

LEANER SIX SIGMA®

HOW TO MAKE LEAN
SIX SIGMA EVEN LEANER

THIRD EDITION

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Introduction

This document contains the graphics described in the Audible version of Leaner Six Sigma: *How to Make Lean Even Leaner*.

We offer Lean Six Sigma Yellow, Green, Black, and Master Black Belt public workshops via Zoom, private classes, and individual study.

Please note that some graphics were combined in one section to make it easier to review, and additional information (not in the audiobook) is also included. So, in some cases, there is not a direct reference.

If you have questions or suggestions, please get in touch with us at SixSigma@SSDGlobal.net.

Charts and Graph used in Audio Version
 Lean Six Sigma: How to Make Lean Six Sigma Even *Leaner*

Based on Material from *Leaner* Six Sigma®

Note: Some items were just referenced in the audiobook, so there are additional charts and graphs. These charts will appear as “Referenced.”

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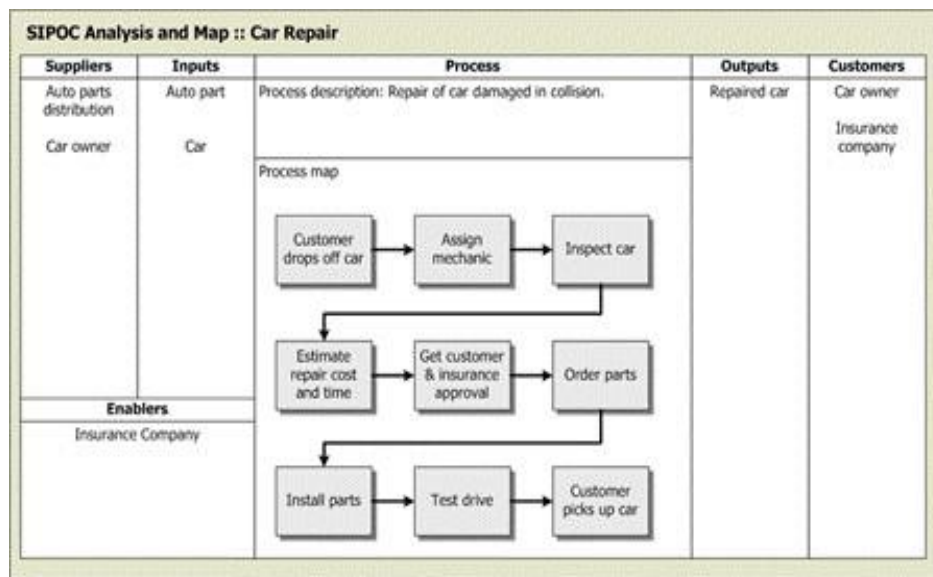


