SPACE

Supply chain Progress towards Aeronautical Community Excellence

SPACE

Standard Tools' Kit

Version 1

SPACE

Supply chain **P**rogress towards **A**eronautical **C**ommunity **E**xcellence

1. Table of Contents

2. Preface

This document has been created by SPACE. It describes the best practice tools used in the most performing industries.
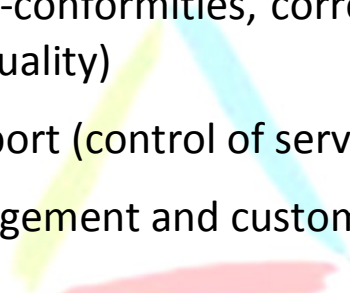They have been selected by SPACE in order to provide a guide for SPACE experts, Executive Members, supplier development experts, and suppliers' continuous improvement project managers.

They can be used to support every improvement project in the area of supply chain management. They cover the three main domains of supply chain management improvement projects:

- Planning organization and systems
- Lean manufacturing
- Quality tools

As they are defined as a standard in the Supply Chain Management Handbook, created by IAQG (International Aerospace Quality Group), they also cover the main processes of a company,:

1. Sales, master scheduling and sequencing

2. Contract requirement flow down

3. Design and Development

4. Supplier sourcing selection & approval (Purchasing process)

5. Planning of product realization

6. Order management & logistics (internal & external

7. Manufacturing & inspection (production and service provision

8. Supplier operational management and product validation (purchasing process)

9. Control of non-conformities, corrective & preventive actions (on-time, on-quality)

10. Customer support (control of service operations)

11. Business management and customer satisfaction monitoring

The goals of these improvement projects are to:
- Improve delivery performance
- Reduce waste
- Reduce lead times
- Increase reactivity
- Improve productivity
- Improve quality
- Reduce cost
- …

These tools are not exclusive.

The main intent of this booklet is to spread out the tools' usage, so don't hesitate to use them, to copy them, to distribute them within your company, to your suppliers, etc…

The tools are presented in no order. You will find then a Tools' Summary indicated in which situation each of these tools can be applied.

3. Tools' Summary

Tools	Tools categories		
	Planning organization and systems	**Lean manufacturing**	**Quality**
FMEA			
5 WHY'S			
8D			
Check sheet			
Histogram			
Scatter diagram			
Control chart			
Flow chart			
Cause & effect analysis			
Pareto analysis			
First pass yield			
Key characteristics			
Overall Equipment Efficiency			
Skill matrix			
Value Stream Mapping			
Line balancing			
Visual management			
Takt time			
Kanban			
Process Mapping			
Total Productive			

Maintenance			
Single Minute Exchange of Die			
Poka Yoke			
Line of balance			
Manufacturing Resource Planning (MRPII)			
Input – Output Control			

4. List of Abbreviations

Abbreviation	DESCRIPTION
FMEA	Failure Modes and Effects Analysis
RPN	Risk Priority Number
KC	Key Characteristics
UCL	Upper Control Limits
LCL	Lower Control Limits
CCA	Capacity Contingency Assessment
FPY	First Pass Yield
KC	Key Characteristics
OEE	Overall Equipment Effectiveness
TPM	Total ProductiveMaintenance
VSM	Value Stream Mapping
BPR	Business Process Re-engineering
SMED	Single Minute Exchange of Die
LOB	Line of Balance
MRP II	Manufacturing Resource Planning

5. FMEA (Failure Modes and Effects Analysis)

What is it?

FMEA is a risk assessment technique for systematically identifying potential failures in a system, product or a process before enter into service. There are four types of FMEA:

- FMEA Concept : To verify the feasibility of a product concept based by clients demand

- FMEA Product : To design the most robust product fitting with the customer expectation

- FMAE Process : To identify the potential risks generating a non-conformity in a manufacturing process

- FMAE Logistics : To identify the potential risks of delivery failure in the logistics system

How to proceed?

1. Describe concept, product, process and logistics

2. Identify the potentials of failures; functions, product specifications and process steps

3. Quote risks by 3 indices: Occurrence (O), Detection (D) and Severity (S), ranging from 1 (lowest risk) to 10 (highest risk).

4. Consider the overall Criticity value **(Criticity = O × D x S)** ranking from 1 to 1000

5. Define the actions to mitigate higher risks

6. Reconsider the risks to make sure that Criticity remains < 100 and severity < 7.

7. Implement the actions

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8. If the risks cannot be effectively removed, define Key Characteristics(KC)

9. Monitor KC on Process and Product

Example:

	Potential Failure Mode	Potential Failure Effects	S	Potential Failure Causes	O	Current Process Controls	D	S*O*D	RPC
0 - Apply resin mix	Unfinished, incomplete, deformed or cracked part	Scrapped part Production Delays	9		6	Traceability	2	108	MH
					1	Temp. control	2	18	MH

Preliminary risk assessment

① ② ③ ④ ⑤ ⑥

1) What part is being assessed?
2) In what ways can the part fail perform or deliver requirements?
3) What are the failure's effects or impacts?
4) How severe is the effect on the customer?
5) What causes process going wrong?
6) How often does the failure mode occur because of that cause?

7) What are the current or planned Controls (Prevention & Detection)?
8) How well can the controls detect the failure mode or the causes?
9) Criticity value (O × D x S)
10) Risk Priority Code **Low-Medium**, **Medium High**, **High-Critical**
11) Corrective actions and new rating

Action results

Recommended Actions	S	O	D	S*O*D	RPC
	6	2	2	24	LM
· Implement resin life check / monitor record.	6	1	2	12	LM

Tips

✓ FMEA is a teamwork that require to gather the experts on Concept, Product and Process

✓ FMEA is living documents which need to be updated any time where a new risk is identified.
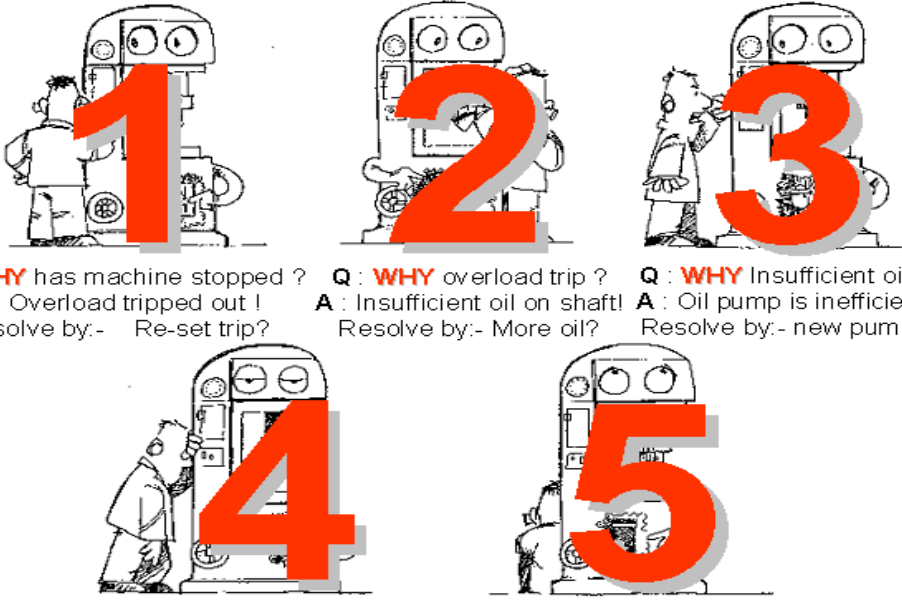
6. 5 Why's

What is it?

5 Why's is a simple problem-solving technique helping users to get quickly the root of the problem.

How to proceed?

- Ask five times why the failure has occurred to reach to the terminal cause of the problem

Example:

Q : **WHY** has machine stopped ?
A : Overload tripped out !
Resolve by:-   Re-set trip?

Q : **WHY** overload trip ?
A : Insufficient oil on shaft!
Resolve by:- More oil?

Q : **WHY** Insufficient oil ?
A : Oil pump is inefficient!
Resolve by:- new pump?

Q : **WHY** is pump not efficient ?
A : Pump drive shaft worn !
Resolve by:- Change Shaft?

Q : **WHY** is this shaft worn ?
A : Oil filter blocked with swarf !
Resolve by:- Clean filter?

Tips

- ✓ It is carried out by a team of persons related to the problem
- ✓ It doesn't prompt an intuitive answer, other problem-solving techniques may need to be applied

7. 8 D

What is it?

8D is a problem-solving technique to improve the way escapes and problems are managed, to reduce their impacts, contain them as far upstream as possible and prevent recurrence, by implementing efficient corrective action plans.

