Lean Six Sigma

Yellow Belt

Courseware

Version 1.0

FIREBRAND

ORIENTATION

Lean Six Sigma

Yellow Belt

Welcome

Welcome to the

Lean Six Sigma

Yellow Belt

Training

WHY AM I HERE?

- Employers want their employees to have this knowledge and training
- Bottom line:
  - At the end of the course, you will be better prepared to contribute to your current or future organization's Lean Six Sigma journey

Introductions

Be prepared to share with the class your:

- Name
- Designation
- Organisation
- Location
- Expectations for the course
- Summary of your project (*if any*)

LEAN Six Sigma Belts, Executives, Champions

- White Belt – understands basic LSS concepts from an awareness perspective
- Yellow Belt – participates in process improvement projects as a team member
- Green Belt – Leads GB projects, assists BB with data collection & analysis
- Black Belt – Leads BB projects, trains & coaches teams
- Master Black Belt – Functions at the program level, acts as an organization's LSS technologist & internal consultant
- Champions – Translates the company's vision, mission, goals & metrics to create an organizational deployment plan & identify individual projects
- Executives – Provide overall alignment by establishing the strategic focus of the LSS program within the context of the organization's culture & vision

FIREBRAND LEAN SIX SIGMA YELLOW BELT
Objectives of this Course

At the end of this course, you will

- Understand the history and principals of Lean and Six Sigma
- Explain the differences between Lean and Six Sigma
- Gain a basic understanding & working knowledge of Lean Six Sigma principles
- Explain how Lean Six Sigma is deployed within a business
  - Methodology
  - Tools
  - Outcomes
- Understand the role of a LSS team member

Lean Six Sigma Concepts, Tools & Terms You Will Learn ….

- 5 Whys
- 6S
- 8 wastes
- A3 thinking and tool
- Andon
- Balanced work
- C_p, C_{pk}
- Capacity, throughput, queuing, bottleneck
- Cause and effect diagrams
- Check lists/sheets
- Control charts
- Current state
- Customers (external & internal)
- Cycle time
- DMAIC
- Enterprise stakeholders
- Enterprises
- Flow
- Future state
- Gemba (genba)
- Genchi genbutsu
- Histograms
- Integrated teams
- Kanban
- Kitting
- Lean is a journey
- Lean is a way of thinking
- Little's law
- Mistake proofing
- Muda, muri, mura
- Non value-added time
- Pareto charts
- Plan-do-study-act (PDSA)
- Process maps
- Processing time
- Pull
- Relational coordination
- RPIW
- Single piece flow
- Spaghetti diagrams
- Stakeholder value
- Standard work
- Takt time
- Three actuals
- Time value charts
- UCL, LCL
- USL, LSL
- Value added, non-value added, waste
- Value streams
- Value stream mapping and analysis (VSMA)
- Variation impact
- Visual control
- Wait time
- ….. and more

FIREBRAND LEAN SIX SIGMA YELLOW BELT Certification Exam

When
- Day 2, 2.30pm

Duration
- 1 hour (60 minutes)

Number of Questions & Format
- 30 questions, open book

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

Passing Score
- 70%

FIREBRAND

ORIENTATION

Organizational Process
Improvement Programmes

LEAN

Six Sigma Methodology

Phase 1 - Define

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

Phase 2 - Measure

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

Phase 3 - Analyse

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

Phase 4 - Improve

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

Phase 5 - Control

- Ensure that the improvement continues

Process Improvement Programmes – A Comparison

Programme	SIX SIGMA	LEAN THINKING	THEORY OF CONSTRAINTS
Objective	Reduce Variation	Remove waste	Manage constraints
Methodology	1. Define	1. Identify Value	1. Identify constraint
	2. Measure	2. Identify Value Stream	2. Exploit constraint
	3. Analyze	3. Flow	3. Subordinate processes
	4. Improve	4. Pull	4. Elevate constraint
	5. Control	5. Continuous Improvement	5. Repeat cycle
Focus	Problem focused	Flow focused	Constraint focused

LEAN & Six Sigma

- Lean & Six Sigma are synergistic
  - Both focus on delivering VALUE to customers
    - LEAN does this by focusing on FLOW & WASTE ELIMINATION
    - Six Sigma does this by focusing on VARIATION REDUCTION
- Lean Six Sigma is the unified framework
  - Many enterprises have their own name for this unified framework:

Pratt & Whitney - *ACE*
USAF – *AFSO21*
Boeing – *Lean+*
New York City Health & Hospitals Corp - *Breakthrough*

FIREBRAND

END of ORIENTATION

FIREBRAND

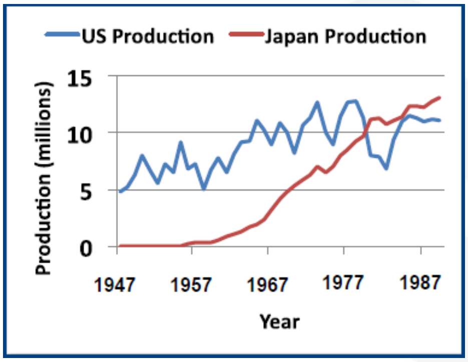
LEAN

In the beginning….

Where Did “LEAN” Come From?

- From the ‘Toyota Production System’
  - Adapted to the US Aerospace industry
- Coined by an MIT graduate student

Where Did “LEAN” Come From? *continued*



Selected Metrics for US & Japan Automobile Manufacturers

Product Development (mid 1980s)	Japanese Producers	American Producers
Avg. Engineering Hrs per New Car (millions)	1.7	3.1
Avg. Development Time per New Car (months)	46.2	60.4
Employees in Project Team	485	903
Supplier Share of Engineering	51%	14%
Ratio of Delayed Projects	1 in 6	1 in 2
Summary of Assembly Plant Characteristics for Volume Producers, 1989		
	Japanese in Japan	American in N Am
Productivity (hrs/veh)	16.8	25.1
Quality (defects/100 veh)	60	82.3
Inventory (days for 8 sample parts)	0.2	2.9
Work Force on Teams	69.3%	17.3%
Suggestions per employee	61.6	0.4
Number of Job Classifications	11.9	67.1
Training Hrs of New Production Workers	380.3	46.4

LEAN Thinking

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

LEAN Thinking, *continued*

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

A Simple LEAN tool….
The 5S Approach

- Methodology for creating and maintaining an organised, clean, high performance workplace
- Target areas:
  - People, materials, equipment methods and information

The 5S Approach	
Sort	• Get rid of what is not needed
Store	• Arrange and identify for ease of use
Shine	• Clean daily. Clean up what's left
Standardise	• Create standards and standard methods
Sustain	• Set discipline, plan and schedule

Individual Activity 1 – 5S in Practice

- We will apply 5S to a workplace & measure the improvement in executing your job…
- Your job…. Find 1 to 49 in sequence
  - **Circle 1 to 49 in sequence**
  - You have **20 seconds**

1. Sort – Decide on what is needed

Sort	
Definition	• To sort out necessary and unnecessary items • Clear Workplace and remove all un-needed items such as files, binders, electronics, and excess materials
Benefits	• Removes waste • Creates a safer work area • Increases available workspace • Simplifies the **visualisation** of the process
Tips	• Start in one area, then sort through everything • Discuss removal of items with all persons involved • Do it safely and recycle as appropriate

2. Store - arrangement of items needed

Store	
Definition	• To arrange all necessary items - have a designated place for everything and to put everything in its place
Benefits	• Visually shows what is required or is out of place • Reduces time to locate items/documents • **Saves time**, not having to search for items
Tips	• Things used together should be kept together • Use labels, tape, floor markings, and signs to label items • Keep items that are shared in a central location (eliminate excess, equal access)

3. Shine - sweep and cleanliness

Shine	
Definition	• To keep areas clean on a continuing basis; while continuously raising the standards
Benefits	• A clean workplace is indicative of a quality product and process • A clean workplace helps to identify abnormal conditions and improve morale
Tips	• Storing "everything in its place" makes time available for cleaning • **Identify individual responsibilities** for cleaning

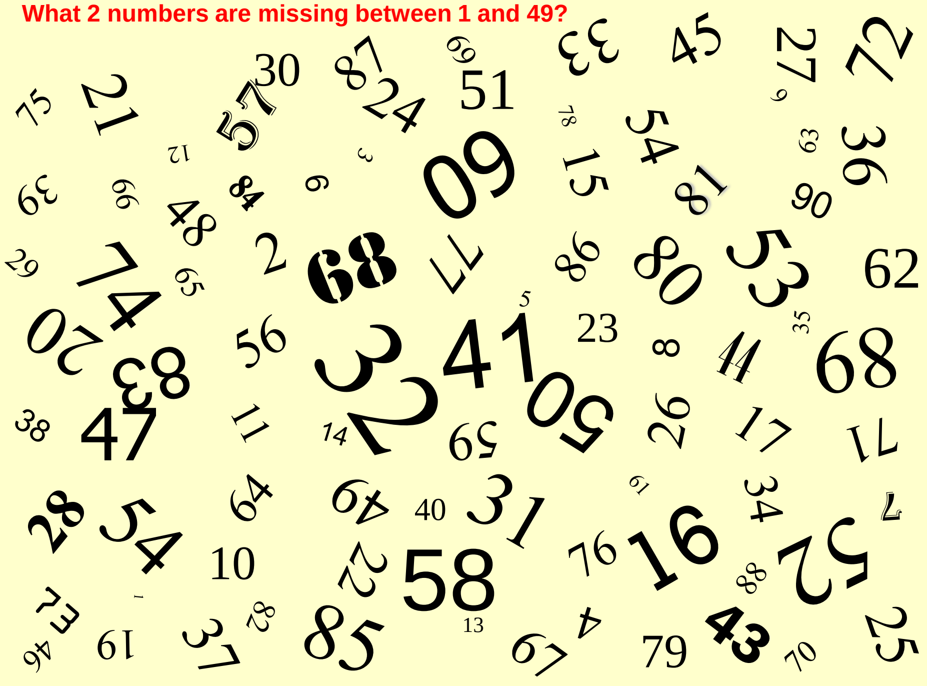
4. Standardise – create a common language

Standardise	
Definition	• To maintain the sorting, storage and shining activities into the workplace at a consistent level
Benefits	• Helps uncover problems and reveal their magnitude • Without standardisation of sorting, storage and shining, the **improvements from the first 3S's will disappear**
Tips	• Keep the work place neat and clean for visual identifiers to be effective in uncovering problems • Develop a system that will enable anyone in the workplace to see problems as they occur

5. Sustain – training & disciplined culture

Sustain	
Definition	• Practicing and repeating the 4S's regularly until they become a way of life in the workplace • Assessing the current practices and developing appropriate corrective actions
Benefits	• Sustain the 5S's into our everyday process as a habit. • Commitment and discipline toward housekeeping is essential in taking the first step in being World Class
Tips	• Develop schedules and checklists for the 4S actions

What 2 numbers are missing between 1 and 49?

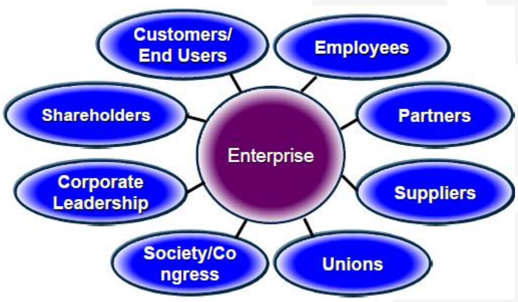


So easy!!!!

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17		19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41		43	44	45	46	47	48	49	

LEAN Enterprise

- Multiple stakeholders



- "Any group or individual who can affect or is affected by the achievements of the organization's objective"
  - Freeman, Strategic Management: A Stakeholder Perspective, Pitman, 1984

LEAN Enterprise, *continued*

- "Value - how various stakeholders find particular worth, utility, benefit, or reward in exchange for their respective contributions to the enterprise."
  - Murman et al, Lean Enterprise Value, Palgrave, 2002

- "A **LEAN enterprise** is an integrated entity that efficiently creates value for its multiple stakeholders by employing lean principles and practices."
  - Freeman, Strategic Management: A Stakeholder Perspective, Pitman, 1984

Your LEAN Journey…..

- How long did it take Toyota to develop all aspects of the TPS, including the LEAN thinking (culture) that underpins that system?
  - 20 years?
  - 10 years?
  - 5 years?
  - 1 year?

Your LEAN Journey….. The Kanban Example

- Kan (*card*) + ban (*signal*)
- Indicates material, parts, information is authorized to move downstream towards the customer
- 1950s – Toyota's first *Kanban* experiments
- 1960s – Toyota introduced *Kanban* company-wide
- 1970s – *Kanban* implemented throughout the supplier supply chain
- It took Toyota 30 years to build the "LEAN" enterprise

Your LEAN Journey…..*Case Study: Rockwells Collins*

- http://d1baxxa0joomi3.cloudfront.net/a72f84dc5dd7495c250af043893ad589/basic.mp4

Results In the Office:
- Reduced Publishing Cycle Time 72%
- 70% Work In-Process Reduction
- 38% Productivity Improvement
- 77% Manuals Inventory Reduction

Results In the Factory:
- 25% Improvement in Productivity
- 46% Reduction in Inventory
- Cycle Time Reductions of up to 75%

Your LEAN Journey…..*continued*

- How long might it take your company to implement LEAN thinking across your enterprise, using the knowledge, best practices & knowledge now available from Toyota and others?

Your LEAN Journey…..*continued*

WELCOME
to
The Start of
Your Lean Journey!