Figure 1 - SIPOC

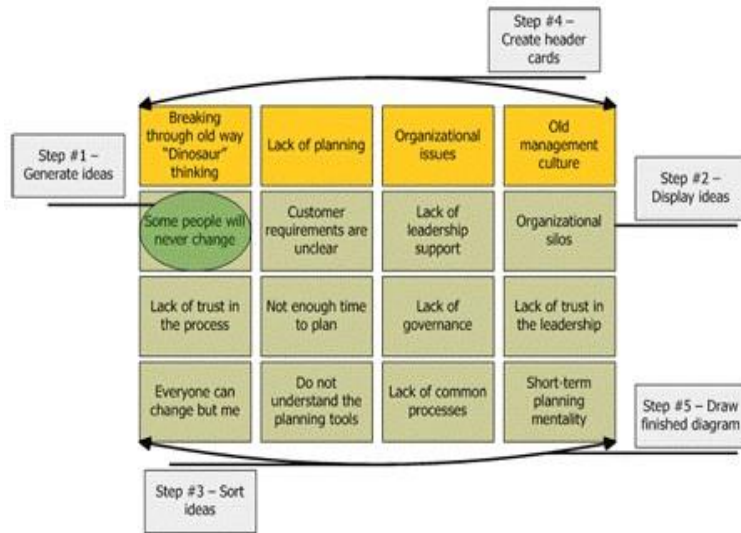


Figure 2 Affinity Diagram

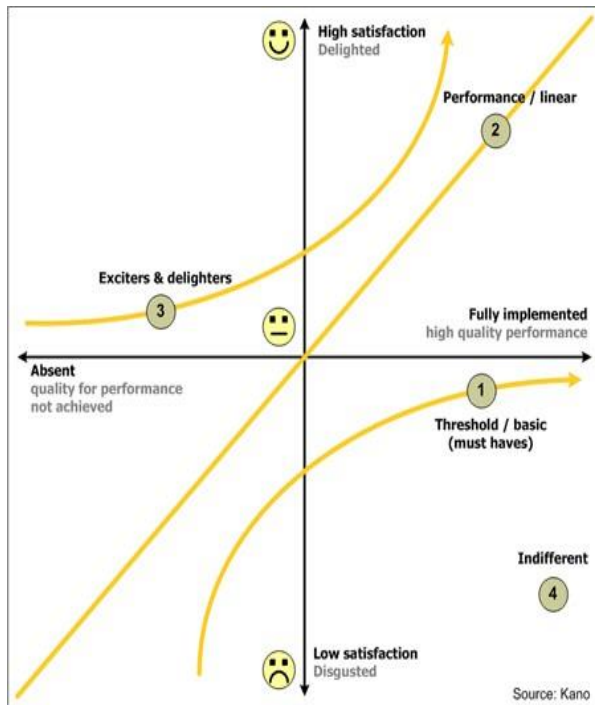


Figure 3Kano Model

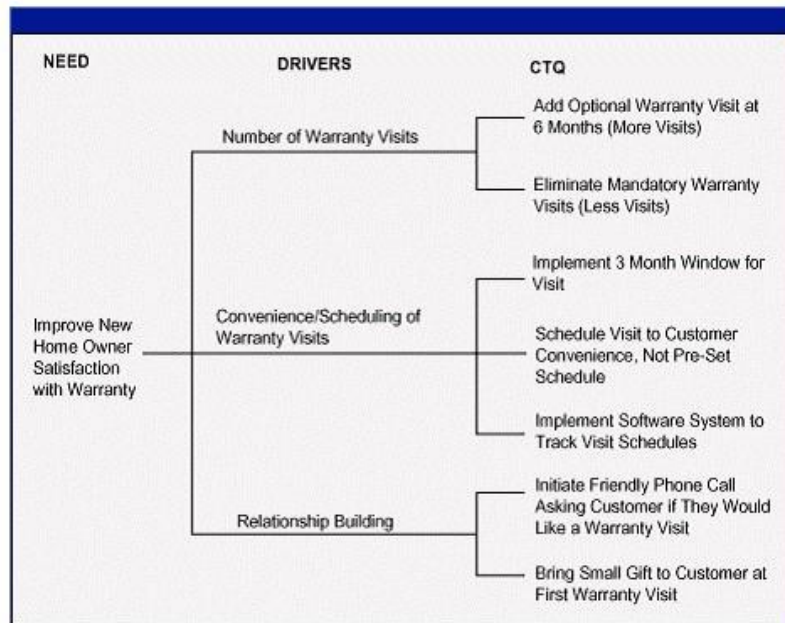


Figure 4 Drivers

Criteria provide common method of judging items to be prioritized

Criteria are prioritized by weighting values (e.g. 4 means twice as important as 2)

Items to prioritize \ Criteria:	Low cost of implementation Weight = 2	High increase in sales Weight = 4	Final score
Add a fold-away handle	3 x 6	2 8	14
Reduce the weight	2 4	4 16	20
Use brighter prints	5 10	3 12	22

Items scored against criteria

Weighted score is score x weight (e.g. $3 \times 2 = 6$)

Weighted scores added for final score (e.g. $4 + 16 = 20$)