Launching a formal Root Cause Analysis and problem solving process shall always be considered when an issue (undesirable conditions, defects and failures) is detected.

How to proceed?

Follow the 8+1 steps of the method
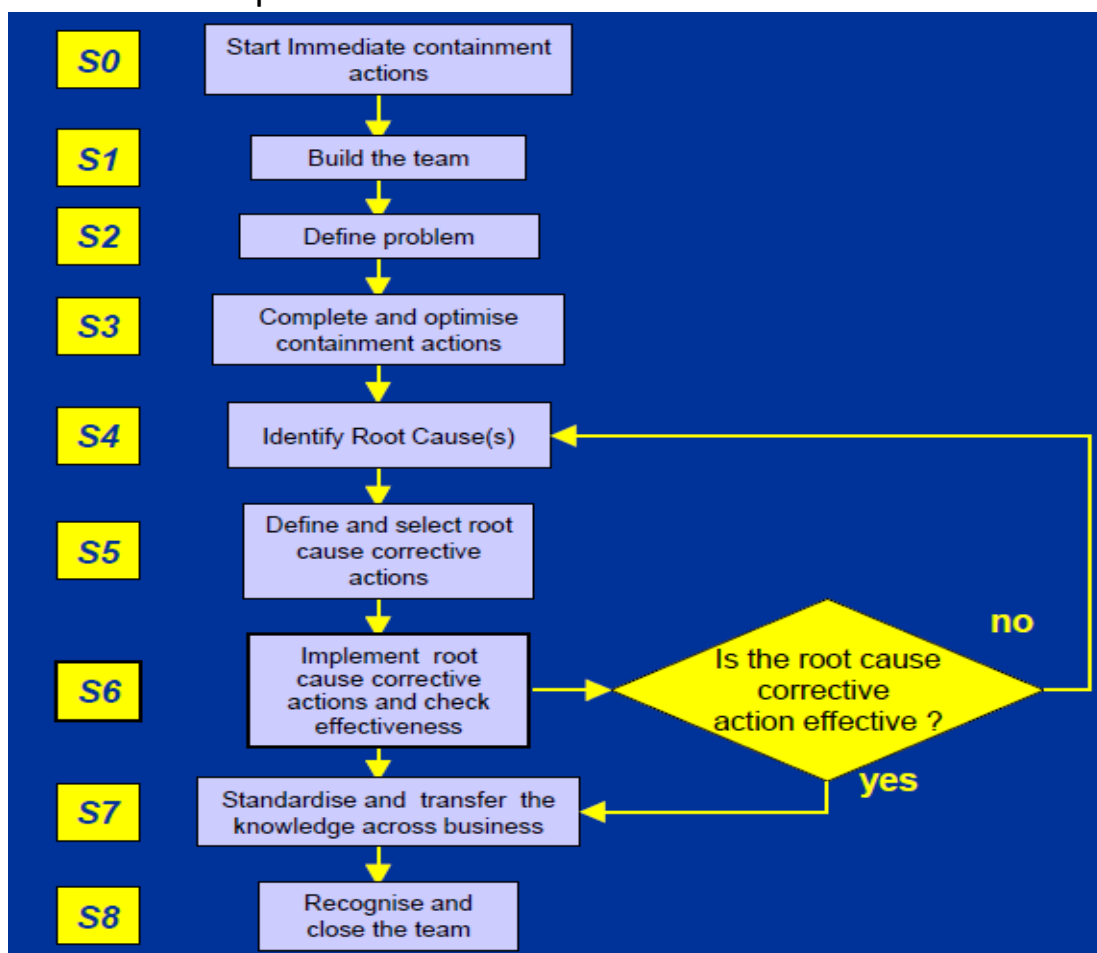
<u>Tips</u>

- ✓ Top management buying into the whole corrective action process is a must
- ✓ Effective communication is mandatory

8. Check Sheet

What is it?

A check sheet is a structured, prepared form for collecting and analyzing data. This is a generic tool that can be adapted for a wide variety of purposes.

How to proceed?

1. Decide what event or problem will be observed. Develop the operational definitions.
2. Decide when data will be collected and for how long.
3. Design the form. Set it up so that data can be recorded simply by making check marks or Xs or similar symbols and so that data do not have to be recopied for analysis.
4. Label all spaces on the form.
5. Test the check sheet for a short trial period to be sure that it collects the appropriate data and whether it is easy to use.
6. Each time the targeted event or problem occurs, record data on the check sheet.

Example:

The figure below shows a check sheet used to collect data on telephone interruptions. The tick marks were added as data was collected over several weeks.

Telephone Interruptions

Reason	Day					
	Mon	Tues	Wed	Thurs	Fri	Total
Wrong number	卌	‖	‖	卌	卌 ‖	20
Info request	‖	‖	‖	‖	‖	10
Boss	卌	‖	卌‖	‖	‖‖	19
Total	12	6	10	8	13	49

Excerpted from Nancy R. Tague's The Quality Toolbox, 2nd Edition, ASQ Quality Press, 2004, p 141-142

http://www.asq.org/learn-about-quality/data-collection-analysis-tools/overview/check-sheet.html

9. Histogram

What is it?

A frequency distribution shows how often each different value in a set of data occurs. A histogram is the most commonly used graph to show frequency distributions. It looks very much like a bar chart, but there are important differences between them.
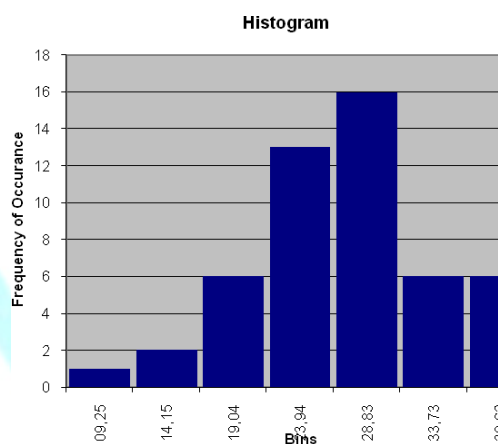
How to proceed?

1. Collect at least 50 consecutive data points from a process.
2. Use the histogram worksheet to set up the histogram. It will help you determine the number of bars, the range of numbers that go into each bar and the labels for the bar edges. After calculating *W* in step 2 of the worksheet, use your judgment to adjust it to a convenient number. For example, you might decide to round 0.9 to an even 1.0. The value for *W* must not have more decimal places than the numbers you will be graphing.
3. Draw x- and y-axes on graph paper. Mark and label the y-axis for counting data values. Mark and label the x-axis with the *L* values from the worksheet. The spaces between these numbers will be the bars of the histogram. Do not allow for spaces between bars.
4. For each data point, mark off one count above the appropriate bar with an X or by shading that portion of the bar.

Example:

1	125,36	26	119,42
2	126,66	27	120,83
3	130,28	28	136,53
4	133,74	29	120,4
5	126,92	30	136,58
6	120,85	31	121,73
7	119,42	32	132,72
8	128,61	33	109,25
9	123,53	34	125,42
10	130,15	35	117,67
11	126,02	36	124,01
12	116,65	37	118,74
13	125,24	38	128,99
14	126,84	39	131,11
15	125,95	40	112,27
16	114,41	41	118,76
17	138,62	42	119,15
18	127,4	43	122,42
19	127,59	44	122,22
20	123,57	45	134,71
21	133,76	46	126,22
22	124,6	47	130,33
23	113,48	48	120,52
24	128,6	49	126,88
25	121,04	50	117,4

Data Table

Bin	Frequency
109,3	1
114,2	2
119	6
123,9	13
128,8	16
133,7	6
138,6	6

Excerpted from Nancy R. Tague's *The Quality Toolbox*, 2nd Edition, ASQ Quality Press, 2004, p 292-299

http://www.asq.org/learn-about-quality/data-collection-analysis-tools/overview/histogram.html
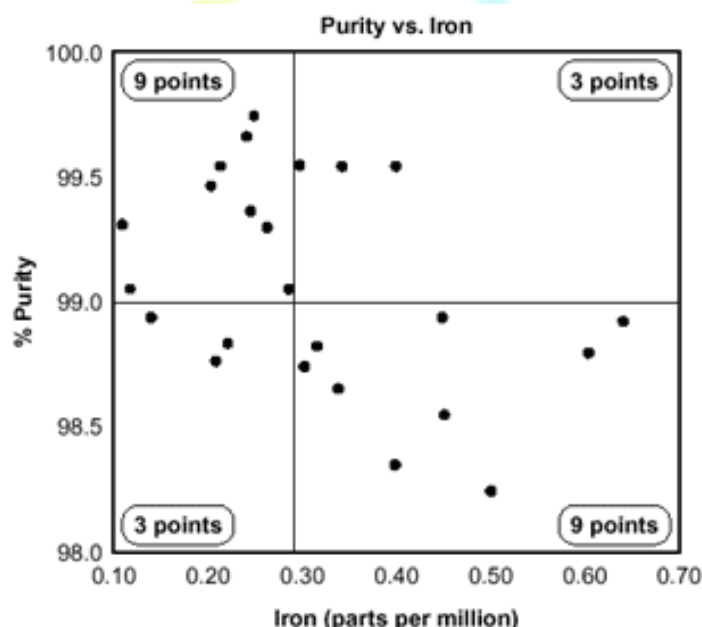
10. Scatter Diagram

What is it?

