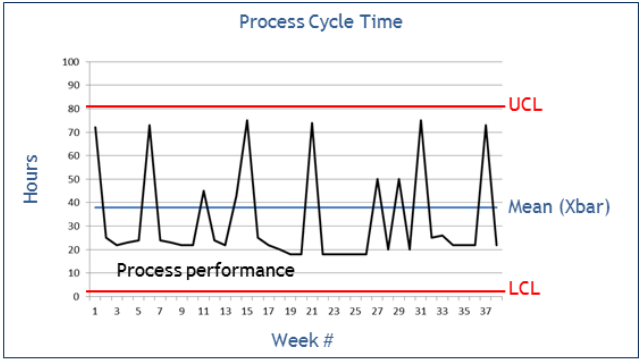
Upper Control Limit (UCL) = X bar + 3σ

Lower Control Limit (LCL) = X bar - 3σ

- Plot the process performance and compare to the control limits to determine how the process is performing and decide if corrective action is required.

Example

- The example below refers to the number of overtime hours completed during a working week.
- This figure is plotted over a period of 37 weeks.
- In the example below, the average or mean value is displayed in blue.
- The Upper and Lower control limits are shown in red.
- The actual figures are illustrated by the black line.



- The inference is that the process is operating well within the calculated control limits. However, there is significant variation which means that further analysis is required.

Improvement Projects

Frequently, the mechanism for driving continuous improvement in an organisation is the implementation of a series of improvement projects.

These projects are established to address particular issues in a time-based, goal focused manner.

Time-based – the project has a defined duration by which the outcomes must be achieved

Goal-focused – the project is formed to achieve certain pre-defined outcomes e.g. productivity improvement of X%, reduction of downtime by Y%.

The steps in establishing an improvement project are outlined in Figure 9.

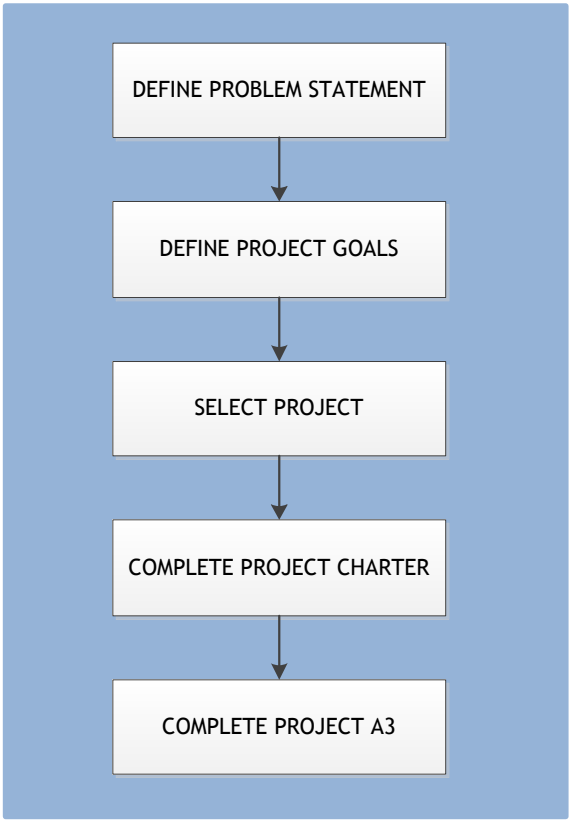


Figure 9 Steps in establishing a project

Setting up a project

The first step is to get a clear idea of the nature of the issue – to clearly define the issue. A Problem Statement is used in this definition process.

The next step is to develop a project charter, which should be initiated by the project manager or (in some cases) the project sponsor. The project sponsor is the person who provides the resources for the project.

The sponsor will be responsible for appointing a project manager and defining that project manager's level of authority.

The project manager and project team then start to define the scope of the project and the specific objectives and deliverables.

The deliverables are the specific outcomes which will result from completing the project.

For example:

- A productivity improvement
- A reduction in machine downtime
- A reduction in the number of defects or amount of scrap produced by a process

Purpose of a project charter:

- To clearly state the purpose and aims of the project
- To remove any ambiguity about the project
- To ensure clear understanding of the project scope

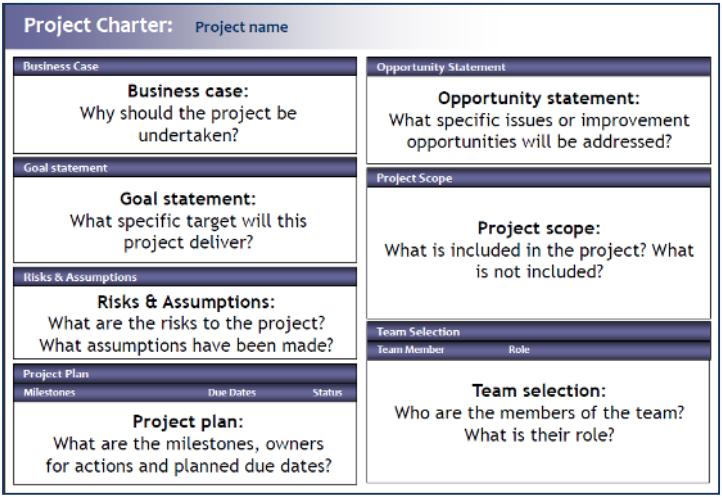


Figure 10 Sample project charter

A3 process

The A3 is a methodology for defining, scoping, managing and reporting on an improvement project.