In Summary …

- LEAN Six Sigma practices emerged from the Japanese auto & US electronics industries
- 5S is a simple and effective lean tool
- LEAN thinking applies across an enterprise
- An enterprise has a core and extended boundaries, and many stakeholders.
- Lean has been successfully demonstrated in aerospace, healthcare, and other enterprises
- Lean is a "journey" not a "state"

FIREBRAND

THINK LEAN

Learning Objectives

- At the end of this module, you will be able to:
- Describe the elements of a process
- Draw a process map
- Explain "value"
- Describe the five fundamental LEAN principles
- Describe several concepts & tools for implementing LEAN principles

Definition of a process

Dictionary

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

Practical

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

A Process is not the same as a procedure

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

Process outputs go to "customers"

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

Block Diagrams

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

Example block diagram

Block Diagrams

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

Block Diagrams are typically used for presentations or management overviews

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

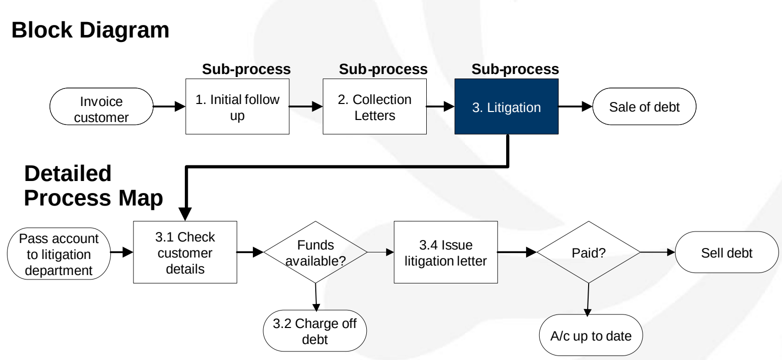
The block diagram scopes the detailed process map

The block diagram can provide context:

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

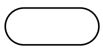
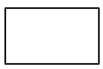
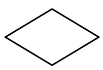
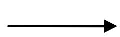
The levels of process detail

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

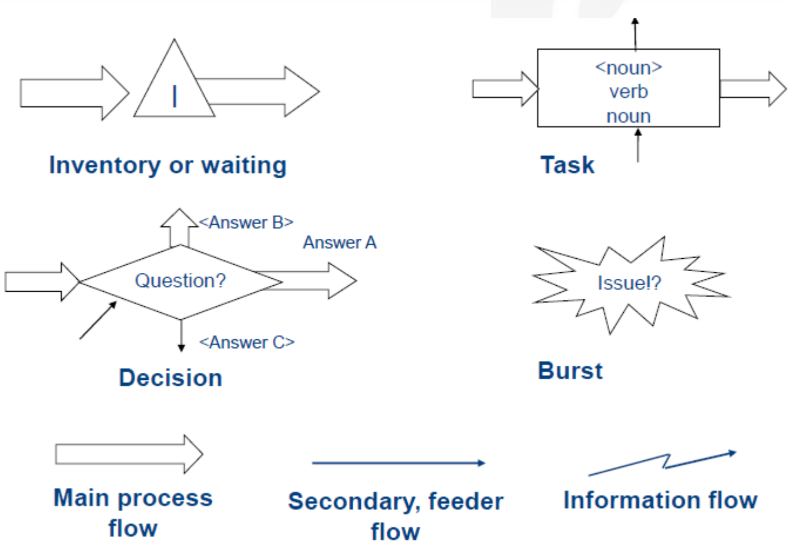


Symbols used in detailed process maps

All Process Maps use symbols to depict the flow.

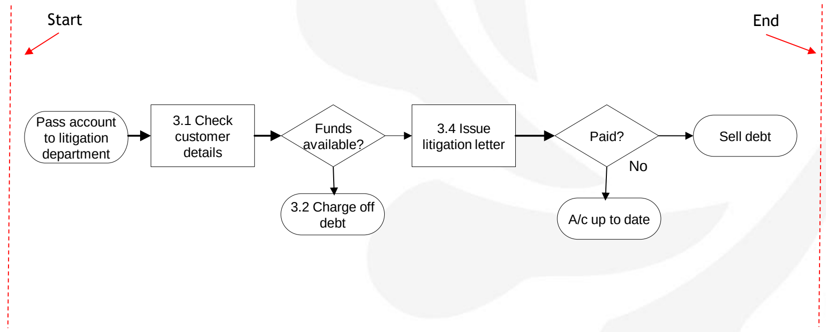
Symbol	Description
	Start and End Symbol
	Action
	Decision Point
	Direction of Flow

Additional Mapping Symbols



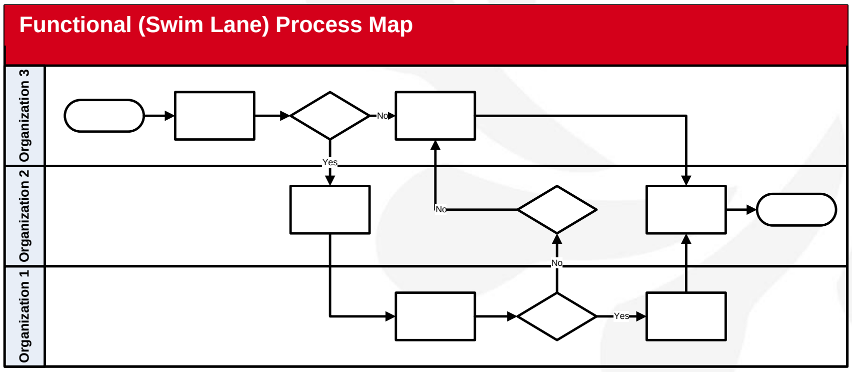
Identifying boundaries for your process

Boundaries define the start and end points of the process:

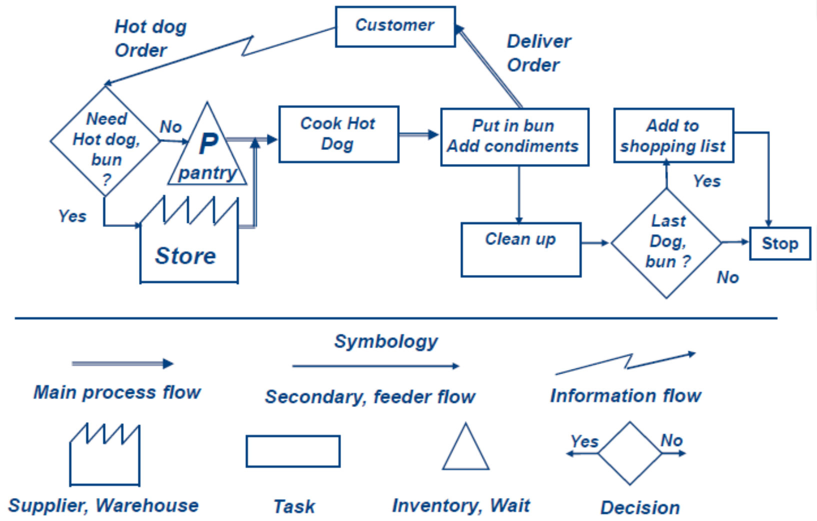


Functional process maps

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



Example Process Map for "fixing a hot dog"



Team Exercise 1 – Sasha & Andy Hot Dog Stand Process Map

- Please develop a process map for S & A Hot Dogs

5 LEAN Thinking Fundamentals

5 Principles of Lean

Specify Value	Value Stream	Flow	Pull	Perfection

- Specify **value**: Value is defined by customer specifications for a product or service
- Identify the **value stream**: Map out all end-to-end linked actions, processes and functions necessary for transforming inputs to outputs to identify and remove **waste**
- Make value **flow** continuously: Having eliminated waste, make remaining value-creating steps "flow"
- Let customers **pull** value: Customer's "pull" cascades all the way back to the lowest level supplier, enabling just-in-time production
- Pursue **perfection**: Pursue continuous improvement

Specify VALUE

Value | Value Stream Flow Pull Perfection

Value Added Activity — Emphasize
- Transforms or shapes material or information or people
- And it's done right the first time
- And the customer wants it

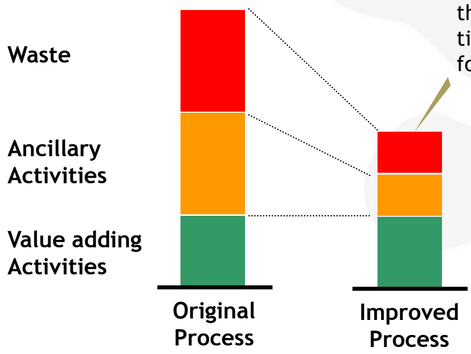
Non-Value Added Activity – Necessary Waste — Minimize
- No value is created, but cannot be eliminated based on current technology, policy, or thinking
- Examples: project coordination, regulatory, company mandate, law

Non-Value Added Activity - Pure Waste — Eliminate
- Consumes resources, but creates no value in the eyes of the customer
- Examples: wait time, inventory, rework, excess checkoff, accidents

Reducing Waste & Ancillary Activities

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

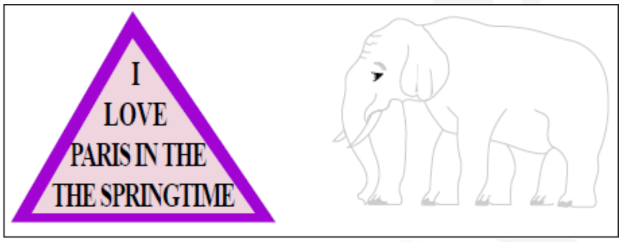
Understand value from the point of view of the customer. It is essential not to spend time on activities which do not add value for the customer.



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

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

Individual Exercise 2 - Quality Inspection & Value



In which of the 3 Value categories would you place inspection?

Identify the Value Stream

Value | **Value Stream** | Flow | Pull | Perfection

- A value stream is…
  - ALL the linked end-to-end activities that take place to deliver value
  - Starts with raw materials or initial information
  - Ends with the end customer/user

Customer needs/requirements, schedules

Material or information or people

Product or service valued by the customer

What Moves In a Value Stream?

Value | **Value Stream** | Flow | Pull | Perfection

In manufacturing… material flows

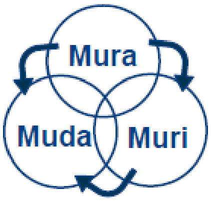
In design & services…information flows

In human services…people flow

Analyzing the Value Stream

Value | **Value Stream** | Flow Pull Perfection

- **Muda – Non value added**
  - **Look for the eight wastes (next slide)**
- **Muri – Overburden of people or equipment**
  - **Results in safety and quality problems**
- **Mura – Unevenness**
  - **Irregular or fluctuating production or workload due to poor planning, staffing, inoperative equipment, missing supplies, or irregular demand.**



- **Mura is a root cause**
  Muda is an outcome

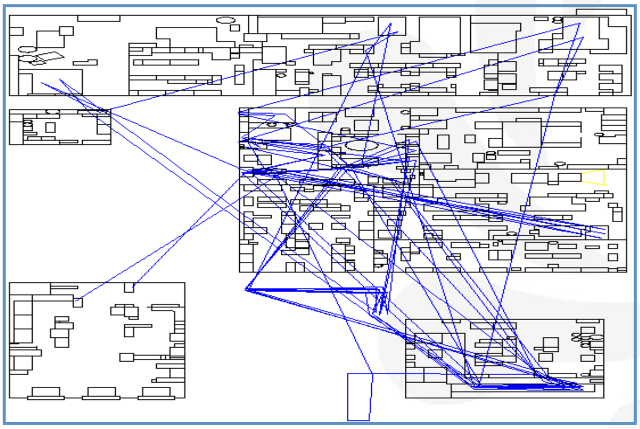
8 Forms of Waste

T
I
M
W
O
O
D
S

8 Forms of Waste - *Continued*

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

Unnecessary Movement



Spaghetti Charts are a powerful visual tool of seeing unnecessary movement

Kitting reduces unnecessary movement

Value | **Value Stream** | Flow | Pull | Perfection

- Combining all relevant materials, parts and/or information into a single package which can be delivered to the Point-Of-Use (POU) in a process to reduce unnecessary movement

Mistake-proofing (poka yoke)

Value | **Value Stream** | Flow | Pull | Perfection

Mistake-proofing is an action taken to:

- Remove the opportunity for an error in a process, or
- Make the error so obvious that it cannot reach the customer
- Also called **Poka-Yoke**, a Japanese term that means to avoid (yokeru) inadvertent errors (poka)

Mistake-proofing, *continued*

Value | **Value Stream** | Flow | Pull | Perfection

Mistake-proofing prevents or detects errors through three techniques:

Technique	Prevention	Detection
Shutdown	When a mistake is about to be made	When a mistake or defect has been made
Control	Errors are impossible	Defective items can't move on to the next step
Warning	That something is about to go wrong	Immediately when something does go wrong

Checklists

- Reduce defective work by
  - Standardizing work elements
  - Removing arbitrary & subjective decision making

Team Exercise 2 – Identifying Wastes via Muda Walk

- Please identify value, necessary waste & pure waste process steps within your S & A Hot Dog process map
- Use the 8 wastes as a guide……

Go to the Gemba

- Gemba (or genba) – "the actual place"
- Basic tenet of lean thinking – go to the place where work is being done and observe first hand the process in action
- Japanese call this genchi genbutsu, or "go see for yourself"
- Honda calls this the three actuals:
  - Go to the actual place
  - Talk to the actual people
  - Doing the actual work
- Relying on data and observations produced by others does not give a complete understanding

Make Value Flow

- Create Flow:
  - Focus on what is flowing through the process
  - Don’t be limited by organizational boundaries
  - Eliminate bottlenecks, minimize buffers