The scatter diagram graphs pairs of numerical data, with one variable on each axis, to look for a relationship between them. If the variables are correlated, the points will fall along a line or curve. The better the correlation, the tighter the points will hug the line.

How to proceed?

1. Collect pairs of data where a relationship is suspected.
2. Draw a graph with the independent variable on the horizontal axis and the dependent variable on the vertical axis. For each pair of data, put a dot or a symbol where the x-axis value intersects the y-axis value. (If two dots fall together, put them side by side, touching, so that you can see both.)
3. Look at the pattern of points to see if a relationship is obvious. If the data clearly form a line or a curve, you may stop. The variables are correlated.

Example:

Excerpted from Nancy R. Tague's *The Quality Toolbox*, 2nd Edition, ASQ Quality Press, 2004, p 471-474
http://www.asq.org/learn-about-quality/cause-analysis-tools/overview/scatter.html
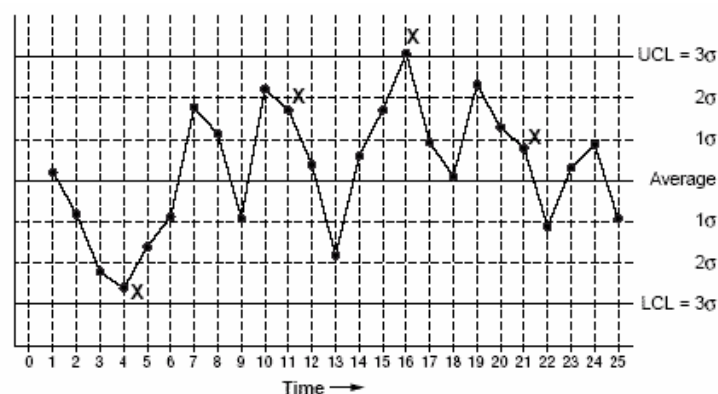
11.   Control Chart

What is it?

The control chart is a graph used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average, an upper line for the upper control limit and a lower line for the lower control limit. These lines are determined from historical data. By comparing current data to these lines, you can draw conclusions about whether the process variation is consistent (in control) or is unpredictable (out of control, affected by special causes of variation).

How to proceed?

1. Choose the appropriate control chart for your data.
2. Determine the appropriate time period for collecting and plotting data.
3. Collect data, construct your chart and analyze the data.
4. Look for "out-of-control signals" on the control chart. When one is identified, mark it on the chart and investigate the cause. Document how you investigated, what you learned, the cause and how it was corrected.
5. Continue to plot data as they are generated. As each new data point is plotted, check for new out-of-control signals.
6. When you start a new control chart, the process may be out of control. If so, the control limits calculated from the first 20 points are conditional limits. When you have at least 20 sequential points from a period when the process is operating in control, recalculate control limits.

Example:

Excerpted from Nancy R. Tague's The Quality Toolbox, 2nd Edition, ASQ Quality Press, 2004, p 155-158.
http://www.asq.org/learn-about-quality/data-collection-analysis-tools/overview/control-chart.html

12. Flow Chart

What is it?

A flowchart is a picture of the separate steps of a process in sequential order.

Elements that may be included are: sequence of actions, materials or services entering or leaving the process (inputs and outputs), decisions that must be made, people who become involved, time involved at each step and/or process measurements.

How to proceed?

1. Define the process to be diagrammed. Write its title at the top of the work surface.

Filling an Order
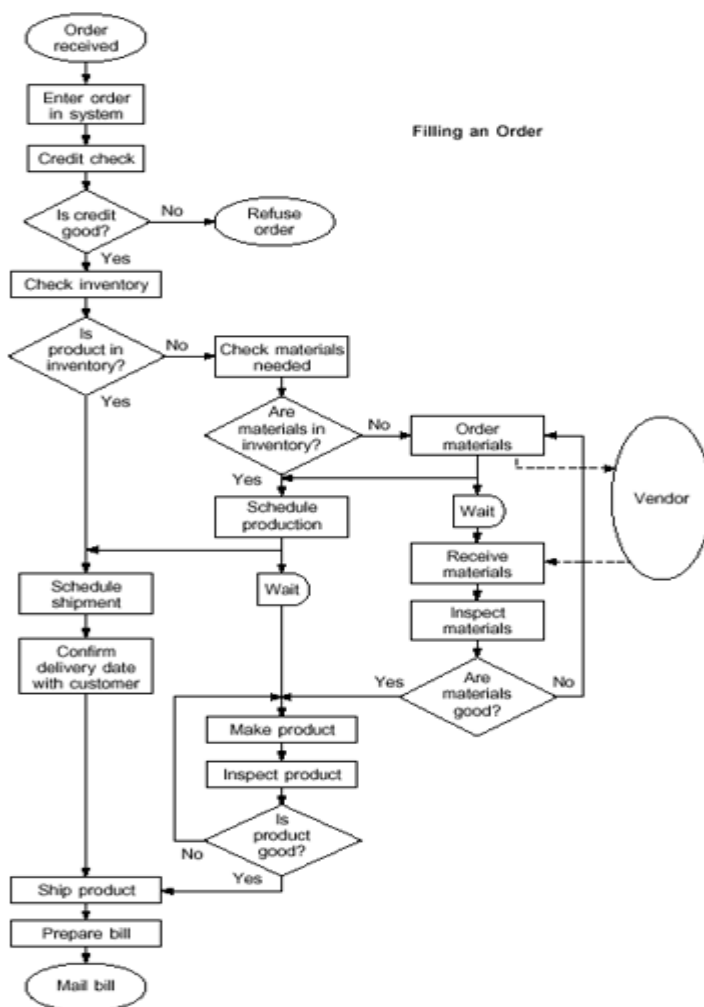
2. Discuss and decide on the boundaries of your process: Where or when does the process start? Where or when does it end? Discuss and decide on the level of detail to be included in the diagram.

3. Brainstorm the activities that take place. Write each on a card or sticky note. Sequence is not important at this point, although thinking in sequence may help people remember all the steps.

4. Arrange the activities in proper sequence.

5. When all activities are included and everyone agrees that the sequence is correct, draw arrows to show the flow of the process.

6. Review the flowchart with others involved in the process (workers, supervisors, suppliers and customers) to see if they agree that the process is drawn accurately.

Process	Decision	Wait	Link	Input or output	Documen	Start or end point

Excerpted from Nancy R. Tague's *The Quality Toolbox*, 2nd Edition, ASQ Quality Press, 2004, p 255-257.
http://www.asq.org/learn-about-quality/process-analysis-tools/overview/flowchart.html

13.   Cause & Effect Analysis

What is it?

The cause and effect diagram identifies many possible causes for an effect or problem. It can be used to structure a brainstorming session. It immediately sorts ideas into useful categories. Also Called: fishbone or Ishikawa Diagram

How to proceed?

1. Agree on a problem statement (effect). Write it at the center right of the flipchart or whiteboard. Draw a box around it and draw a horizontal arrow running to it.

2. Brainstorm the major categories of causes of the problem. If this is difficult use generic headings: Methods, Machines (equipment), People (manpower), Materials, Measurement, Environment

3. Write the categories of causes as branches from the main arrow.

4. Brainstorm all the possible causes of the problem. Ask: "Why does this happen?" As each idea is given, the facilitator writes it as a branch from the appropriate category. Causes can be written in several places if they relate to several categories.

5. Again ask "why does this happen?" about each cause. Write sub-causes branching off the causes. Continue to ask "Why?" and generate deeper levels of causes. Layers of branches indicate causal relationships.