Figure 5 Matrix

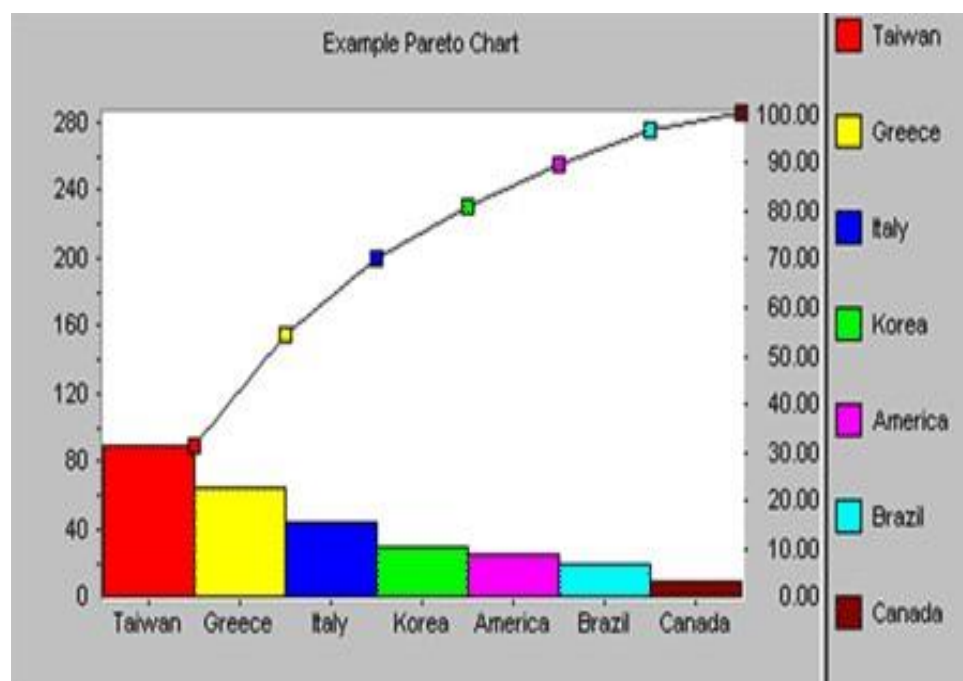
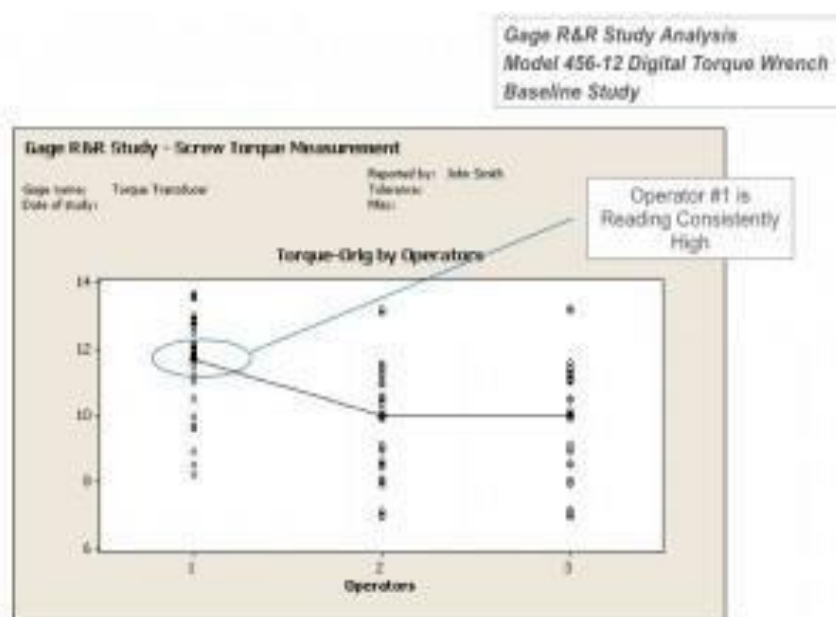


Figure 6 Pareto Chart



Gage R&R (Referenced)