Flow Time

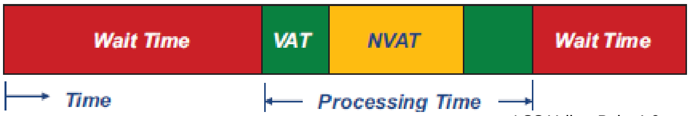
- Time is an essential metric for improving flow
- There are different ways to measure time
  - Wait time
  - Processing time
  - Cycle time
  - Customer demand or lead time

Wait and Process Time

Value | Value Stream | **Flow** | Pull | Perfection

- **Wait time**
  - The time Work in Process (WIP) is idle - in queues, buffers or storage
  - Other Names: queue time, delay time

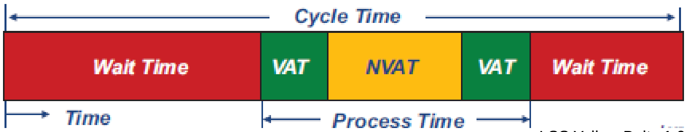
- **Processing time**
  - The time that activities are being performed on WIP
  - Processing time may consist of Value Added Time (VAT) and Non Valued Added Time (NVAT) activities.
  - Other names: Touch Time (TT), In Process Time (IPT), Response Time (RT), Activity time



Cycle Time

Value | Value Stream | **Flow** | Pull | Perfection

- The time required to execute activities in a process
- It can be measured for:
  - A single task or activity
  - A group of tasks or activities
  - A single process
  - A group of processes, e.g., customer order to customer delivery
- Cycle time includes processing time and wait time
- Other names: lead time or span time or throughput time



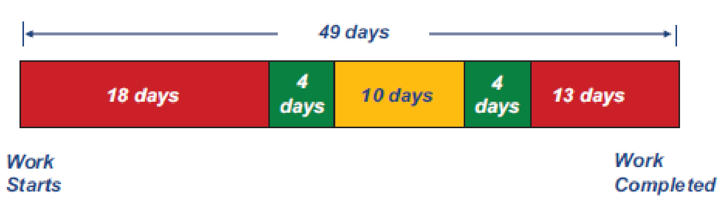
Team Exercise 3 – Calculate S & A Hot Dogs Process Times

- Please calculate the time, in seconds, for the 11 process steps, and the total cycle time
  - Make sure to convert everything to time per order
  - Don't forget effects of rework
- Sum times to calculate an average cycle time for the customer to get a hotdog (order to delivery)

Time Value Charts

Value | Value Stream | **Flow** | Pull | Perfection

- **Visual display of the breakdown in time for a given process**
- **Actual numbers must be measured or estimated**



Big cycle time savings comes from removing wait and non-value added time out of a process!

Let Customers Pull Value

Value | Value Stream | Flow | **Pull** | Perfection

- Push system – each activity delivers its output when it is done
  - Results in build up of batches with lots of inventory; defective goods pile up
- Pull system – each activity delivers its output just as the next activity needs its input
  - Triggered by the customer (external & internal)
  - Results in smooth flow with no batches or voids
  - Minimizes inventory and rework due to defects
- Inherently, there is very little waste in a pull system
- Pull systems are agile and responsive to customer demand

Moving from Flow to Pull

Value | Value Stream | Flow | **Pull** | Perfection

Pull requires flow plus predictable cycle time, using
- Takt time
- Balanced work
- Standard work
- Single piece flow
- Kanban system
- Just in time delivery of all material and information

Creating pull:
- Start with the customer and work backwards through the system
- If cycle time <= customer expectation time then pull can be accomplished
- If cycle time > customer expectation time then buffer inventory is needed (or cycle time must be reduced!)

Pull System Example: Dell Computers

Value Value Stream Flow **Pull** Perfection

- Dell developed the selling highly customized computer systems direct to customers
- Customer order initiates the pull process
- Orders can ship same day
- Partnerships with suppliers allow very quick replenishment of *vendor-owned* Dell inventory
- Dell ships 110,000 systems/day with very low inventory costs

Aspects of the Dell system have become standard practice for many consumer products

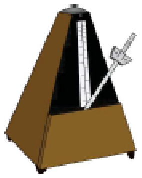
Takt Time – Measure of Customer Demand

Value Value Stream Flow **Pull** Perfection

Takt Time is…

- From the German word "Taktzeit"
  - "takt" is German for "stroke"
  - "zeit" is German for "time"
- A reference number that provides a drum beat for the process

$$\text{Takt time} = \frac{\text{Available time}}{\text{Customer demand rate for available time}}$$

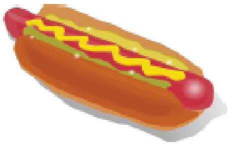


<u>Example:</u>
The available time is a year or 235 days.
There are 40 orders for this year.

What is the takt time?

235/40 ~ 6 days

S & A Hot Dog Stand Takt Time



Sasha *Andy*

- What is the takt time for S&A Hot dogs for
  - 50 customers?
  - 75 customers?
- Time available is 4 hours (240 minutes)
  - 50 customers – takt time is 240 / 50 = 4.8 min
  - 75 customers – takt time is 240 / 75 = 3.2 min

Balanced Work

Value Value Stream Flow | **Pull** | Perfection

Takt time example, continued…

To meet takt time, a product has to be delivered every 6 days. But if it takes 30 days to build, how is this possible?

	Cycle Time 30 days						Takt Time 6 days
Unit Number	7	6	5	4	3	2	1

Divide process in to 5 BALANCED steps of 6 days each

Each unit is worked at each step

This strategy requires the steps take the same time

Standard Work

Value | Value Stream | Flow | **Pull** | Perfection

- **Best process currently known, understood, and used today (evidence based)**
- **Tomorrow it can be better based on continuous improvement**
- **Standard work is the key to repeatability and effective innovation**

Single Piece Flow

Value | Value Stream | Flow | **Pull** | Perfection

Single Piece Flow

- Processing one unit at a time through all the steps to completion
- Only one unit in work at any step in the process
- LOW inventory levels
- Defects found immediately

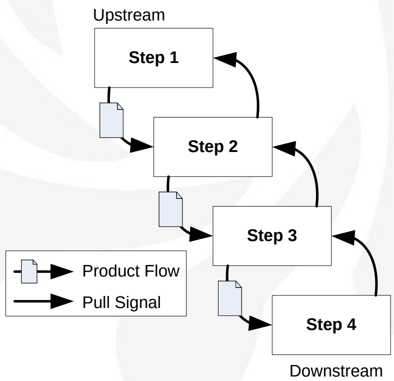
Batch & Queue

- Processing multiple units at the same time
- Optimizes efficiency of *each step*
- HIGH inventory levels
- Leads to larger scrap & rework

How pull systems work

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

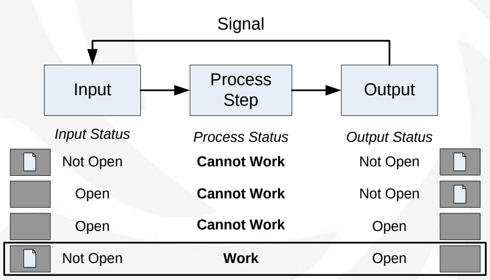
- Pure pull systems are used for commodity items such as cash in the ATM channel
- In-process pull systems are used to control the work flow of unique items such as loan applications



The rules of a pull system

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

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



In all other circumstances, the employees and equipment at th

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

The process characteristics that maximize the value of a Pull System

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

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

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

Visual Control and Andon

Value | Value Stream | Flow | **Pull** | Perfection

- *Visual control* helps identify the status of the process at a glance
  - Makes the process apparent to everyone involved with or observing it
  - Only valuable if used for *active* process management

- *Andon* is a specific visual control device, typically a group of lights indicating the current status of the process
  - Each step has a set of lights which indicates whether the step is proceeding as planned, needs monitoring, or requires immediate attention
  - In a pull system, if action is required, the entire process stops to correct the problem

Pursue *Perfection*

Value | Value Stream | Flow | Pull | **Perfection**

- Let customer demand pull value through the value stream
- Continuously eliminate waste in every process
- Design & build quality into the product & service
- Ensure transparency to everyone involved
- Remember…. LEAN is a journey, not a state ☺

5 Whys & Root Causes

Value | Value Stream | Flow | Pull | **Perfection**

5 whys can be used to help determine the root cause of mistakes

Example: The Jefferson Monument is deteriorating!

Why? It gets washed all the time.

Why? It always has bird droppings on it.

Why? Birds come into the monument to feed on spiders.

Why? The spiders are there feeding on gnats.

Why? The gnats are there because the lights are left on all time.

Five is only a "rule of thumb" – use as many "whys" as needed to get to root cause.

In Summary…

FIREBRAND

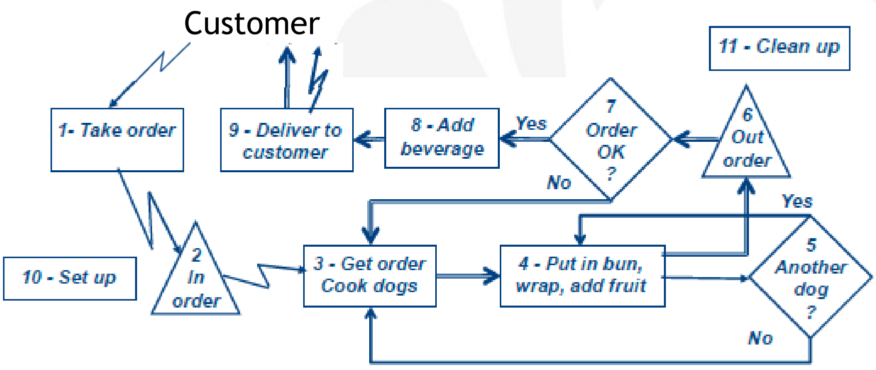
Value Stream Mapping

The basics….

Learning Objectives

- At the end of this module, you will be able to:
  - Sketch a basic value stream map
  - Demonstrate basic value stream analysis
  - Recognize steps for process improvement using value stream mapping & analysis

S & A Hot Dog Stand Process Map



How can Sasha and Andy improve their productivity to meet growing customer demand?

Value Stream Map

- A tool used to improve a process by identifying added value and eliminating waste
- A process map that follows the *value creation process*
  - "strap yourself to the product (or service) and see where you go"
- A process map with *data* added
  - Times: processing, wait, cycle
  - Quality: number of rejects
  - Inventory
  - Resources
    - Number of people
    - Space
    - Distance traveled
  - Whatever else is useful for analyzing the process

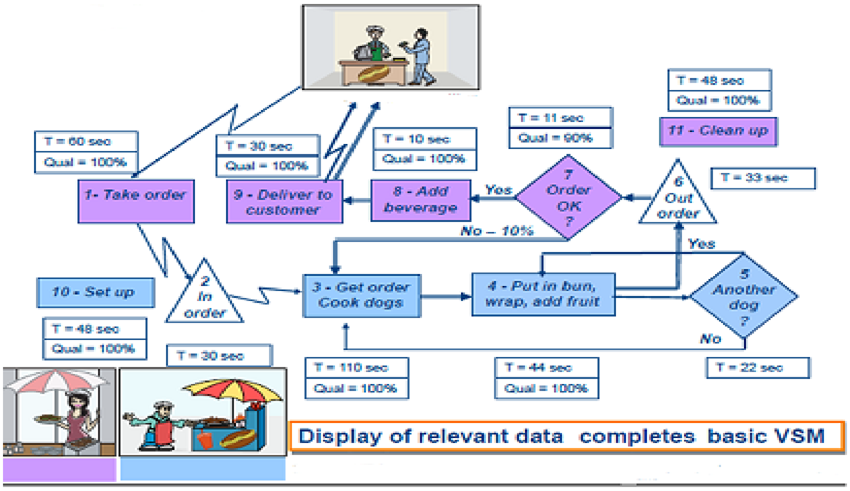
Steps for Creating a VSM

1. Define customer value and the process
   - "Walk" the process to identify tasks and flows
   - Identify value-added and waste process steps
2. Create the "current state" VSM
   - Gather data on resources, time, quality for each step
3. Analyze map to determine opportunities for improvement
   - Identify bottlenecks and other flow impediments
   - Brainstorm actions to eliminate waste and add value
4. Create a "future-state" map to visualize the desired and realistic next state
5. Create action plans to move toward future state

Step 1: S&A Customer Value & Process Map

- Customer Value
  - Good food
  - Faster service
- Current demand
  - 50 customers
  - 100 hot dogs

Step 2: Add Data



S & A Takt & Cycle Times

Current demand
50 customers

Open from 10AM - 2PM

$$\text{Takt time} = \frac{\text{Available time}}{\text{Customer demand}} = \frac{4\text{hrs} \times 60\text{min/hr}}{50 \text{ customers}} = 4.8\text{min} = 288 \text{ sec}$$

Cycle time (summed from previous data) = 7.4 min = 446 sec

**Valid alternate calculation –
assume setup/cleanup is done "when things are slow"**

10 - Set up

11 - Clean up

$$\text{Takt time} = \frac{\text{Available time}}{\text{Customer demand}} = \frac{4\text{hrs} \times 50\text{min/hr}}{50 \text{ customers}} = 4.0\text{min} = 240 \text{ sec}$$

Cycle time (excluding set up & clean up) = 5.8 min = 350 sec

Cycle time > takt time, but two workers – can demand be met?