6. When the group runs out of ideas, focus attention to places on the chart where ideas are few.
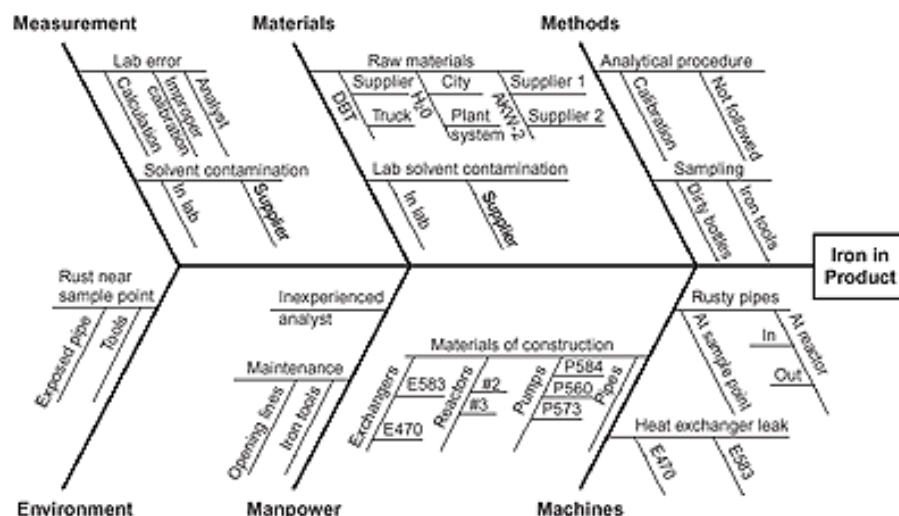
Example:

Excerpted from Nancy R. Tague's *The Quality Toolbox*, 2nd Edition, ASQ Quality Press, 2004, p 247-249.
http://www.asq.org/learn-about-quality/cause-analysis-tools/overview/fishbone.html
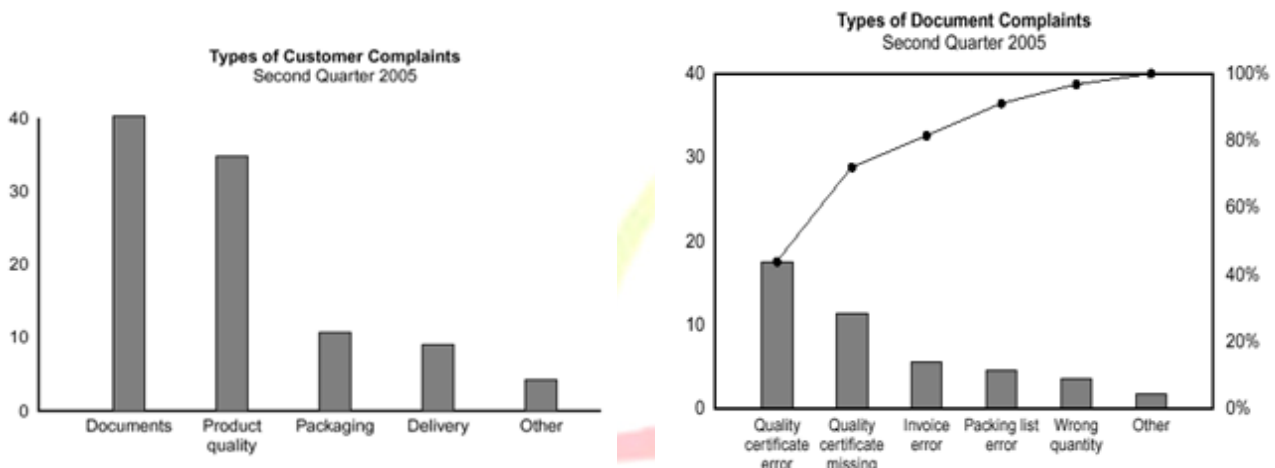
14. Pareto Analysis

What is it?

A Pareto chart is a bar graph. The lengths of the bars represent frequency or cost (time or money), and are arranged with longest bars on the left and the shortest to the right. In this way the chart visually depicts which situations are more significant.

How to proceed?

1. Decide what categories you will use to group items.
2. Decide what measurement is appropriate. Common measurements are frequency, quantity, cost and time.
3. Decide what period of time the Pareto chart will cover: One work cycle? One full day? A week?
4. Collect the data, recording the category each time. (Or assemble data that already exist.)
5. Subtotal the measurements for each category.
6. Determine the appropriate scale for the measurements you have collected. The maximum value will be the largest subtotal from step 5. (If you will do optional steps 8 and 9 below, the maximum value will be the sum of all subtotals from step 5.) Mark the scale on the left side of the chart.
7. Construct and label bars for each category. Place the tallest at the far left, then the next tallest to its right and so on. If there are many categories with small measurements, they can be grouped as "other."

Examples:

Excerpted from Nancy R. Tague's *The Quality Toolbox*, 2ᵈ Edition, ASQ Quality Press, 2004, p 376-378.
http://www.asq.org/learn-about-quality/cause-analysis-tools/overview/pareto.html

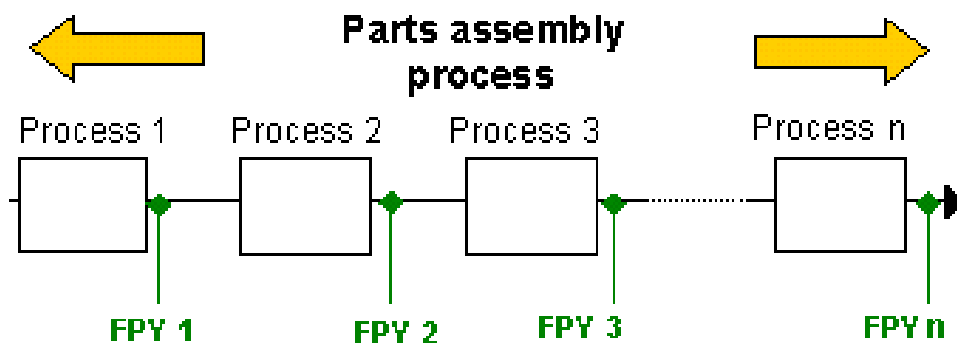# 15.   First Pass Yield

What is it?

FPY is an effective measurement to record defect. It also contributes to:
- Improve the quality performance and material management by defining bottleneck
- consolidate a global production process

How to proceed?

$$\frac{\text{The number of units coming out of a process}}{\text{The number of units going into that process}} = \text{FPY}$$

(in a specific period)

Example:

Parts assembly process

Process 1   Process 2   Process 3   Process n

FPY 1   FPY 2   FPY 3   FPY n

100 units enter 1 and 90 leave. The **FPY1** for process 1 is 90/100 = .9

90 units go into 2 and 80 units leave. The **FPY2** for process 2 is 80/90 = .89

80 units go into 3 and 75 leave. The **FPY3** for 3 is 75/80 = .94

75 units got into n and 70 leave. The **FPYn** for n is 70/75 = .93

The total process yield is equal to FPY1 * FPY2 * FPY3 * FPYn or .9*.89*.94*.93 = .70

16.   Key Characteristics

What is it?

Key Characteristics (KC) is product features, manufacturing processes, and assembly characteristics that significantly affect a product's performance, function, fit, and form [Lee & Thornton, 1996].

KC methods are tools and processes used by design and manufacturing organizations to identify the critical parameters that cannot withstand a significant amount of variation -- particularly if the variation causes a significant loss e.g. scrap, rework, repair, or failure.(Basak Ertan, "Analysis of Key Characteristic Methods and Enablers Used in Variation Risk Management" ,1996)

The use of KC methods can help to reduce cost in a production if they are identified correctly.

How to proceed?

Selecting and evaluating key characteristics is done throughout the product life cycle, from early in the product definition phase through design, fabrication, assembly, and operation.