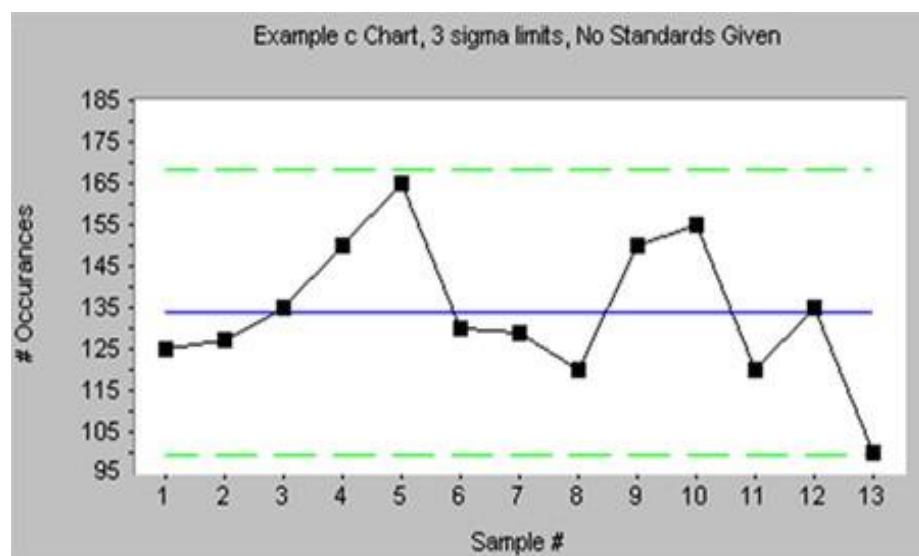


Figure 7 Example of a Control Chart

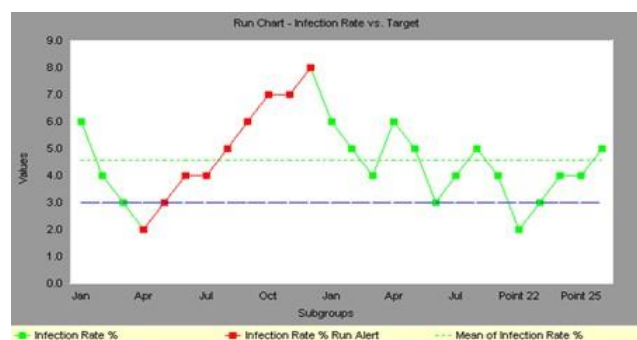


Figure 8 Example of a Run Chart

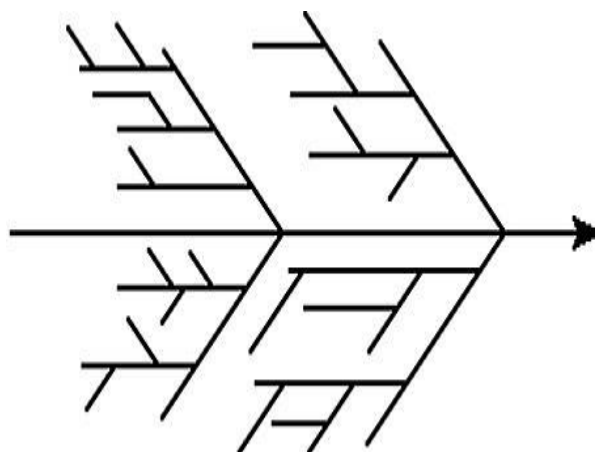


Figure 9 Example of a Fishbone Diagram

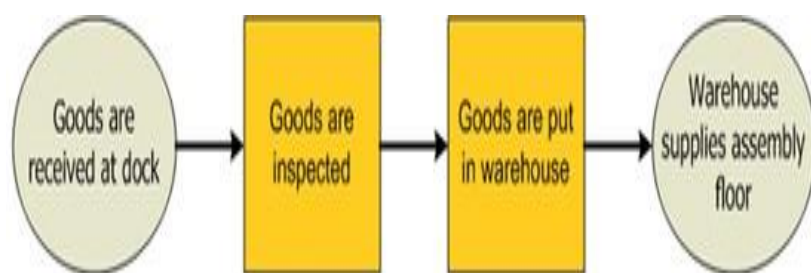


Figure 10 Example of a High-level Flow Diagram

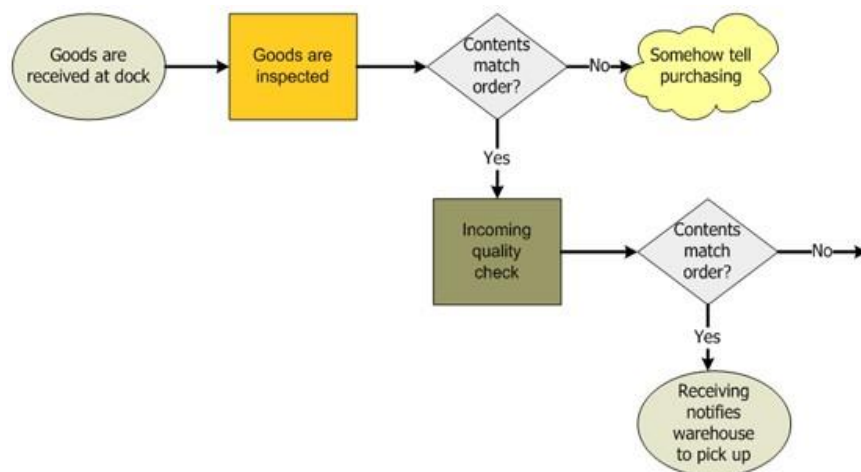


Figure 11 Example of a Flow Diagram

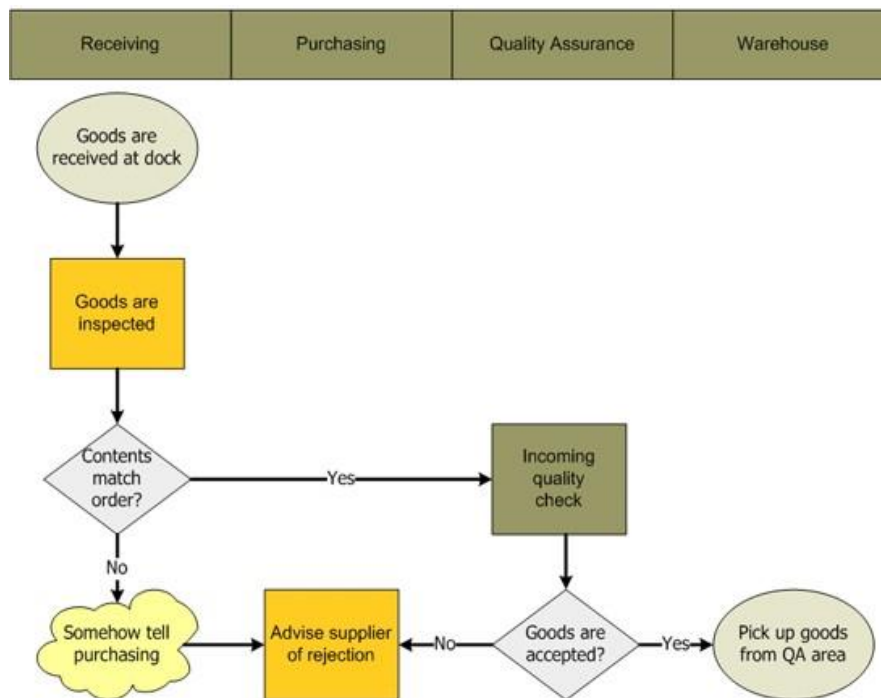


Figure 12 Example of a Deployment Diagram

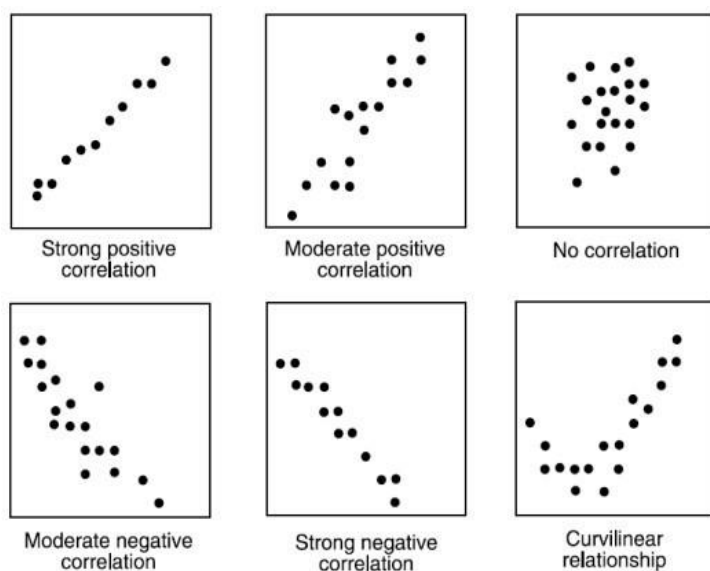
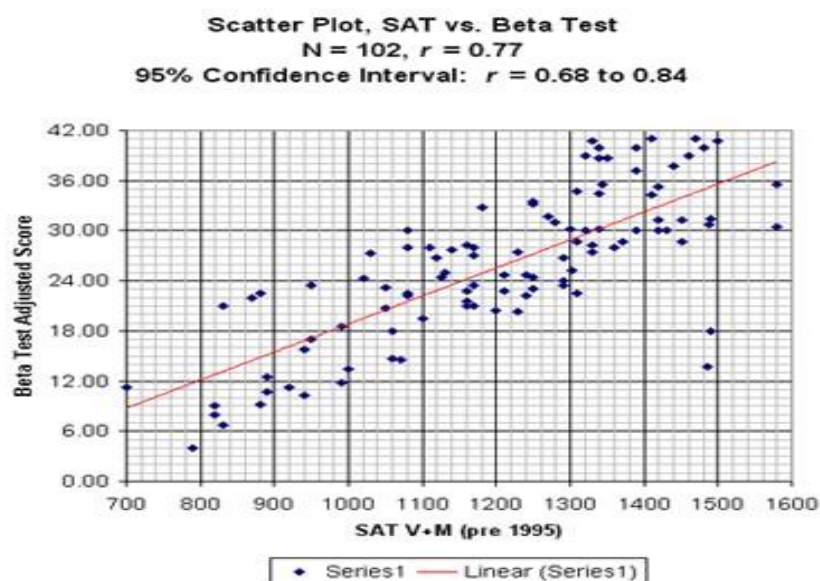
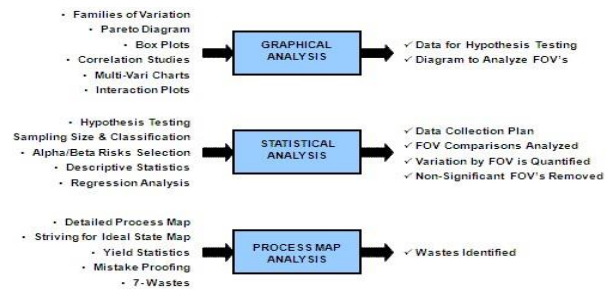