Step 3: Value Stream Analysis
Team Exercise 3

- Please calculate the total:
  - Value added time
  - Non value added time
  - Wait time
- Calculate the total "touch time" that Sasha & Andy spend on a single order

Utilization and Capacity

VAT is only slightly over 50% ⇒ Opportunities for improvement

Available time = 4 hours = 240 min

Worktime: Touch time per order X number of orders
Sasha's tasks: 159 /60 min X 50 cust. = 133 min
Andy's tasks: 224 /60 min X 50 cust = 187 min

Utilization: Worktime / time available
Sasha's: (133 min / 240 min) X 100% = 55 %
Andy's: (187 min / 240 min) X 100% = 78 %

Capacity: Time available / touch time per order
Andy working at 100% = (240min X 60) / 224 sec = 64

Summary – S&A Value Stream Analysis (VSA)

- Current production (50 customers) is a little below current capacity (64 customers) of Andy and Sasha
  - Process improvement needed to meet growing demand
- Andy and Sasha are both underutilized
  - But utilization is not balanced between them
- Cycle time of 7.43 min per customer (or even 5.8 min) too long
  - Should be able to shorten cycle time to meet demands of customers for faster service

Bottom Line
Sasha and Andy should implement process improvement for week 3 to meet growing demand!

Improvement Brainstorm
Team Exercise 4

- Help Sasha & Andy figure out what to improve:
  - How can utilization be improved?
  - How can cycle time be reduced?
  - What has to be done to serve 75 customers?
  - What has to be done to serve 100 customers?

Tips for Creating a VSM

- Involve the entire team
- Walk the process
- Use symbols or icons that are meaningful & understood by all involved

Quality Tools

The 7

Learning Objectives

- At the end of this module, you will be able to:
  - Describe how quality is essential to LEAN in achieving customer satisfaction
  - Describe a process's Yield & Rolled-Throughput Yield
  - Use the 7 basic quality tools

The Price of Non-Conformance

- Did you know that the hidden costs of non-conformance can be 300% measured costs?
- Direct Measured Costs include
  - Scrap / re-work
  - Service calls
  - Warranties / concessions
- Indirect / Hidden Costs include
  - Excess inventory
  - Overtime
  - NVA steps
  - Queues & delays
  - Reputation / image

Baseline Rolled Throughput Yield (RTY)

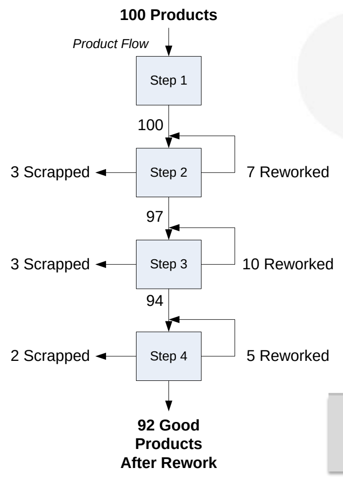
Yield is the percentage of products that are judged as “good” from the total number of products processed.

- The “product” is the reference product from the Value Stream Map.

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

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

How Yield is calculated



$$\text{Yield} = \frac{\text{Number of “Good Products”}}{\text{Number of Products Processed}}$$

$\text{Yield}_1 = 100 / 100 = 1$

$\text{Yield}_2 = 97 / 100 = 0.97$

$\text{Yield}_3 = 94 / 97 = 0.97$

$\text{Yield}_4 = 92 / 94 = 0.98$

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

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

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

RTY is the preferred measure of product quality

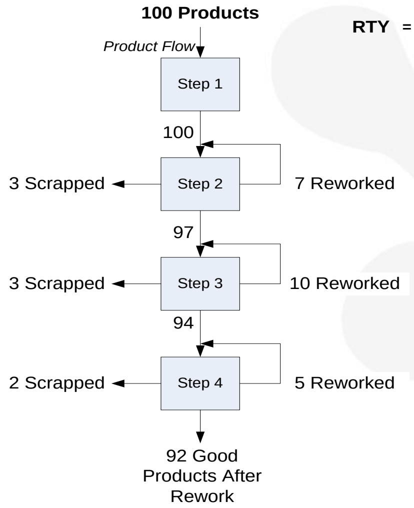
The Rolled Throughput Yield (RTY) reveals the rework that occurs in a process (the hidden factory).

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

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

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

How RTY is calculated



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

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

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

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

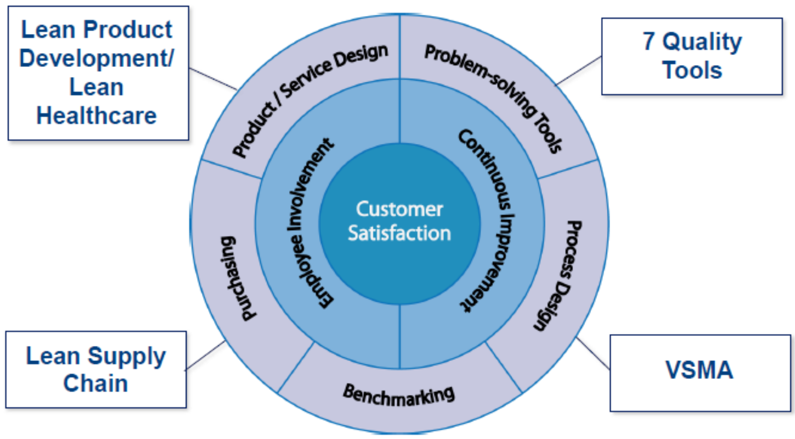
$RTY_4 = (94 - (2+5)) / 94 = 87/94 = 0.93$

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

Problems with Inspection-based Quality Control

- **Inspection does not add value to the customer – it simply screens or detects (most of the time) defective products from leaving the factory.**
- **Inspection is subject to multiple errors**
  - **Inspector skill and attention**
  - **Measurement capability**
  - **Environment (Human Factors)**

TQM?



Total Quality Management (TQM) and Lean are related

The 7 Basic Quality Tools

- Flow charts
- Cause & Effect Diagrams
- Check Sheets
- Histograms
- Pareto Charts
- Scatter Diagrams
- Control Charts

Flow Charts

Flow chart examples

- Process maps
- Software program flows

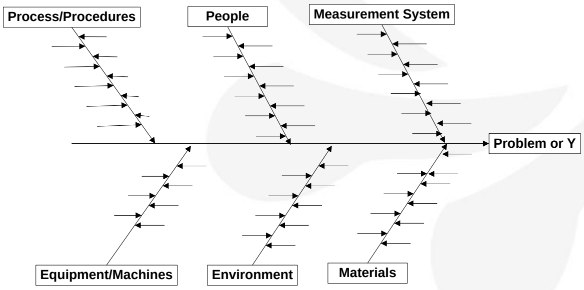
Why are Flow Charts a quality tool?

- Visual description improves comprehension
- Helps assure process steps are done in the right sequence
- Ties outputs to inputs
- Assists with data collection

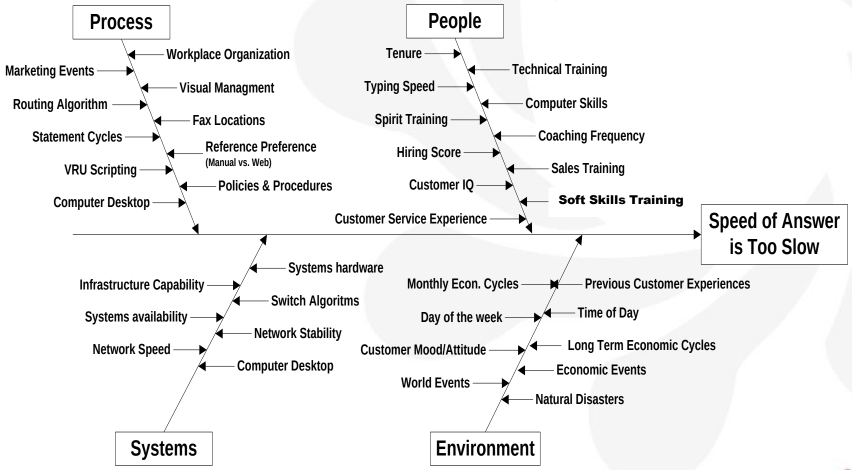
Overview of the C&E Diagram

The C&E Diagram:

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



Example of a Cause-Effect diagram



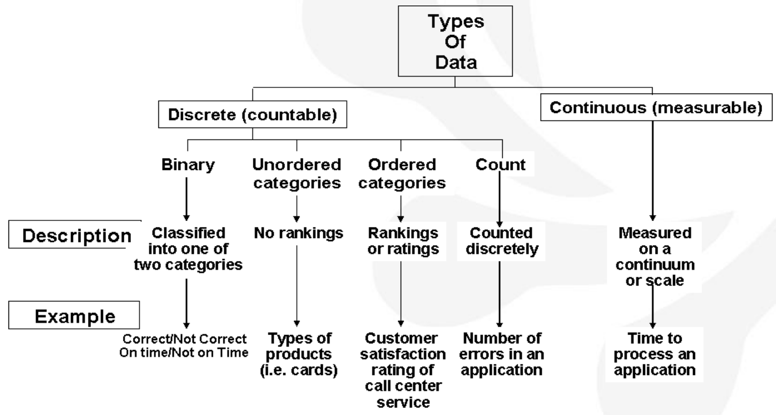
Check Sheets

- A structured tool for collecting data

Problem	Monday	Tuesday	Wednesday	Total
Speaker's voice	~~IIII~~ II	IIII	III	14
Room noise	IIII	III	III	10
Typos on slides	~~IIII~~ IIII	~~IIII~~ II	~~IIII~~ I	22
Fuzzy projection	III	I		4
Missing material	~~IIII~~ III	~~IIII~~ I	III	17
Total	31	21	15	67

A purely hypothetical example!

Types of Data



Continuous Data

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

Examples:

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

Discrete data

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

Examples:

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

Data Classification Individual Exercise 2

Continuous or discrete?

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

Time - 5 minutes

Continuum of data possibilities

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

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

The data at your disposal can be in many forms:

Less Desirable

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

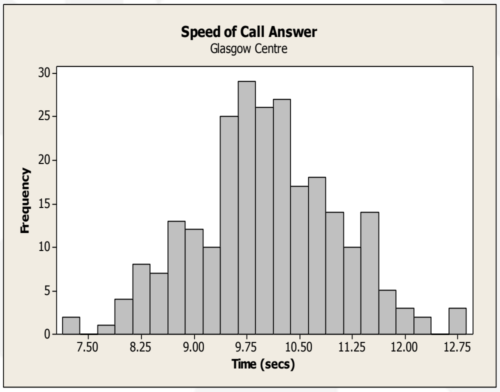
More Desirable

Descriptive statistics

Shape of the data (Bell-Shaped or skewed)

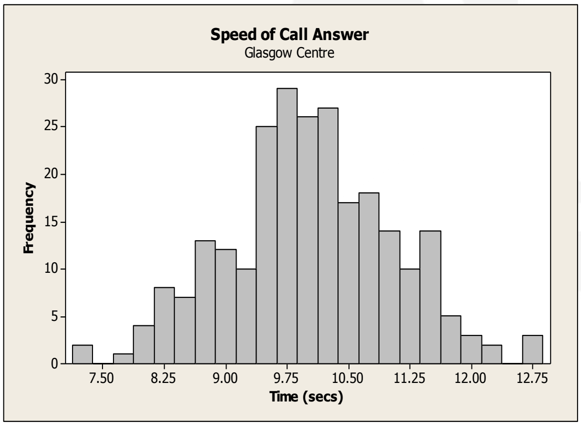
Centre of the data (mean, median or mode)

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



Assessing shape - Histogram

- *What does the shape of this Histogram suggest?*



Parts of a Histogram

A histogram is made up of three components:

Vertical or Y-Axis:

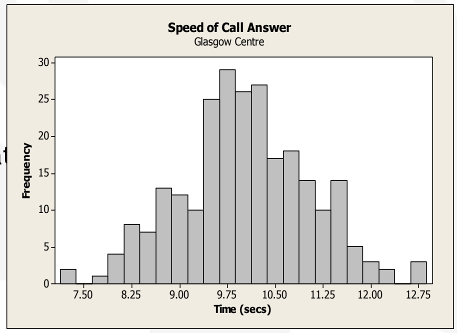
- Indicates the scale for the frequency the bars

Horizontal or X-Axis:

- The scale of values into which the dat values fit
- Data values grouped into interval

Bars:

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



Advantages and limitations of using a histogram

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

Use Histograms to answer the following questions:

What is the shape of my continuous data?

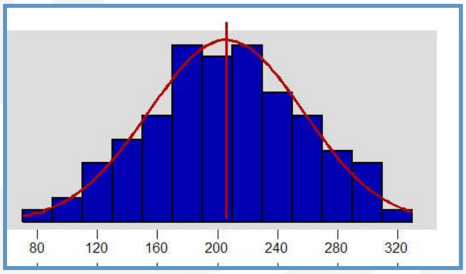
Does my process perform to specifications?

123

Measures of the central location

The three measures of centre:

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



Formula for calculating mean

Calculating mean:

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

Steps for calculating mean:

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

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

μ Population mean

Calculating the median

What is the median?

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

$\tilde{x}$ Sample median

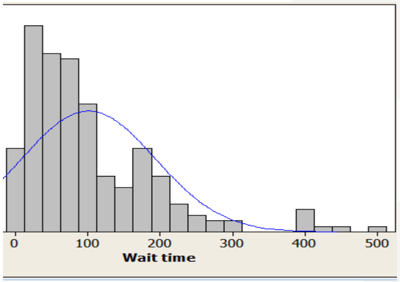
η Population median

Steps to calculate median:

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

The impact of shape upon centre

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



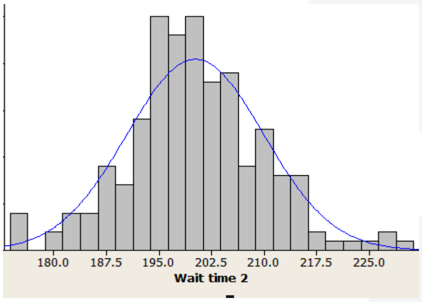
The mean wait time is 100 seconds. The median wait time is 74 seconds.