- Use a cross-functional team approach. Include customers and suppliers.
- Investigate customer needs and requirements, including specifications, problems, used-on information, and so on.
- Collect and analyze historical data: quality problems scrap, rework, rejections, waste, unit performance, test results, and so on.
- Investigate and document the production processes.
- There is no one method for selecting key characteristics; however, risk analysis has often proven to be an effective tool (see Example1 below)
- Draw a flowchart, develop a measurement plan and identify tooling needs
- Record the information in Control Plan (see Example2 below)
- Continue the process to reduce variation, solve problems, and pursue continuous improvement. High-level key characteristics should be flowed down to lower level key characteristics and key process parameters
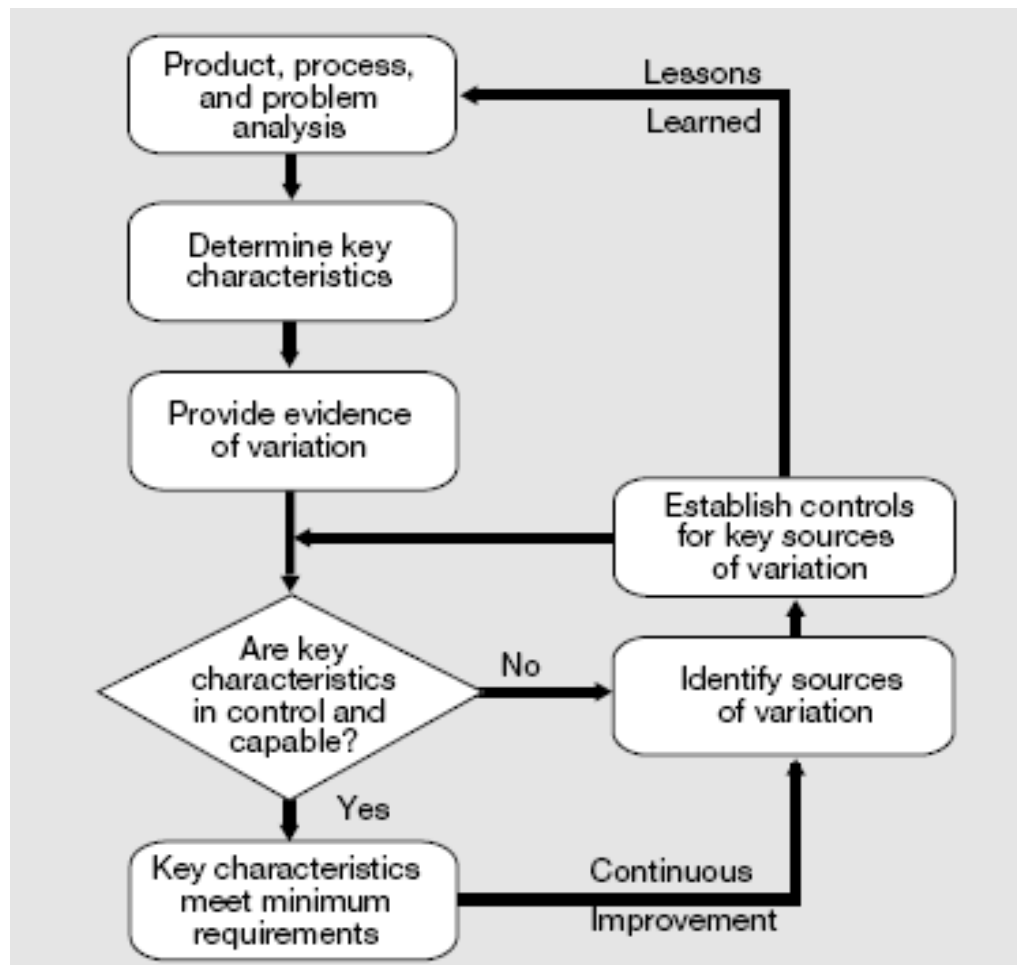
Adapted from "AQS Tools", 1998

From page 4 of http://www.boeing.com/companyoffices/doingbiz/supplier/d1-9000-1.pdf

Example 1: Tools used in identifying key characteristics
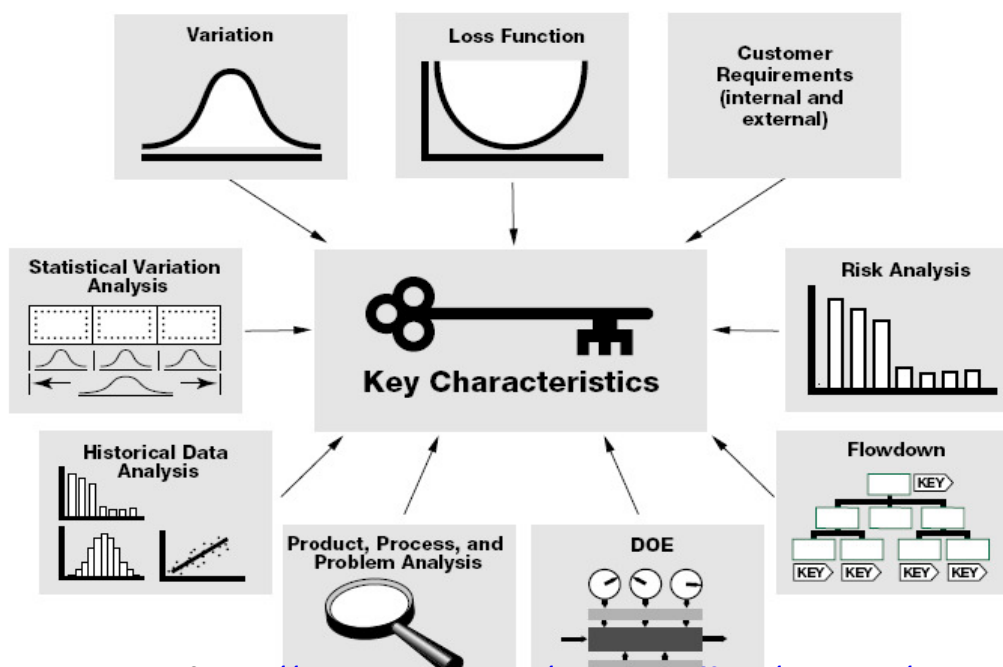
From page 39 of http://www.boeing.com/companyoffices/doingbiz/supplier/d1-9000-1.pdf

Example 2: *Control Plan*

Key Characteristic							Gage Variation		Process Variation				
KEY⟩ Characteristic	Engineering specification	Process step where measure-ment taken	Control chart used	Sample (subgroup) size	Sampling frequency	Initial Cpk	Type, make, and model of gage	Gage capability	Process step and operation number	Key process parameters	Process parameter settings	Control method	DOE ?
❶	❷	❸	❹	❺	❻	❼	❽	❾	❿	⓫	⓬	⓭	⓮
Lower edge trim	0.500 ± 0.005	After routing	X̄-R	5	4 per shift	0.84	Height gage Fowler T27 X	0.0017 PTC= 16.6%	Routing 120	Router speed Cut depth	2000 rpm 0.250 in	Machine setting	Yes

Part/Process Name _____	Team Captain _____ ⓯	Date (orig) _____
Part/Process Number _____	Company Name _____	Revision Number _____
Used-on Part Number _____		Revision Date _____

From page 60 of http://www.boeing.com/companyoffices/doingbiz/supplier/d1-9000-1.pdf

17. Overall Equipment Effectiveness

What is it?

OEE is a "best practices" metric for monitoring how well a piece of equipment is utilized and improving the efficiency of your manufacturing processes (i.e. machines, cells, assembly lines, etc.).

How to proceed?

OEE takes the most common sources of manufacturing productivity losses and places them into three categories

Availability is the ratio of Operating Time to Planned Production Time, and accounts for Downtime Loss.

Availability = Operating Time / Planned Production Time

Performance is the ratio of Net Operating Time to Operating Time, and accounts for Speed Loss.

Performance = (Ideal Cycle Time x Total Pieces) / Operating Time

Quality is the ratio of Fully Productive Time (time for Good Pieces) to Net Operating Time (time for Total Pieces).

Quality = Good Pieces / Total Pieces

OEE is the ratio of Fully Productive Time to Planned Production Time.

OEE = Availability x Performance x Quality**, or**
OEE = Good Pieces x Ideal Cycle Time / Planned Production Time

Tips

✓ Understanding of TPM's principles(Total ProductiveMaintenance)
✓ Understanding of the Six Big Losses

18.   Skill matrix

What is it?

It is an integral part of visual management system whose main objectives are to;

- Assist in resource planning and development
- Establish all skills required in a right area and team
- Quickly Identify current available skills and future requirements
- Monitor and control training effectiveness
- Examine where our strengths & weaknesses are

How to proceed?

Make visual on the skills matrix the ability or competency for each team member against each task.

Measure team members against procedures & performance measures.

· Establish all tasks required in the team or area.
· Establish all the team members.

· Develop all procedures for all tasks.
· Define skills required for each task.
· Define level of ability/competency.
· Define how we measure performance.

Example:

|	No Knowledge (0)	Learner (1)	Practitioner (2)	Specialist (3)	Expert (4)
Key	"Cannot do"	"Know all elements of task"	"Can do the basics"	"Can manage fully"	"Can teach others how to do"

19.   Value Stream Mapping

What is it?

- A diagram of all the actions (both value added and non-value added) required bringing a product through from raw material to the customer.
- The current state map revealing all forms of waste and their sources
- The future state map is a vision of a lean business utilising flow.

How to proceed?

1. Identify the customer requirement.

2. Draw a current state value stream map, which is the current steps, delays, and information flows required to deliver the target product or service. This may be a production flow (raw materials to consumer) or a design flow (concept to launch).

3. Assess the current state value stream map in terms of creating flow by eliminating waste.

4. Draw a future state value stream map. The following questions must be kept in mind;

    - What are the Customer requirements (Takt time)?
    - How to apply Continuous Flow Processing?
    - Which process is the pacemaker?
    - How to control the upstream processes?
    - What size shop stock is required?
    - Is it sequential or fill-up pull?
    - Where to level production?
    - At what frequency will Kanban be released?
    - What further improvements can be made?