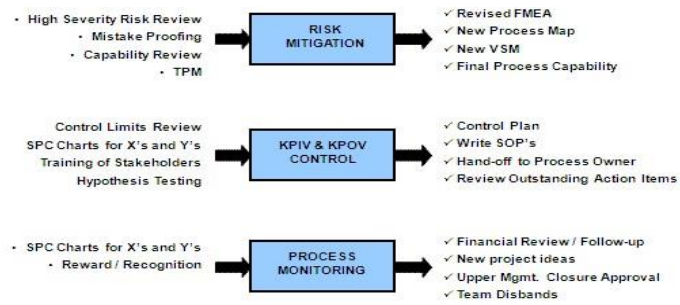


Figure 13 Scatter Plot and Scatter Plot Patterns



Types of Analysis (Referenced)



Example of Risk/KPIV/Process Diagram (Referenced)

Key Terms – Leaner Six Sigma

These terms were mentioned in the audio version, but they are repeated here for reference

Lean Six Sigma Key Terms - Simplified

The 4Ms categories are used to provoke thought in an Ishikawa diagram (cause-and-effect diagram): material, Method, Machine, and Man.

5Why's- The practice of asking why five times when presented with a problem to identify potential root causes.

5S- A process and method for creating and maintaining an organized, clean, safe, and high-performing workplace. The steps are Sort, Set, Shine, and Standardize and Sustain. All

A3 Report - A Toyota-developed standard report shows a problem, analysis, and corrective action plan on a single piece of paper, usually A3 size.

A-B Control- A method used to regulate working relationships between a pair of operations such that overproduction is minimized. Machine A cannot feed machine B until it is empty or waiting for work.

ABC Production Analysis- Volume based groupings used to segment part numbers to define the inventory policy that they fall within.

Abscissa- The horizontal axis of a graph.