Which one should we use?

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

The impact of shape upon centre, *Continued*

- Another wait time example:



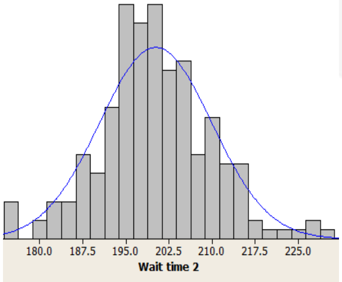
This Histogram represents the wait times for another hotel. The mean wait time is 200.1 seconds and the median is 200.1 seconds.

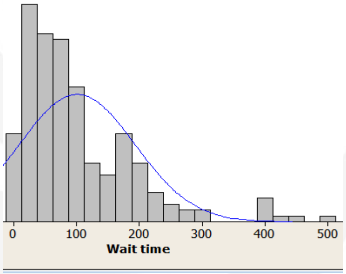
There is no/little difference between the two statistics for centre of the data.

Why is this?

Guidelines for use of mean and median

Mean or Median?

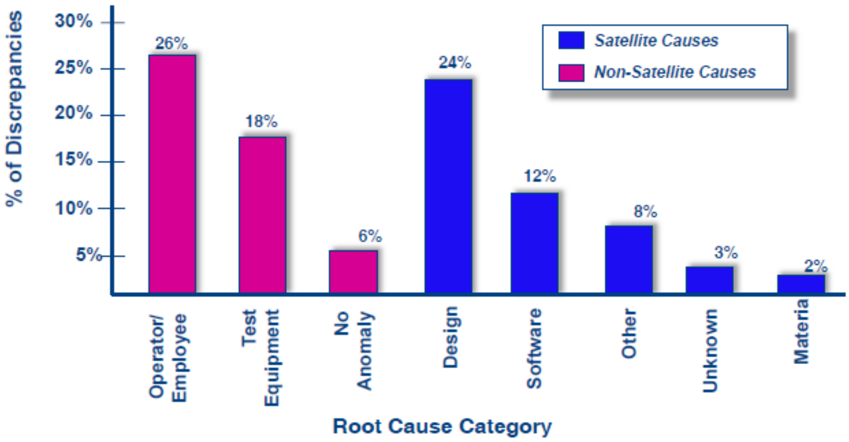




If the data is bell-shaped, use the mean to describe the centre of the data.

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

Pareto Charts



Scatter Plot

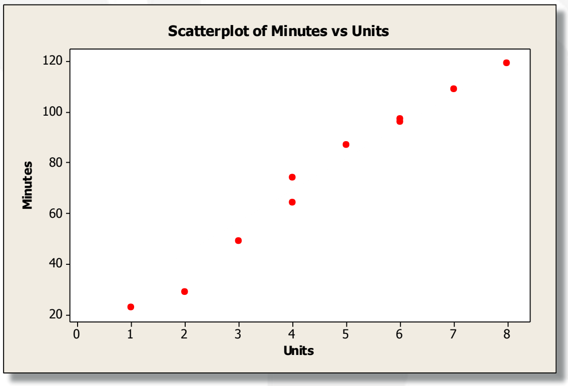
A Scatter Plot illustrates the relationship between two continuous variables.

Components

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

Tests the relationship between a continuous Y and a continuous x

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



Using a Scatter Plot

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

Use Scatter Plots to:

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

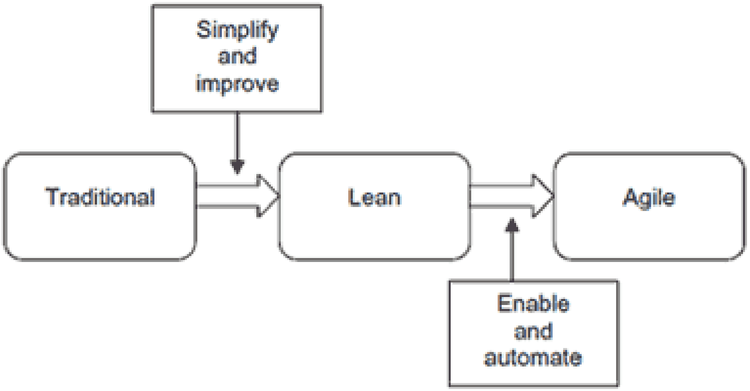
In Summary….

- Inspection is an ineffective way to produce high quality products and services
- Total Quality Management and Lean Thinking are closely related
- Lean Thinking and TQM both utilized simple, structured, quantitative and qualitative tools to achieve quality
- There are seven basic quality tools
- But remember – capable people are the most important factor in achieving quality

LEAN Enterprise Process Flow Chart

Business Context	Process Mapping	Process Simplification	Process Management	Process Stabilization	Continuous Improvement
• Customer wants and needs • Environment, challenges • Goals and objectives • Strategies and tactics • Benchmarking • Visioning • Scope and approach • Project planning	• Education • Measurements • Flowcharting, line analysis • Modeling • Brainstorm opportunities • Prioritize opportunities • Organization readiness assessment • Goal setting • Quick wins	• Process flow improvement • Operation improvement • Five Ss • TPM • Defect prevention (mistake-proofing, Seven QC tools, etc.) • Quick changeover (QCO)	• Pull design • Kanban design • Measurement management • Information design • Rationalize paperwork • Turn on training • Turn on prep	• Turn on pull system • 24-hour support • Rapid changes and improvements	• Institutionalize positive change • Benchmarking • Continuous improvement reviews • Limited automation (I/T and mechanical) • Expand scope

Enterprise Transformation Process



FIREBRAND

SIX SIGMA

The Basics…

Learning Objectives

- At the end of this module, you will be able to:
  - Recognize that Six Sigma is a valuable approach for improving process quality
  - Interpret a basic Statistical Process Control chart
  - Distinguish between process and specification control limits
  - Describe a capable process

What is Six Sigma?

- **Six Sigma is a 5-phase problem solving methodology that**
  - **Understands a business problem**
  - **Translates it into a statistical problem**
  - **Solves the statistical problem**
  - **Translates it back into a business solution**
- **Using Six Sigma reduces the amount of defective products manufactured or services provided, resulting in increased revenue and greater customer satisfaction.**

Six Sigma Methodology

Phase 1 - Define

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

Phase 2 - Measure

- Map the “as-is” process and measure the current performance

Phase 3 - Analyse

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

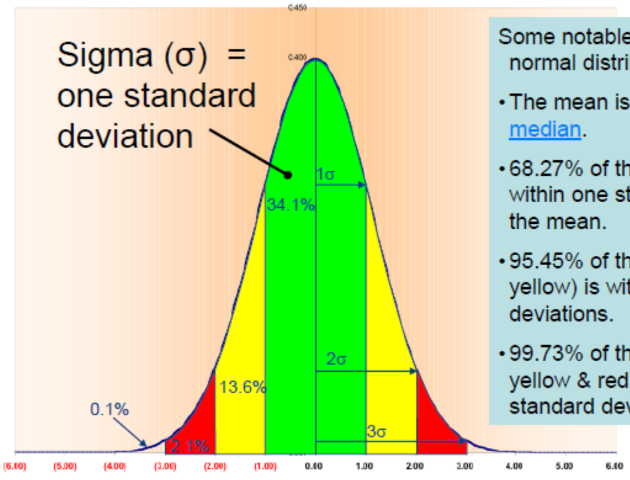
Phase 4 - Improve

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

Phase 5 - Control

- Ensure that the improvement continues

Standard Normal Distribution



Some notable qualities of the normal distribution:

- The mean is also its mode and median.
- 68.27% of the area (green) is within one standard deviation of the mean.
- 95.45% of the area (green & yellow) is within two standard deviations.
- 99.73% of the area (green & yellow & red) is within three standard deviations

Defects

- "Defect" is defined as any process output that does not meet the customer"s specifications.
- Improving quality means reducing the defects per million opportunities (DPMO). There are two attributes to this metric that can be controlled:
  - *Opportunities* – reducing the number of steps, handoffs and other "opportunities" will help improve quality
  - *Defects* – reducing the number of defects for each process step through continuous process improvement will help improve quality

Six Sigma Practical Definition
Is 99% Good Enough?

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

Stability - Introduction

What is process stability?

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

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

Understanding Common and Special Causes of Variation

Variation can be common cause or special cause.

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

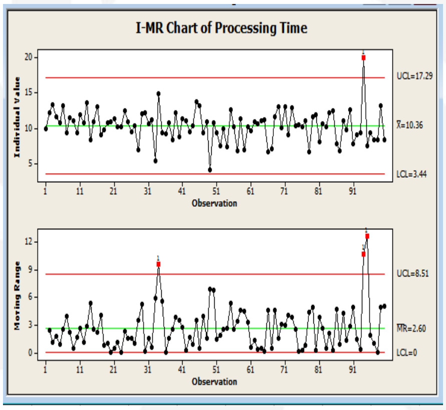
The two causes of variation

How you interpret variation …

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

Introduction to Control Charts

- What are control charts and why are they useful?
  - Display a project metric in the order it is collected over time
  - Are used to determine whether a process measure is stable (in a state of statistical control)



The two categories of Control Charts

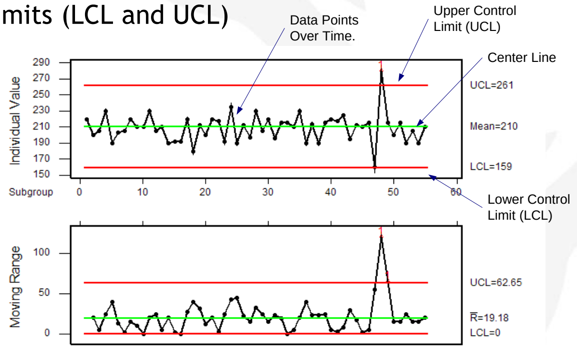
Control Charts can be used for continuous or discrete data.

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

The components of a Control Chart

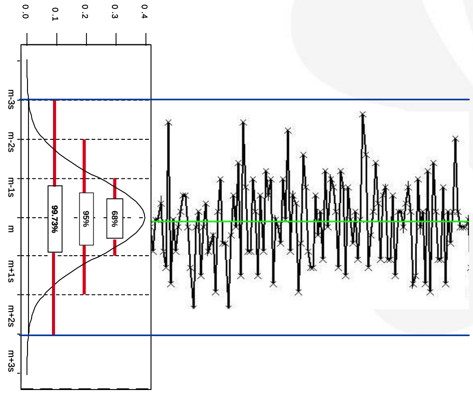
All Control Charts have three components:

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



Understanding Control Limits, *Continued*

How control limits work:



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

Control limits are not specification limits

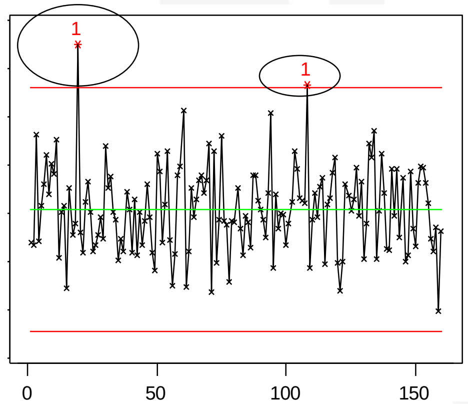
Control limits should not be confused with specification limits:

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

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

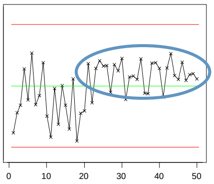
The two indicators of a special cause of variation

1. Any point outside a control limit

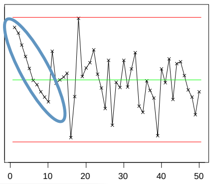


The two indicators of a special cause of variation
Continued

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

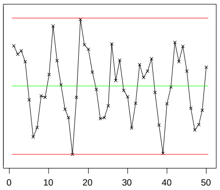


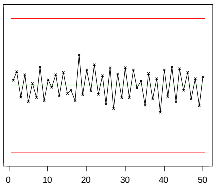
Shifts
A series of points above or below the centre line



Trends
A series of data points that continuously increase or decrease

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





Applications of Control Charting in DMAIC

The two primary applications for Control Charts in DMAIC

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

Selecting the best control chart for the Measure Phase

How do I choose the correct chart for my project?

Questions to ask:

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

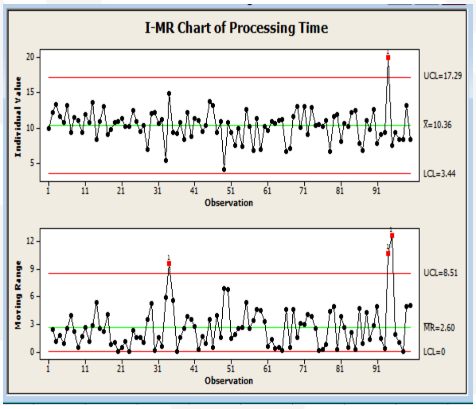
Control Charts used to assess stability of the primary metric

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

Structure of the Individuals and Moving Range Chart

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

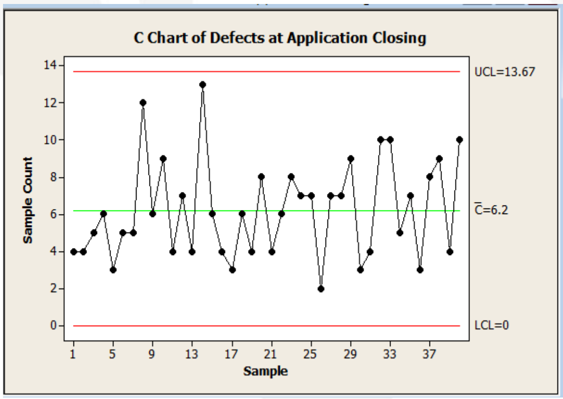
- Individuals Chart monitors the individual observations over time.
- Moving Range Chart monitors the change of the individual observations over time.