5. Implement the future state. Draw up a tactical Implementation Plan to move from the current state to the future state.

    - Show the high level objective (compelling need).
    - Have a set of objectives/actions for each loop.
    - Define Milestones for each objective.
    - Show owners for delivery of each objective.

- Monitor progress and highlight issues.

Example:

Current State

Future State
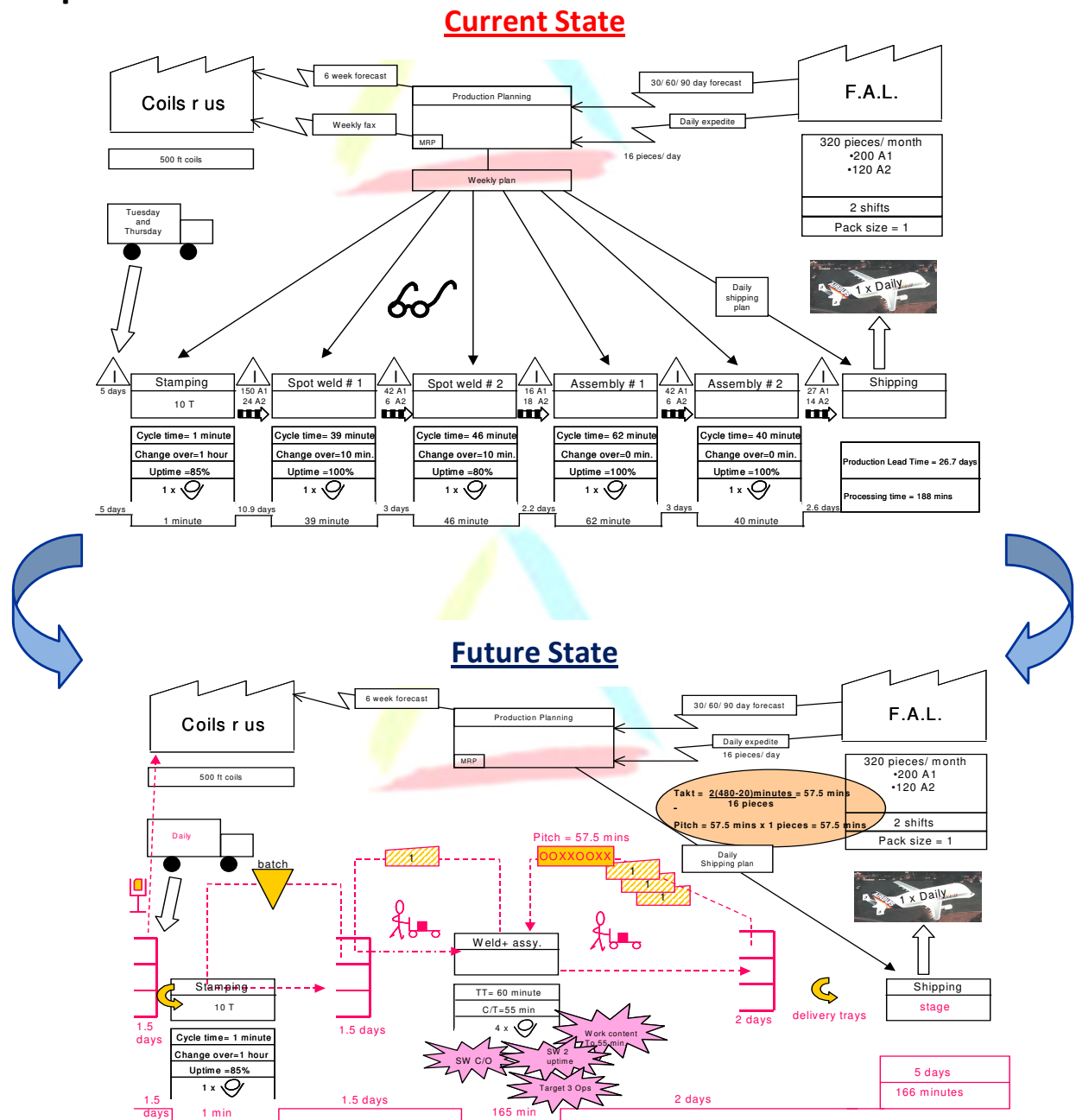
Tips

- ✓ Appoint a value Stream Manager
- ✓ Involve a multi functional team
- ✓ Further implementation continues area by area in loops
- ✓ Iteration loop is possible to be set up

20.　　Line Balancing

What is it?

- It is the assignment of the tasks to work station within a production line in order to optimize the performance and meet with the customer demand's rate (TAKT Time)
- It's a technique to determine the product mix run down an assembly line in order to provide a consistent flow of work.

How to proceed?

- Determine the parameters of the line : Takt time, work load, number of work stations (staffing and equipments),
- According to the routing, allocate work to each work station.

Example:

Takt vs Cycle time chart - Track 4 through to test
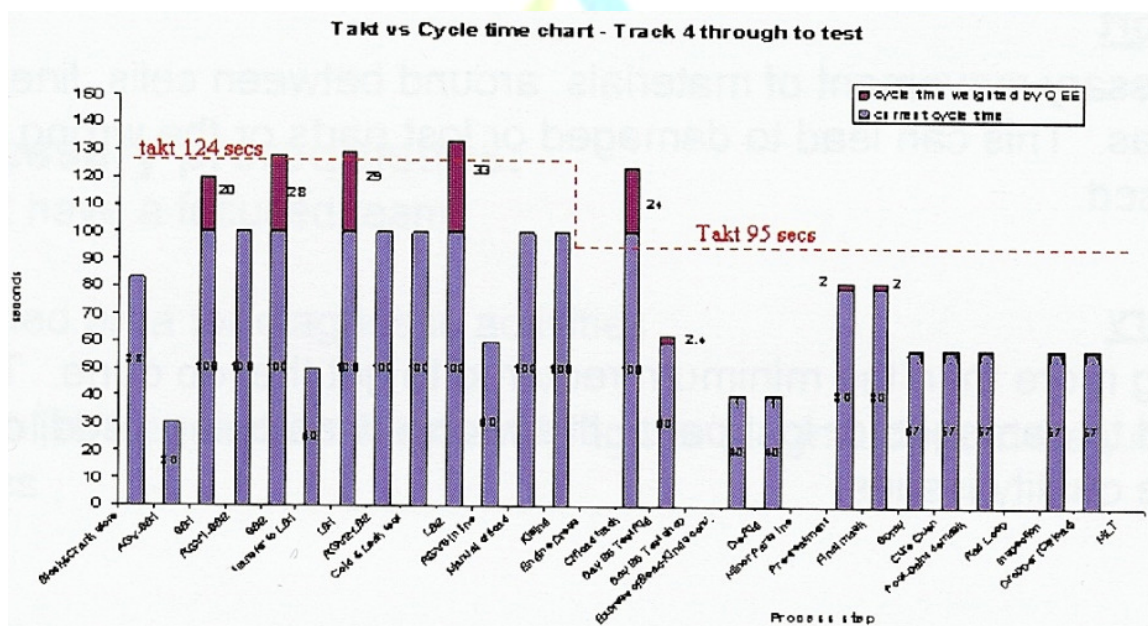
Tips

- ✓ Excel Spreadsheets or ready-made programme designed for line balancing can be applied
- ✓ Understand OEE measures
- ✓ Use actual data(not theoretical data) i.e. cycle times inclusive of OEE losses

21.   Visual Management

What is it?

- It is a communicating and controlling mechanism that reflects the state of process at any given time.

- It creates an information-rich environment, by the use of visually stimulating signals, symbols and objects. The use of signs, lights, notice boards, brightly and contrasting painted equipments and graphic displays that catch people's attention and communicate important information is visual management in the working environment.

- make the problems, abnormalities, or deviation from standards visible to everyone and thus corrective action can be taken immediately

How to proceed?

1. Identify the key information and item needed or the problem which should be prevented
2. Design a simple and usual display environment that that makes the problems or deviations from standards visible to everyone.
3. Test the method and find the feedback from those involved.
4. Train every involved user
5. Update and review regularly

<u>*Tips*</u>

- ✓ Develop with the owners of process
- ✓ Clearly define responsibilities
- ✓ Ensure that the tool is seen, used and developed by those managing the process or activity

22.   Takt time

What is it?

- The rate of production required meeting the customer's demand rate.

- It's used to synchronize the pace of production to match with the pace of sales (see line balancing), to provide the target rate for the production, targeted cycle time, staffing level, targets of improvement actions, line balancing and bottleneck identification.

How to proceed?