At the same time it represents a process by which a Lean expert acts as a mentor to a less experienced practitioner.

- "A3" is just a paper size (international 11" x 17")
- A3 planning began in the 60s as the Quality Circle problem-solving format
- At Toyota, it evolved to become the standard format for problem-solving, proposals, plans, and status reviews
- Lays out entire plans or reports, large or small, on one sheet of paper
- Should tell a story, laid out from upper left hand side to lower right, which anyone can understand
- Must be visual and extremely concise
- What is important is not the format, but the process and thinking behind it
- A typical layout for an A3 is illustrated in Figure 11.

A3 Process

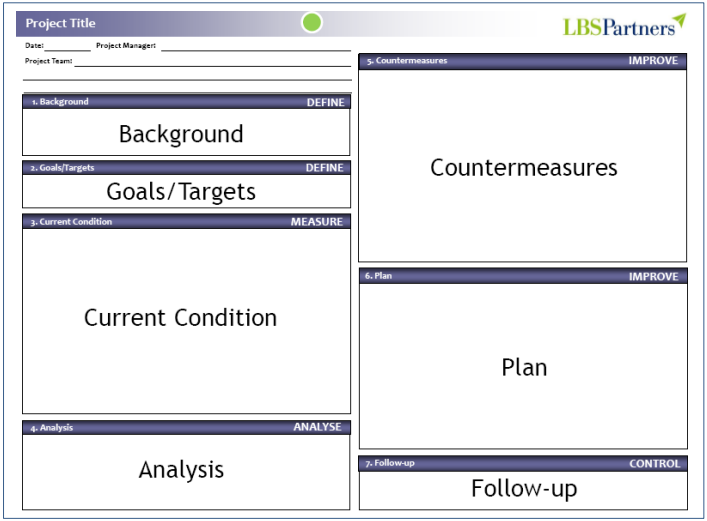


Figure 11 A3 format

One of the main benefits of the A3 process is that it forces the project manager to clearly think about the purpose of the project and how and when it will be implemented. Having this documented in a clear and concise fashion helps communication and removes ambiguity.

On subsequent pages each section of the A3 will be reviewed in detail.

A3 process – section headings

SECTION	DMAIC STEP	DESCRIPTION
BACKGROUND	DEFINE	Starts the definition process – includes the reason for undertaking the project
GOALS/ TARGETS	MEASURE	Clearly defines what the project is supposed to achieve – defined in terms of % improvement for example
CURRENT CONDITION	MEASURE	Establish the current condition, the target condition and the gap between them
ANALYSIS	ANALYSE	Details the analysis performed to determine the root cause and the conclusions reached - uses graphs/charts/diagrams/ sketches as appropriate

A3 process – section headings (continued)

SECTION	DMAIC STEP	DESCRIPTION
COUNTER-MEASURES	IMPROVE	Details the steps which are proposed to remedy the causes of the issues experienced. Use graphs/charts/ diagrams/sketches as appropriate
PLAN	IMPROVE	Specifies the plan to execute the project, usually includes a Gantt chart which specifies the actions, owners and completion dates
FOLLOW-UP	CONTROL	Can be used to set out follow up actions after the current project has been completed

A3 – Storytelling Tools

The table below displays the sections of the A3 format. It ties the sections to the "storytelling" or problem solving tools generally used to illustrate them.

SECTION	STORYTELLING TOOLS	
BACKGROUND	Chart	Sketch
GOALS/ TARGETS	Graph	Sketch
CURRENT CONDITION	Check sheet Pareto diagram Sketch Current state map	Histogram Scatter diagram Control chart Graph
ANALYSIS	Control chart Sketch Scatter diagram	Cause & effect diagram Histogram Pareto diagram Graph
COUNTER -MEASURES	Diagram Sketch Graph	Chart Future state map
PLAN	Project milestones	Gantt chart
FOLLOW UP	Sketch	Chart

Figure 12 A3 storytelling tools

A3 process (continued)

The A3 format is used initially to logically and concisely define a problem, however the process of mentoring the less experienced Lean practitioner is integral to the A3 methodology.

The student and mentor work together on a regular and on-going basis to complete the specific activities related to the project as laid out in the pre-defined format.

Following the A3 format; completing each section and updating it regularly contributes to the successful implementation of any continuous improvement project.

In summary, the A3 process:

- Structures effective and efficient dialogue
- Enables mentoring, fact-based problem-identification and more
- Fosters understanding leading to agreement
- Enables problem-solving, decision-making, execution and more
- Develops people and engages them to accept responsibility and take initiative

Team Skills

What is a team?