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

The C Chart

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



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

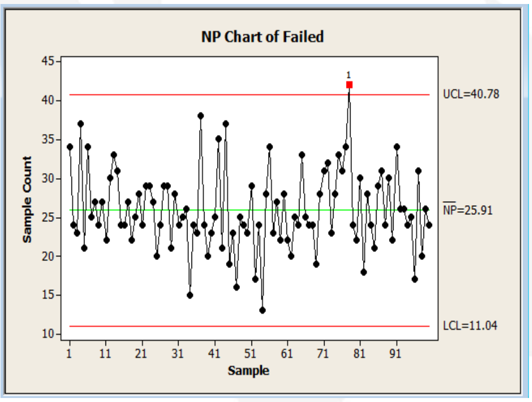
The NP Chart

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

Differs from the C Chart:

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

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



The importance of identifying special causes

Special cause variation indicates a need to investigate:

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

How you interpret variation ...

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

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

Definition of Process Capability

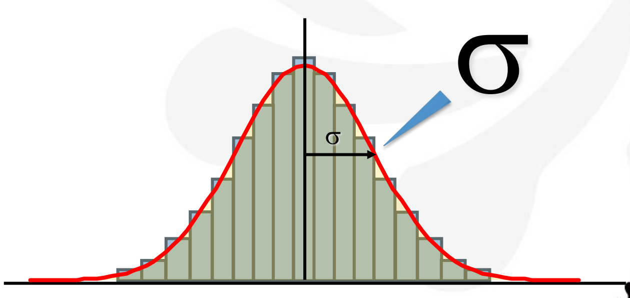
*Process capability is the ability of a **stable** process to meet customer requirements.*

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

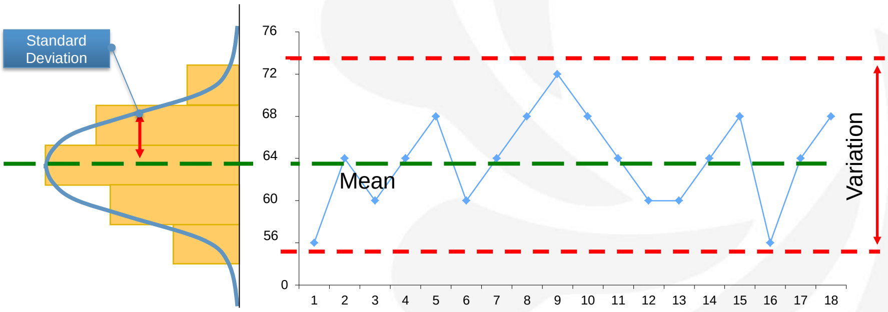
Definition of Sigma

What is ~~Six~~ **Sigma**?

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



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

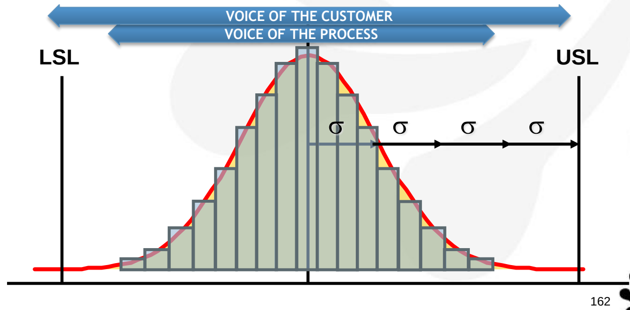


Variation exists in all processes.

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

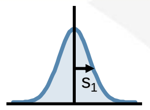
Definition of Sigma Level

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



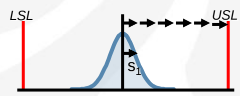
Picturing capability

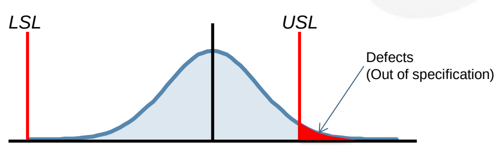
A universal business metric that can be used to indicate the capability of the process (VOP) to meet an output specification (VOC)



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

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





The first measure of capability: Sigma Level

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

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

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

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

The second measure of capability: DPM

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

The relationship between DPM and Sigma Level:

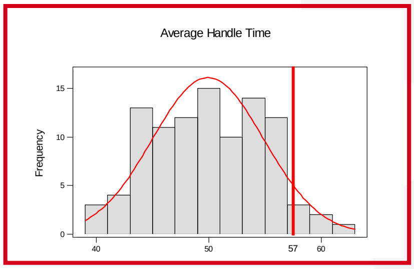
Sigma Level	DPM
1	691,462
2	308,538
3	66,807
4	6,210
5	233
6	3.4

DPM is the number of defectives in every million units.

Note that it is “defectives per million” rather than “defects per million.”

Calculating sigma with continuous data

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



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

What is the sigma level for 57 seconds?

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

$$Z + 1.5 = Sigma$$

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

The Sigma Calculator

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

FIREBRAND

Sigma Level Calculator (Instructions in red text below)

Calculating Sigma Level for Continuous Data

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

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

Calculating Sigma Level for Discrete Data

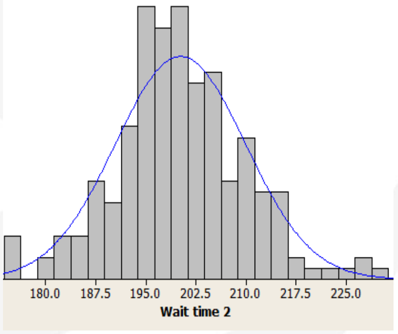
Enter Number of Items Evaluated	30
Enter Number of Defective Items	1
This is your Sigma Level	3.33
This is your Yield	96.67%
This is your DPM	33,333

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

Steps to calculate sigma level for continuous data

Three Requirements

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



Steps to calculate sigma level for continuous data

Steps to use the Sigma Calculator for continuous data:

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

1. Enter the average (x bar).

2. Enter the standard deviation (s).

3. Enter the specification limits for the project metric.

4. The calculator displays these values automatically.

Calculating sigma with discrete data

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

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

When:

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

N = Number of units evaluated

Steps to calculate sigma level and DPM for discrete data

Steps to use the Sigma Calculator for discrete data:

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

1. Enter the number of items in the sample.

2. Enter the number of defective items.

3. The calculator displays these values automatically.

Individual Exercise 3: Quantify process capability

Capability Analysis

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

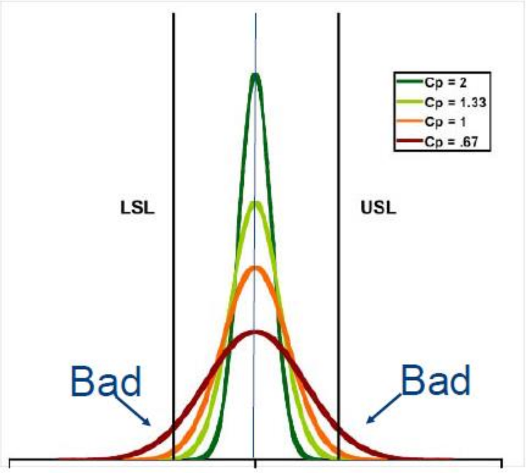
Time - 5 mins

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

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

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

Another way of assessing process capability

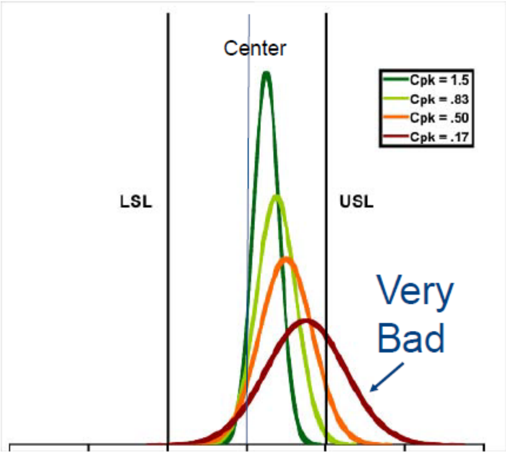


C_p, a term used to define process capability, is mathematically expressed by:

$$C_p = \frac{USL - LSL}{6\sigma}$$

The figure shows centered distributions with various C_p levels. Note C_ps less than two have visible tails outside the acceptable limits.

Another way of assessing process capability… *continued*



If the distribution is off center, the probability of a bad result drastically increases. In this case C_{pk} is used. It is the smaller of

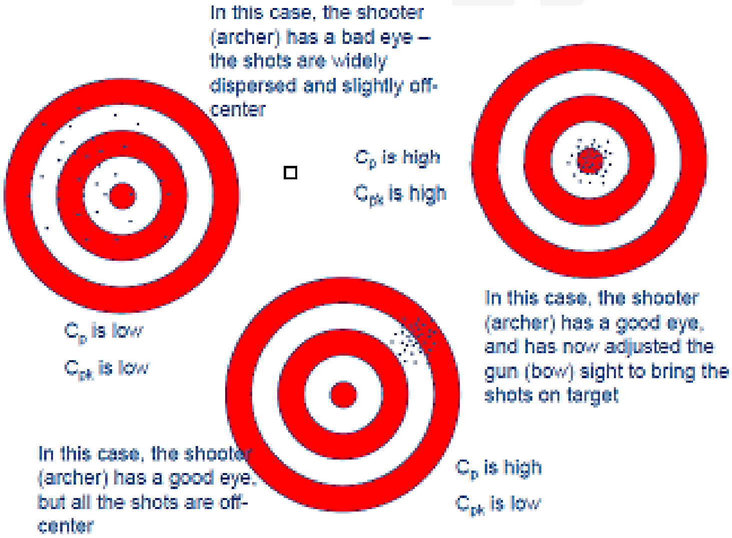
$$C_{pk} = \frac{USL - Mean}{3\sigma}$$

or

$$C_{pk} = \frac{Mean - LSL}{3\sigma}$$

This figure shows the same distributions off-center by 1.5σ. The C_{pk}s are smaller than the corresponding C_ps. This illustrates the need to both control variation and accurately hit the desired mean.

Cp versus Cpk



Six Sigma Overview Summary

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

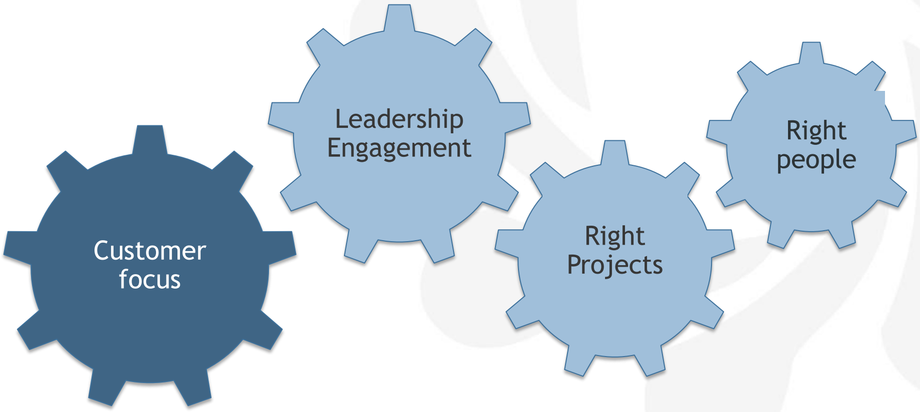
FIREBRAND

ORIENTATION

Deploying Lean Six Sigma in the business

Deploying Lean Six Sigma in the business

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



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

Customer focus

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

Customer focus

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

Leadership Engagement

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

Leadership Engagement

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

Right Projects

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

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

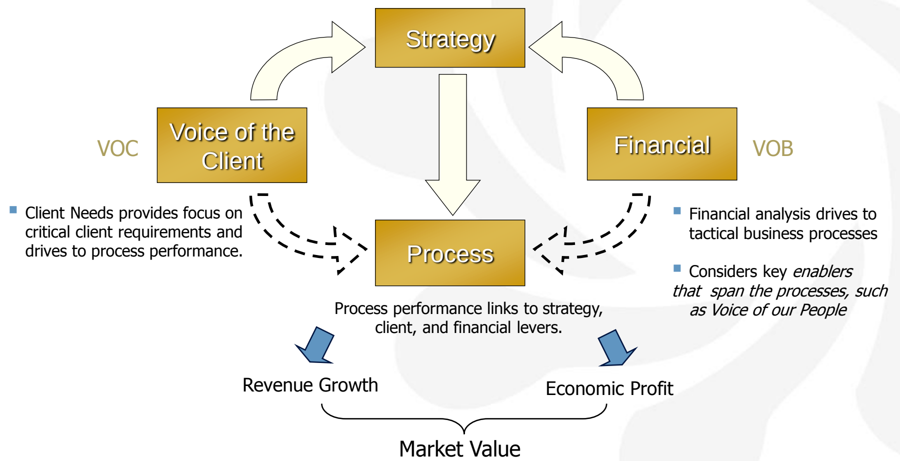
Right Projects

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

Right Projects

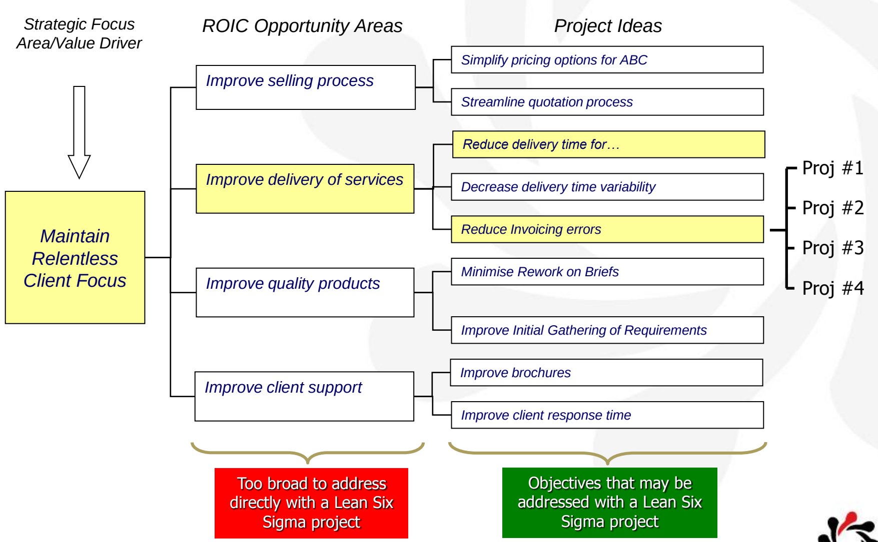
1 Identify Value Levers	2 Identify Project Opportunities	3 Screen Initial List of Opportunities	4 Scope and Define Projects	5 Prioritise List of Defined Projects
▪ Identify value levers in the business • Strategic • Financial • Client • Operational (Process) ▪ Prioritise value levers	▪ Translate Value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