TAKT Time = $\dfrac{\text{Available Working Time/ Shift (Seconds)}}{\text{Customer Demand Rate/ Shift (Units)}}$

- Calculation can be done over periods of day, a week etc. as long as both sides are measured over the same period
- The units used are usually time per unit (seconds, minutes or shifts). The number of units per hour, shift, or day is also a way of measure.

<u>*Tips*</u>

- ✓ Ensure available working time is correct, i.e. time actually available to work.

- ✓ Eliminate causes of unplanned downtime.

- ✓ Provide a fast response to problems.

23.   Kanban

What is it?

- It origins from Japanese Concept where kan, 看 カン, means "visual," and ban, 板 バン, means "card" or "board.
- It is a signalling system to trigger the action.
- It is an efficient tool that is a part of a pull system to release the supply or production according to the actual demand and highlight problem areas to achieve Just in Time (JIT).

How to proceed?

1. To signal a need for an item, cards, plastic markers, but also empty bins or trolleys, can be used to activate the movement, production or supply of an item.
2. Each Kanban's bin can be placed basically in production line, the factory store and the suppliers' store.
3. The bins usually have a removable card (called Kanban card) that contains the product details and other relevant information such as preceding and subsequent process etc.
4. The exact quantity of materials required will be called by Kanban cards from production line to the factory store and then to the right production area.
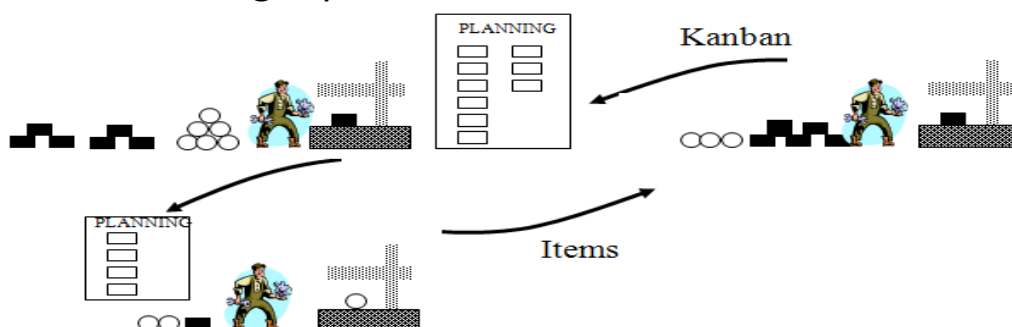
<u>*Tips*</u>

- ✓ It is recommended to overestimate how many Kanban cards are required for each product, end then slowly reduce that number until reaching the optimized quantity.
- ✓ Eliminate common problems such as manual entry errors and lost cards, E-Kanban systems can be integrated into enterprise resource planning (ERP) systems

24.   Process Mapping

What is it?

Process mapping is a workflow diagram to bring forth a clearer understanding of a process or series of parallel processes

It uses standard symbols:

Process step	Symbol
1- Operation	○
2- Inspection	□
3- Transfert	⬠
4- Wait	D
5- Storage	▽

What are the benefits?

•In diagrammatic form, a complete view of the process being studied

•At a glance, one can see what and how the single process steps are linked together

•Enables the identification of bottlenecks and non-value-added activities, so that the waste may be reduced or ideally removed

•Contributes to efficiency and productivity improvement

How does it work?

• determine the boundaries

• Involve the concerned operators

• list and sequence the steps

• Represent the activities flow on the process layout (flow chart)

• Rearrange the process layout in order to reduce the parts movement and the intermediate parts storage: e.g. U line

Example:
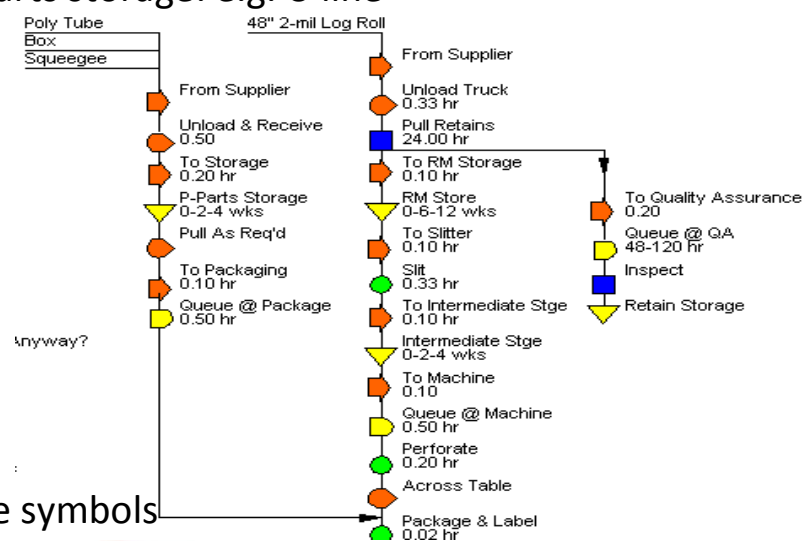
Tips

✓ Use appropriate symbols

✓ A "spaghetti" diagram can also be used, to represent the layout and the physical flow of the parts, within the factory

25.   Total Productive Maintenance

What is it?

- "Improvement of the productivity (measured by Overall equipment effectiveness)with all employees participating"

- "Preventive maintenance plus continuing efforts to adapt, modify, and refine equipment to increase flexibility, reduce material handling, and promote continuous flow", according to the 11th edition of the APICS dictionary.

What is it aimed to?

- Increase work station productivity through total operators involvement
- Maximize equipment effectiveness
- Proactive, not reactive equipment maintenance
- Maintain and improve Equipment Reliability which contributes to safety, quality and productivity.
- Maintain equipment for Maximum Life Utilization.
- Develop Operator Skill building so as to maximize Production Expertise.

What are benefits?

TPM helps to avoid waste by reducing 6 main sources of loss

- Start-up problems (Warm-up, trials)
- Changeover, and adjustment activities
- Machine breakdowns
- Idling and short stops
- Increased machine cycle time (compared to designed machine cycle time)
- Flaws in the process

How to proceed?

Implement the 5 pillars of the TPM, in order to eliminate the sources of loss:

1. Implement improvement activities, to improve equipment efficiency – OEE provides e measure of the success

2. Establish a system of autonomous maintenance, performed by equipment operators : the team has a 'fix it now' attitude when something goes wrong

3. Develop a planned maintenance system: schedules and standards for cleaning and lubrication are created and implemented.

4. Implement education and training, to increase operators skills (either on maintenance operations and technical knowledge)

5. Create a system for maintenance preventive design and early equipment management – feedback from machine users is given to machine manufacturers and designers.

Implement the TPM in 3 stages:

Stage One: Preparation
- Announce the top management decision to introduce and fully support TPM, establish goals, formulate the plan
- Create teams, launch education program

Stage Two: Implementation
- Hold the kick off meeting,
- Improve the effectiveness of each piece of equipment
- Develop an autonomous maintenance program
- Develop a scheduled maintenance program
- Conduct training to improve the skills
- Develop an early equipment management program

Stage Three: Stabilisation
- Perfect the TPM implementation and raise the levels of the TPM program.
- Finally, use the Continuous Improvement philosophy to continue to develop.

26. Single Minute Exchange of Die

What is it?

"SMED is the concept of setup times of less than 10 minutes, developed by Shigeo Shingo in 1970 at Toyota", according to the 11th edition of the APICS dictionary.

How to proceed?

Four basic steps to reducing changeover using the SMED system;
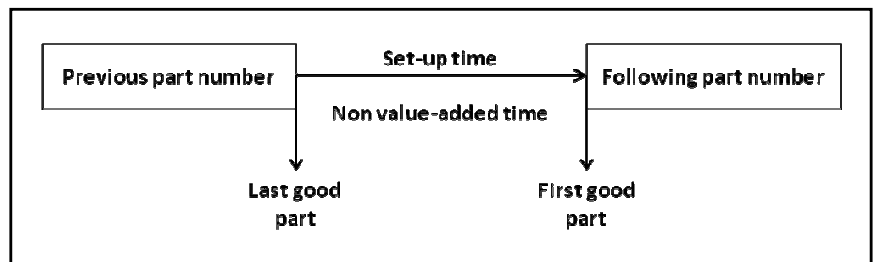
1. Observe the current methodology and identify all the operations.
2. Separate the INTERNAL and EXTERNAL activities. Internal activities are those that can only be performed when the process is stopped, while External activities can be done while the previous or next batch is being produced.
3. Convert (where possible) Internal activities into External ones (pre-heating of tools is a good example of this).
4. Streamline the remaining internal activities, by simplifying them. Focus on fixings - Shigeo Shingo rightly observed that it's only the last turn of a bolt that tightens it - the rest is just movement. Streamline also the external activities.