In general, a team is formed when a group of people must cooperate with each other in order to accomplish a job or achieve a common goal.

This section has been included, to set out the characteristics of a good team together with setting ground rules.

Teams usually have:

- a reason/purpose for working together
- a need for each other's experience and expertise
- a belief that working together will be more productive than working alone

Teams may be assembled on a short or long term basis depending on the nature of the project.

Characteristics of good teams

The key characteristics of good teams are summarised in the graphic below.

Every project meeting should have a definite outcome in mind:

- Each meeting should have:
    - An agenda
    - A planned outcome
    - Results – a set of actions
    - Summary – minutes must be issued

Every team meeting should be aligned to the (project) goal.

Ground rules are guidelines for how team members will treat each other. By creating and agreeing on ground rules in the early stages of a team's development, a team can avoid unnecessary conflict and confusion.

A typical set of ground rules is summarised on the following page.

GROUND RULES	
PUNCTUALITY	• Be on time • Start & finish on time
RESPECT	• Be supportive & courteous • No criticism of team members
LISTEN	• Pay attention/Don't interrupt
SHARE THE WORKLOAD	• Volunteer for assignments • Cooperate
PREPARE/ HAVE AGENDA	• Circulate minutes promptly after the meeting
TALK ONE-AT-A-TIME	• No "sidebars" – meetings within meetings
ATTENDANCE	• Send delegate if you can't attend
STAY ON TRACK	• Meet deadlines • Be focused on mission and goal
CONTRIBUTE/ PARTICIPATE	• Encourage discussion • Express ideas/raise questions
GIVE/GET FEEDBACK	• Celebrate • Be positive • Clarify when necessary

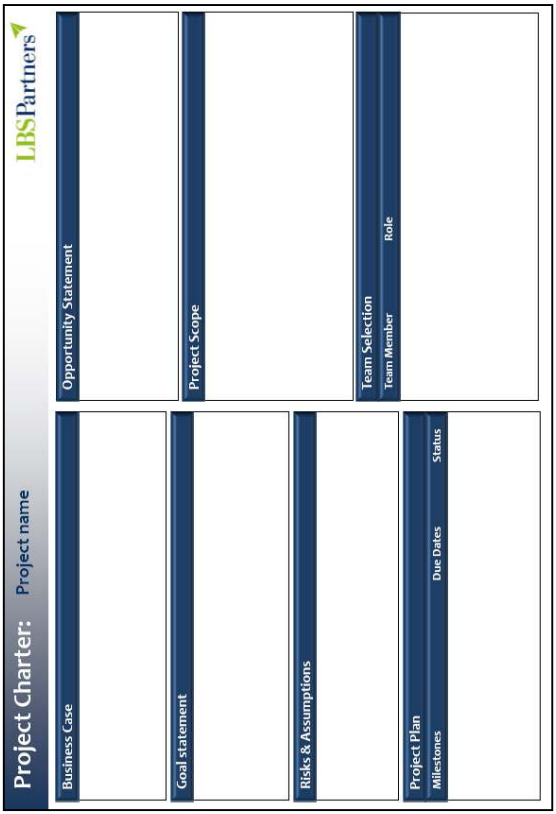
Templates

Standard forms are presented on the succeeding pages, to assist in any problem solving process.

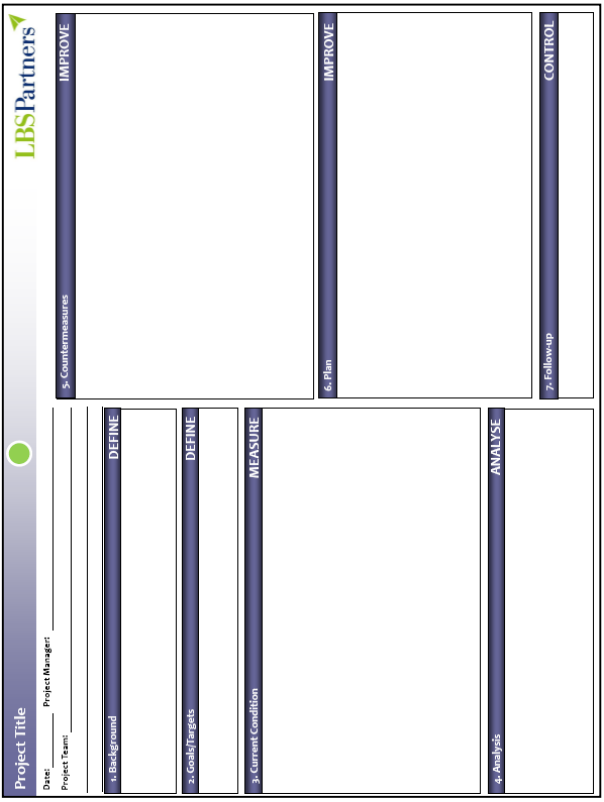
- **Project Charter**– to help establish a project, its scope, goals and targets
- **A3** – to assist in managing the project and tracking it to completion

Please note that the original templates are freely available from www.lbspartners.ie

1. Project Charter



2. A3 Template



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