Right Projects – Identify Value Levers

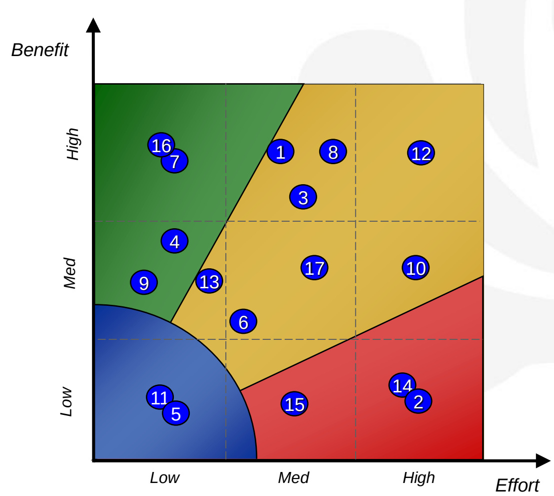


Insight: Tools such as Scorecards and Dashboards are used to translate Strategy into Key Process Metrics in order to sustain improvement results

Right Projects – Identify Project Opportunities



Right Projects – Screen Initial List of Opportunities



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

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

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

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

Right Projects - Scope and Define Projects

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

We'll cover more on charters within the Define module

Right Projects - Scope and Define Projects
Problem Statement

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

A POOR Problem Statement

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

A GOOD Problem Statement

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

Right Projects - Scope and Define Projects
Project objective

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

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

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

Right Projects - Scope and Define Projects
Primary Metric

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

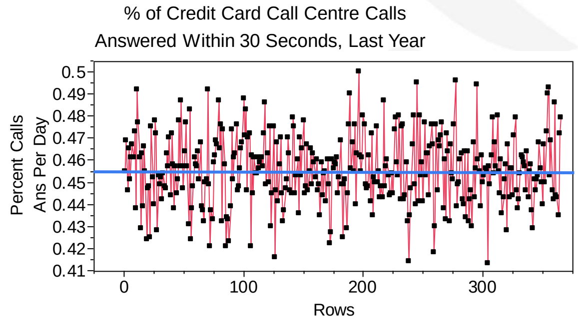
Right Projects - Scope and Define Projects
Secondary Metric

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

Right Projects - Scope and Define Projects
Contact Centre case study

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

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



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

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

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

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

Right Projects – Prioritize List of Defined Projects

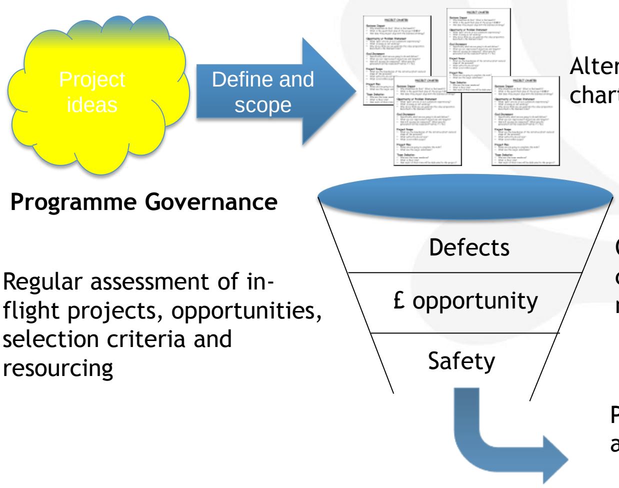
The project charter will drive the most appropriate project “vehicle”

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

Ensuring that the correct projects are selected is critically important

Right Projects – Prioritize List of Defined Projects

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



Alternative project charters

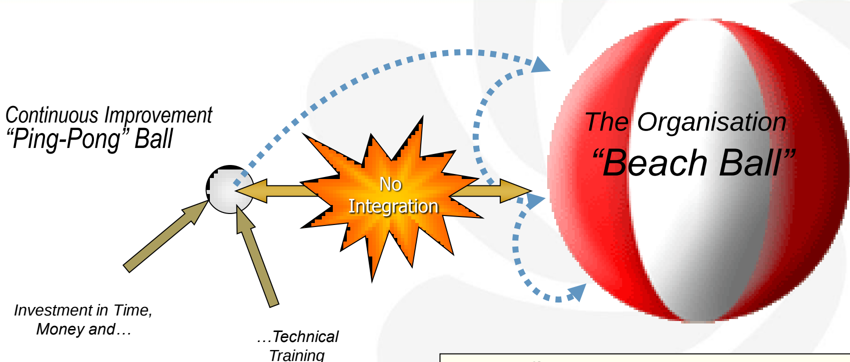
Programme Governance

Regular assessment of in-flight projects, opportunities, selection criteria and resourcing

Quantitative and qualitative criteria used to select from multiple project options

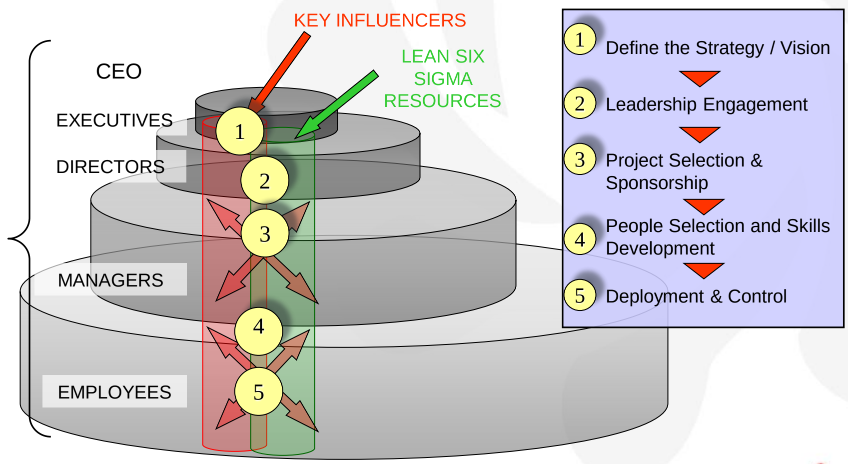
Project charter assigned

Right People -The Typical Flawed Approach



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

Right People -The organisational view



Right People - Being a Green Belt

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

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

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

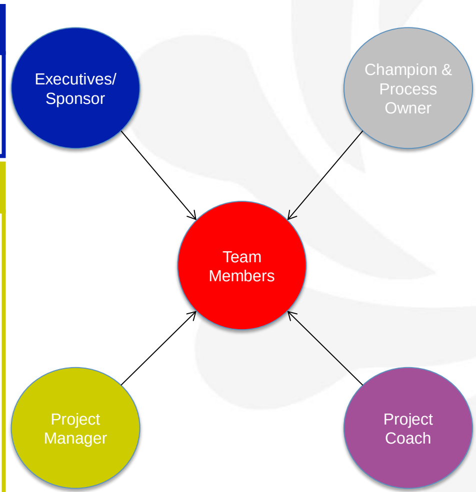
Right People - Lean Six Sigma Roles & Responsibilities

Executives / Sponsor

- Owns vision, direction, business results
- Leads Change

LSS Project Manager

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



Champion & Process Owner

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

Coaching

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

In Summary ….

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

LAI Lean Academy Glossary v7.6

Term	Description
5 Whys	A process of asking “why?” five times in a row to get to the root cause for something. Five is a guideline or rule of thumb. Sometimes fewer or more questions are needed. 5 Whys is not a unique process. Different people may arrive at different root causes.
5S	Sort, Straighten, Scrub, Standardize, Sustain. A disciplined approach to improve workplace efficiency by eliminating non-value added clutter and materials, making it easy for workers to find just what they need, just when they need it. The original Japanese 5S terms are *Seiri, Seiton, Seiso, Seiketsu, and Shitsuke*. Various translations into English are found, each keeping S as the first letter. There is an implied progression to start with the first S and move towards the final S.
6S	Americans added Safety to 5S, and there are various versions of where Safety fits and its actual verbiage. The LAI Lean Academy uses Sort, **Safe**, Straighten, Scrub, Standardize, and Sustain.
8 wastes	Categories of waste (muda) used to help identify non-valued added activities: overproduction, inventory, transportation, unnecessary movement, waiting, defective outputs, over processing, unused employee creativity. The first seven originated from Toyota. The eighth was added, realizing that non-engagement of employees in continuous process improvement was a waste of human resources. Variations of these wordings are found.
A3	Named for the A3 size of paper (approx 11” x 17”) used to capture an improvement plan. A3 is both a tool (a formatted piece of paper) and a way of thinking about continuous process improvement.
Activity time	Another name for processing time, the time that work is being done on a task.
Andon	A specific visual control device, usually a set of red-yellow-green lights, to show the current status of a process station.
Balanced work	Having the time for each step of a multistep process be approximately the same as the overall takt time to enable smooth flow with no bottlenecks.

LAI Lean Academy Glossary v7.6

Term	Description
Batch and queue	The practice of a given work station processing multiple units at one time (a batch), placing the outputs into a buffer (a queue) for the next step in the workflow.
Benchmarking	An activity of visiting operations external to the organization to observe their work practices to help in determining best practices.
Bottleneck	The activity with the greatest utilization or load. In a balanced work process, there are no bottlenecks.
Capacity	The maximum sustainable flow rate or throughput of an activity. Actual capacity takes into account detractors that reduce the theoretical throughput.
Castle wall	A graphical technique used on value stream maps that has alternating high and low flats, thereby looking like a rampart. Touch times for an activity are put on the low or high flat and wait times between activities on the other flat. It is both a visual display as well as an enabler for rapid calculation of total end-to-end touch and wait times for a process.
Cause and effect diagram	A root cause analysis tool to help identify the cause(s) of a particular event. The event is put at the “head” of the fishbone and the spines are used to group possible causes into categories. Frequently used categories are Measurement, Personnel, Materials, Methods, Environment, and Machines. Also called Ishikawa or fishbone diagrams.
Cell	A production unit organized so that the separate workstations for each production step are organized in a U shape layout to enable communication and coordination. Workers can visually see the whole production flow. The output of one step is immediately delivered to the next step, which is adjacent.
Check lists/sheets	Check sheets are structured tools for collecting data in a disciplined way. A typical format is a matrix with cells for entering data for the particular row/column instances, e.g. temperature (column A) and blood pressure (column B) for a patient at hour H (row). A checklist is a simplified check sheet with even more structure. Listed items are ticked off as they are executed to assure that no steps have been omitted.

Term	Description
Common cause variation	The sum of many “chances causes,” none traceable to a single major cause. Common cause variation is essentially the noise in the system. When a process is operating subject to common cause variation it is in a state of statistical control.
Continuous process improvement	The use of plan-do-study-act (PDSA) cycles to continuously improve a given process in the pursuit of perfection.
Control chart	A plot of a measured quantity (input or output) versus time (hour, day, month, etc. or sample number), together with the average or mean value and Upper and Lower Control Limits (UCL, LCL). Control charts provide information about the stability/predictability of the process, specifically with regard to its central tendency (to target value) and variation.
Core enterprise	An enterprise (see definition) and other entities tightly integrated through direct or partnering agreements.
Cost of non-conformance	The cost associated with poor quality, including direct costs (scrap & rework, service calls, warranties & concessions) and indirect costs (excess inventory, overtime, non valued added steps, queues & delays, loss of image or reputation).
C_p	A term used to define the capability of a centered process. It is mathematically expressed by: $C_p = \frac{USL - LSL}{6\sigma}$
C_{pk}	A term used to define the capability of an off centered process. It is mathematically given by the smaller of: $C_{pk} = \frac{USL - mean}{3\sigma}$ or $C_{pk} = \frac{mean - LSL}{3\sigma}$
CPI	See definition for continuous process improvement
Current state	The “as is” state of a given process as represented by a current state value stream map.
Customer	The recipient of the output of a process. An external customer generally pays for the deliverable. For an internal customer, the output becomes the input for a downstream process.
CV	Coefficient of variation defined as the standard deviation divided by the average value.