<u>Tips</u>

- ✓ Use video to record and analyze the process
- ✓ Ensure that external setup actions are performed while the machine is still running,
- ✓ Standardize function, not shape
- ✓ Use functional clamps or eliminate fasteners altogether
- ✓ Use intermediate jigs
- ✓ Eliminate adjustments

27.   Poka Yoke

What is it?

Poka-yoke (ポカヨケ) or "fail safe" was first introduced by Shigeo Shingo. It implies the concept of removing faults at the first instance and making a process or product "foolproof".

How to proceed?

Shigeo Shingo recognizes three types of Poka-Yoke:

1. The contact method identifies defects by whether or not contact is established between the device and the product. Color detection and other product property techniques are considered extensions of this.
2. The fixed-value method determines whether a given number of movements have been made.
3. The motion-step method determines whether the prescribed steps or motions of the process have been followed.

Poka-yoke either give warnings or can prevent, or control, the wrong action. It is suggested that the choice between these two should be made based on the behaviors in the process, occasional errors may warrant warnings whereas frequent errors, or those impossible to correct, may warrant a control Poka-yoke.

Example:

➢ Use color-coded parts

➢ Put the template over an assembled component to show operators where specific parts go.

➢ Use counters to tell an operator how many operations have been performed.

➢ Have one prong larger than the other so the electric plug will fit only one way.

28.   Line of Balance

What is it?

- It is a method of identifying the progress of parts in a process against the required completion date on a daily & weekly basis
- It allows having a synthetic and visual representation of procurement coverage included with stock's situation.
- The method is suited for a production of a repetitive nature.

How to proceed?

1. Set up a table presenting in one dimension the production plans, with units identified by serial number or delivery due date and the other dimension showing the bill of material (all references are not required, only critical or main references could be applied & tracked), the number of final deliverable product covered etc..

2. Identify when each component of the BOM will start getting shortage.

   - visualize how many final deliverable products are completed – usually on an array, but can be done also on a cumulative chart
   - illustrate for each subsequent final product which parts are not yet in stock or what the expected delivery date is.

3. Highlight on Critical references' cells for better pro-active planning and follow-up.

   Color code: **Red** - Late, **Amber**-Concern, **Yellow**-Complete on time, **White**-In Process or Not Started, **Green** – available.

Example:

29. Manufacturing Resource Planning (MRPII)

What is it?

- It is a method for the effective planning of all resources of a manufacturing company.

- It integrates many areas of the manufacturing enterprise into a single entity for planning and control purposes, from board level to operative level and from long term plan to daily plan.

- It addresses operational planning in units, financial planning in dollars, and has a simulation capability to answer "what-if" questions and extension of closed-loop MRP

What are the benefits?

- Improved scheduling
- Increased on-time deliveries
- Better control of inventories
- Productive relationships with suppliers
- Reduced working capital for inventory
- Improved cash flow through quicker deliveries
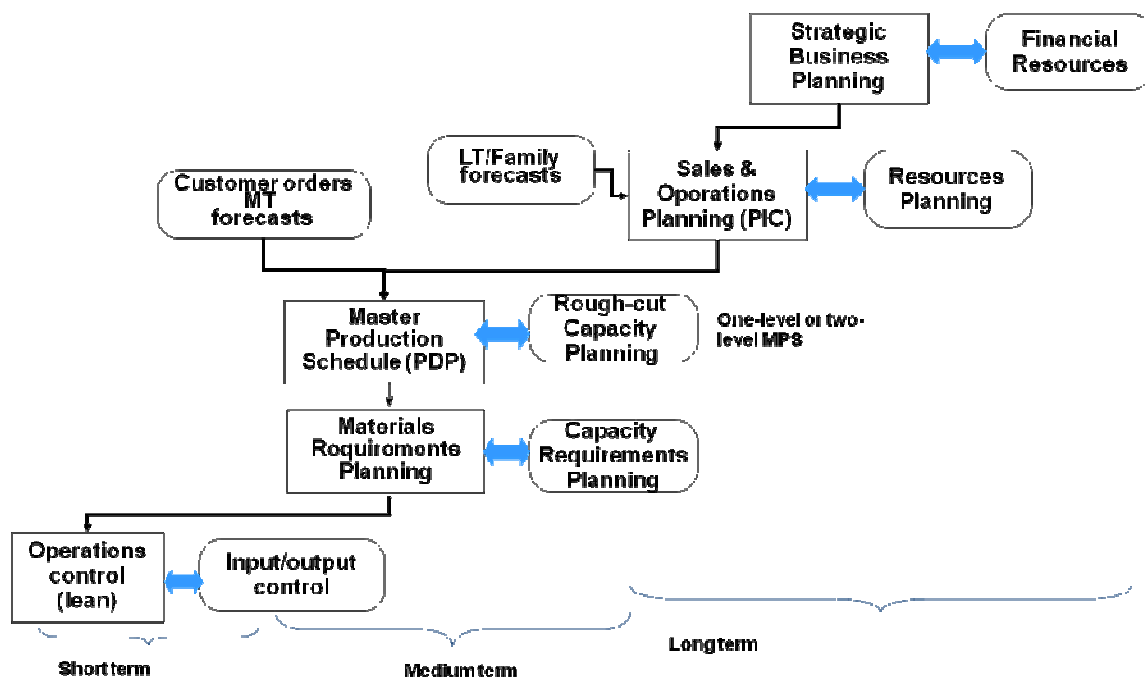
How to proceed?

The specific software package is available depending on how well it fits the needs of manufacturing operation. Here are the key steps :

- Implement monthly Sales & Operation Planning at the steering committee level, to determine production levels and anticipate capacity needs
- Implement weekly Master Production Schedule, at the production department level (stable, level, realistic)
- Run a weekly Materials Requirements Planning and Capacity Requirements Planning, to update materials and capacity requirements
- Implement Execution and Control of Operations, and Input-Output Control

Tips

- ✓ Don't focus on software, but on methods and education
- ✓ Validate only realistic plans – use bill of resources for rough cut capacity plans
- ✓ Focus on data accuracy (inventories, bill of materials, routings, item master)

30.   Input – Output Control

What is it?

- A technique for capacity control where planned and actual inputs and planned and actual outputs of a work center are monitored.

- Actual input is compared to planned input to identify when work center output might vary from the plan because work is not available at the work center

- This technique is used either at work center level or at shop level, to :

    o Control (or reduce) the work-in-process and manufacturing lead time, but using the obvious rule: "*if you want to reduce WIP, don't put more in that what goes out*!"

    o Control the capacity: each time the WIP goes over a certain limit, take immediate action (add capacity).

How to proceed?

1. Define optimum queue size at each work center (based on lead time objective, productivity constraints)

2. Planned inputs and outputs for each work center are developed by capacity requirements planning and approved by manufacturing management.

Input/Output Control

Work center: 201
Capacity per period: 40 standard hours

Period	1	2	3	4	5	Total
Planned input	38	32	36	40	44	190
Actual input	34	32	32	42	40	180
Cumulative variance						
Planned output	40	40	40	40	40	200
Actual output	32	36	44	44	36	192
Cumulative variance						
Planned backlog	32					
Actual backlog	32					

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3. Track the actual values daily, and take immediate appropriate actions: vary capacity, release orders, slow down material flows.

APPENDIX: The Six Big Losses

The Six Big Losses—the most common causes of efficiency loss in manufacturing. The following table lists the Six Big Losses, and shows how they relate to OEE Loss categories.

SIX BIG LOSS CATEGORY	OEE LOSS	EVENT EXAMPLES	NOTES
Breakdowns	Down Time Loss	• Tooling Failures • Unplanned Maintenance • Equipment Failure	There is flexibility on where to set the threshold between a Breakdown (Down Time Loss) and a Small Stop (Speed Loss).
Setup and Adjustments	Down Time Loss	• Setup/Changeover • Material Shortages • Operator Shortages • Warm-Up Time	One way to address this loss is through setup time reduction programs (e.g. SMED).
Small Stops	Speed Loss	• Obstructed Flow • Component Jams • Misfeeds • Sensor Blocked • Cleaning/Checking	Typically only includes stops that are under five minutes and that do not require maintenance personnel.
Reduced Speed	Speed Loss	• Rough Running • Under Nameplate Capacity • Equipment Wear • Operator Inefficiency	Anything that keeps the process from running at its theoretical maximum speed (a.k.a. Ideal Cycle Time) for a given product.
Startup Rejects	Quality Loss	• Scrap • Rework • In Process Damage • In Process Expiration • Incorrect Assembly	Rejects during warm-up, startup or other early production. May be due to improper setup, warm-up period, etc.
Production Rejects	Quality Loss	Same as Startup Rejects.	Rejects during steady-state production.

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