Term	Description
Cycle time	The time required to execute all the activities in a process. Other names include lead time or span time or throughput time. Cycle time includes processing time and wait time.
Defect	Any process output that does not meet the customer's specifications.
DFMA	Design for manufacturing and assembly – a set of practices used during design to assure the component or product can be economically manufactured and assembled. One DFMA practice is reduction of part count.
DMAIC	Define-Measure-Analyze-Improve-Control. DMAIC is the six sigma process improvement cycle.
DPMO	Defects Per Million Opportunities – a measure of process quality.
Enterprise	One or more organizations having related activities, unified operation, and a common business purpose.
Extended enterprise	All the entities tied to an enterprise, from the supplier's supplier to the customer's customer.
Fishbone diagram	Another name for cause and effect diagram.
Five lean fundamentals	(1) Specify value; (2) Identify the value stream; (3) Make value flow continuously; (4) Let customers pull value; (5) Pursue perfection.
Flow chart	A diagram representing a process or algorithm, showing each process step in a {box, triangle, diamond, bubble…} connected to other {boxes…} with lines showing flow of {material, information}. Incoming {material, information} is from "suppliers" while outgoing {material, information} is sent to "customers" for the process.
Future state	A desired new state of a given process.
Gemba (genba)	The place where work is being done.
Genchi genbutsu	The act of going to the gemba to observe the actual work being done and talking to the actual people doing the work.
Histogram	A graphical representation of the distribution of a set of data in ranges of the independent variable, or "bins", with rectangles above the bin whose height represents the number of instances or "frequencies" or "count" of the dependent variable for that bin.

Term	Description
Ideal state	An ideal future state for a given process that might not be achievable with current constraints, resources or knowledge. The ideal state represents a "stretch goal".
IPT	Integrated product or process team composed of representatives from all the functional stakeholder groups for a particular product or process.
Ishikawa diagram	Another name for cause and effect diagram, derived from its creator Kaoru Ishikawa.
JIT	Just in Time – the practice of delivering supplies to a customer just as the customer needs then. The contrast would be having supplies stored in inventory until the customer needs them. JIT is a specific example of maintaining flow.
Kaizen	The Japanese word for continuous improvement. It means constant improvement in an unending series of small steps.
Kaizen event	Another name for a Rapid Process Improvement Workshop. Ironically, Kaizen means continual improvement using small steps, where a Kaizen event is a focused workshop introducing a significantly larger improvement.
Kanban	Visual cuing system to indicate material, parts, and/or information is/are authorized to move downstream.
Kitting	Combining all relevant material, parts, and/or information into a single package that can be delivered to the point-of-use in a process to reduce unnecessary movement.
Lean enterprise	An integrated entity that efficiently creates value for its multiple stakeholders by employing lean principles and practices.
Lean thinking	The dynamic, knowledge-driven, and customer-focused process through which all people in a defined enterprise continuously eliminate waste and create value.
Little's law	A conservation law for process flow expressed as WIP = (throughput rate) x (cycle time) = (cycle time)/(takt time). Given any two of these three variables, the other is determined by Little's law. Little's law strictly applies to long term averages of stable systems, i.e. ones which are not starting, stopping or surging. However, it is a useful relationship for normal systems.

Term	Description
Mistake proofing	The use of process or design features to prevent errors or the negative impact of errors. A simple example is a gas cap tether to prevent leaving the gas cap at the gas station.
Muda	Waste, or activities that do not add value (see 8 wastes).
Mura	Unevenness, or irregular or fluctuating production or workload due to poor planning, staffing, inoperative equipment, missing supplies, or irregular demand.
Muri	Overburden of people or equipment, often leading to muda.
Non value added	Something that does not create value for the customer. See definition of “value added”.
Non value added time (NVAT)	The time in a process allocated to non valued added activities.
Pareto chart	A chart named after Vilfredo Pareto which displays instances or counts of a (process) variable versus {categories, causes} of the variable in vertical rectangles above the {category, cause} name. The data is arranged with the tallest bar on the left hand location, with the next tallest bar next, etc. Often a superimposed line of cumulative instances is potted from left to right.
PDCA	Plan Do Check Act – a variant of the name for PDSA.
PDSA	Plan Do Study Act – the basic Deming improvement cycle used for continuous improvement.
PICK chart	A two by two matrix chart where one axis represents the effort or resources for an action and the other axis represents the impact of valued added of an action. The name of each quadrant characterizes the combination of the axis variables: Possibly implement, Implement, Consider, Kill. Candidate actions to address a need are placed in one of the four quadrants during a brainstorming event.
Point of use (POU)	The location where supplies, tools, information, human resources are needed to execute a task.
Poka yoke	The Japanese word for mistake proofing
Process capability	Broadly defined as the ability of a process to meet the customer’s expectations. Mathematically defined by Cp or Cpk.

Term	Description
Process map	A flow chart showing all the steps or activities in a process with the output of each step/activity being connected to the input of a downstream step/activity.
Processing time	The time that activities are being performed on work in process (WIP). Processing time may consist of Value Added Time (VAT) and Non Valued Added Time (NVAT) activities. Other names are: Touch Time (TT), In Process Time (IPT), Response Time (RT).
Pull system	A system where a signal from downstream activity for an input results in the upstream activity delivering an output. In a pure pull system, an end customer order cascades upstream with each process delivering one unit to its downstream customer. A pure pull system has no buffers or inventory.
Push system	A system where an upstream activity delivers output as completed into a buffer or inventory for the next downstream activity.
Quality	A broad term that represents the fitness of a product or service for the customer's expectations.
Queuing	The act or instance of waiting in lines or queues for some action to take place.
Rapid process improvement workshop	A three to five day workshop focused on a specific process improvement opportunity and involving representatives from all the stakeholders involved or affected by the process. The output of an RPIW is a new process design. Other names are: Kaizen events, rapid improvement events.
Relational coordination	An organizational paradigm centered on shared goals, shared knowledge, mutual respect supported by effective communication.
RPIW	See Rapid Process Improvement Workshop
Scatter diagram	A graph of unconnected {x,y} data points.
SDSA	Standardize-Do-Study-Act, a variant of PDSA that emphasizes a standardized process is undergoing continuous process improvement.
Sigma (σ)	The standard deviation of a distribution of data, defined mathematically as: $\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$ where x is the variable, x bar is the mean, and n is the number of data points in the distribution.

Term	Description
Single piece flow	The practice of having only one unit of work in each process step of a flow line. If there were only one worker, s/he would complete all the steps in the production process for one unit, before starting the next unit. In a flow line with multiple workers, the output from one workstation is immediately worked on by the next workstation; i.e. there are no buffers between workers.
Six Sigma	Six Sigma is a data driven philosophy and methodology to eliminate variation from all enterprise processes, named after sigma, the term for standard deviation.
Soft stuff	Refers to the people or organizational practices in a workplace.
Spaghetti chart	A plot that traces the movement of a person or object throughout a work cycle. The trace of movement back and forth from place to place resembles a pile of spaghetti on a plate.
SPC	See definition for Statistical Process Control
Special cause variation	Process variation due to differences between people, machines, materials, methods, etc. The occurrence of a special (or assignable) cause results in an out of control condition.
Stakeholder	Any group or individual who can affect or is affected by the achievements of the organization’s objective.
Stakeholder value	How various stakeholders find particular worth, utility, benefit, or reward in exchange for their respective contributions to the enterprise.
Standard work	The best known process for a task, based upon the current evidence. Standard work is improved though continuous process improvement – see SDSA.
Statistical process control	The application of statistical process methods, particularly control charts, to monitor a process to determine if it is statistically stable.
Supplier	The person or organization that provides input material or information to a process.
Swim lanes	Process or value stream flows that occur in parallel, and sometimes or eventually connect or feed into each other.

Term	Description
Takt time	The available time for performing work divided by the customer demand rate for the product or services from the work unit; e.g. if there are 40 orders that need to be filled in an 8 hour day, the takt time would be (8 x 60)/40 = 12 min. Takt time represents the drumbeat or pace that the flow line needs to operate at in order to meet the customer demand. It comes from the German word Taktzeit. “takt” translates as “stroke” and “zeit” as “time.”
Third party logistics	A provider of logistics support between a supplier and a customer; e.g. FedEx might provide all shipping services between a supplier and customer.
Three actuals	Go to the actual place, see the actual work being done, and talk to the actual people doing the work – another name for genschi genbutsu
Throughput	The number of {units, patients, documents,…} processed during a standard unit of time; e.g. a throughput of 20 patients in a day
Throughput rate	The number of {units, patients, documents,…} being processed per unit of time; e.g. a throughput of 20 patients per 8 hour day would be a throughput rate of 2.5 patients per hour. Throughput is the inverse of takt time; i.e. throughput = 1/takt time. 20 patients per 8 hour day would correspond to a takt time of 24 min per patient.
Time in queue	Another name for wait time.
Time value chart	A horizontal bar chart for a process broken into sequential segments showing periods of wait time (usually in red) and process time (usually in yellow for non value added time and green for value added time). See definition for process time.
Total Quality Management (TQM)	A set of practices or management system focused on continuously improving the quality of products or services. TQM is based on the assumption that everyone involved in the production and delivery of the products or services is responsible for their quality. TQM practices are a subset of Lean practices.
UCL, LCL	Upper (Lower) Control Limits are horizontal lines drawn on a process control chart at the distance of +/- 3σ from the mean or average of the data.

Term	Description
USL, LSL	Upper (Lower) Specification Limits are the customer specified tolerances or variations for a specific process or product; e.g. a hole diameter specified to be 1 inch +/- .01 inches would have its USL = 1.01 inch and LSL - .99 inch. Or for patient falls per month, the LSL = 0, while an USL might be set from benchmark data or mandates.
Utilization	The ratio of work demand to work capacity, a number between 0 and 1. For example if demand for work is 13 hours and there are 2 workers who have 8 hours available, their utilization would be 13/(2x8) = 0.8125
Value	A broad definition is the features of a product or service divided by its cost. Specific definitions can be developed for a particular product or service, but generally value is a relative term that is evaluated by the customer, or "value is in the eyes of the beholder."
Value added activity	An activity in the value stream that directly contributes to customer value, and which satisfies three criteria (1) the customer wants it, (2) the activity transforms or shapes material or information or humans and (3) it is done right the first time.
Value added time (VAT)	The part of the processing time when value added activities are being performed.
Value stream	The linked end to end activities of a process which transform input {material, information, people) to output {product, components, data, services, people, …}. A value stream can consist of valued added and non value added activities, as well as wait time.
Value stream map	A process map with quantitative data added for each process step, including wait times and inventory. Data might include: processing, wait or cycle times; inventory; quality or yield data; labor hours; distance traveled, or more. Only valued added data should be collected and included.
Variation	The differences in the output of an activity for a given input due to Common Cause or Special Cause variation.
Vendor managed inventory	Inventory in a facility that is monitored and replenished by the vendor. An example would be items on a supermarket shelf that are replenished by the supplier's staff rather than the store's staff.

Term	Description
Visual control	Practices that make the state or steps in a process visible to the workforce. Examples include status boards, lights, colored sections of the floor for storing different items, and more.
Visual work instructions	Diagrams or graphic displays that show the instructions to produce a part or subassembly. Assembly instructions for IKEA products represent good examples of visual work instruction. The opposite would be the often frustrating wordy instructions of “insert tab A into slot B” type.
VSM	A value stream map
VSMA	Value stream mapping and analysis – the act of creating a value stream map and then performing analysis of the data to identify bottlenecks, throughput, cycle time, etc.
Wait time	The time that whatever is flowing in a value stream is sitting idle with no value added or non-value added work being done.
Waste	Any activity that does not add value.
WIP	Work in Process – the quantity of work that is flowing in a value stream.

S & A Hot Dogs
Time Exercise

Sasha and Andy have opened a hot dog stand at their local park. They offer a hot dog with choice of fresh fruit and beverage to walk up customers between 10 AM and 2 PM. Customers put on their own condiments. Customers say their hot dogs are good, but the wait is a little long.

After two weeks, they have a brisk, and growing business. Andy and Sasha notice they are barely keeping up with the customer demand, and making a little money after buying their supplies at the end of each day. They would like to improve their process to meet growing customer demand. They collected the following average data for their business processes and need help analyzing it.

	Process step	Data for average day	T/O*
1	Sasha takes orders, collects the money, and chats with the walk up customers. Tacks onto order-in board.	60 sec spent taking customer order 50 customers per day Average order is for 2 dog/fruit/beverage combos	
2	Order on Order-in Board	Order-in spends 30 sec on board	
3	Andy gets order from board. If dogs are ready, Andy starts to fill order. Otherwise he adds more dogs to the grill.	Average time Andy spends cooking a hot dog is 50 sec.	
4	Andy puts dog in bun, wraps it in foil, adds fruit of choice, & puts in serving container.	Takes 20 sec per dog, about half the time spent adding fruit and putting in serving container.	
5	If order isn't complete, Andy repeats steps 4. Otherwise he puts order onto counter and returns to step 3.	10 sec per dog	
6	Order sits on counter for Sasha	Order spends 30 sec on counter	
7	Sasha checks the order	10 sec per order 10% of the orders returned to Andy	
8	Sasha adds beverage	10 sec per order	
9	Sasha calls customer to stand, delivers order and chats a bit	30 sec per customer	
10	Andy sets up his work area, keeping it clean and stocked	10 min each hour	
11	Sasha fills up condiments, keeps serving counter clean, and bags trash	10 min each hour	
		Cycle Time	

* T/O = Time per order in seconds. Include rework time.

As a first step, they have asked that you draw a process map for the above 11 Process Steps listed in the left hand columns. Later you will work with the data.

Lean Academy