Acceptance Criteria- These are specific criteria identified by the customer for each functional requirement. The acceptance criteria are written in simple terms and from the perspective of the customer.

Acceptance Testing- Acceptance testing is a validation activity conducted to determine whether a system satisfies its acceptance criteria. It is the last phase of the software testing process.

Acceptance Region- The region of values for which the null hypothesis is accepted.

Affinity Diagram- Organizes brainstorming ideas into categories or themes. Useful when there are large amounts of information collected during a brainstorming session. It is also called the KJ method, after Kawakita Jiro (a Japanese anthropologist) who first developed the idea.

Agile- A conceptual framework for undertaking software projects. Agile methods are a family of development processes, not a single approach to software development.

Alpha Risk- The probability of accepting the alternate hypothesis when the null hypothesis is true.

Alternative Hypothesis- A tentative explanation which indicates that an event does not follow a chance distribution, a contrast to the null hypothesis.

Andon- the Japanese word for signal referring to a visual system that provides an indicator to supervision when abnormalities occur within processes.

Anova- Analysis of variance- This is a statistical test done by comparing the variances around the means of the condition being compared. In the simplest form Anova gives a statistical test of whether the means of several groups are all equal.

Anova Gauge R&R- Measures the amount of variability induced in measure by the measurement system itself and compares it to the total variability observed to determine the viability of the measurement system.

Assemble to Order- An environment where a product or service can be assembled or provided upon receipt of a customer's order. The product will usually consist of a number of modules that are assembled to the highest level possible and stored such that when the order arrives, it can be assembled quickly and to the customer's specifications.

Assignable Cause- A source of variation which is non-random; a change in the source ("Vital Few" variables) will produce a significant change of some magnitude in the response (dependent variable), e.g., a correlation exists; the change may be due to an intermittent in-phase effect or a constant cause system which may or may not be highly predictable; an assignable cause is often signaled by an excessive number of data points outside limits; an unnatural source of variation; most often economical to eliminate.

Assignable Variation- Variation in data which can be attributed to specific causes.

Assumption- There may be external circumstances or events that must occur for the project to be successful (or that should happen to increase your chances of success). If you believe that the probability of the event occurring is acceptable, you could list it as an assumption. An assumption has a probability between 0 and 100%. That is, it is possible that the event will occur (0%), and it is not a fact (100%). It is somewhere in between. Assumptions are important because they set the context in which the entire remainder of the project is defined. If an assumption does not come through, the estimate and the rest of the project definition may no longer be valid.

Attribute- A characteristic that may take on only one value, e.g.) or one.

Attribute Data- Numerical information at the nominal level; subdivision is not conceptually meaningful; data which represents the frequency of occurrence within some discrete category, e.g., forty-two solder shorts.

Automatic Line Stop- Ensuring that processes producing will stop whenever a defect or problem occurs.

Autonomation- A term developed by Taiichi Ohno to describe "automation with human touch." Automated machines will stop when abnormalities occur so that they will not create large amounts of scrap and do not need an operator to watch the machine.

Average- Also called the mean, it is the arithmetic average of all the sample value. It is calculated by adding all the sample values together and dividing by the number of elements(n) in the sample.

Background Variables- Variables that are of no experimental interest and are not held constant. Their effects are often assumed insignificant or negligible, or they are randomized to ensure that contamination of the primary response does not occur.

Balance Chart- A bar chart or histogram that illustrates work content per operator. It can be used to balance work for operators or machines to achieve improvements in flow.

Balanced Scorecard – is a performance management approach that focuses on customer perspective, internal-business processes, and learning and growth and financials. It was originated by Drs. Robert Kaplan (Harvard Business School) and David Norton as a performance measurement framework that added strategic non-financial performance measures to traditional financial metrics to give managers and executives a more 'balanced' view of organizational performance.

Batch and Queue- Typical mass production method such that a part going through a system will be produced in large batches to maximize “efficiency” and then sit in a queue waiting for the next operation.

Behavior Driven Development- Behavior driven development (or BDD) is an agile software development technique that encourages collaboration between developers, QA and nontechnical or business participants in a software project. BDD focuses on obtaining a clear understanding of desired software behavior through discussion with stakeholders. It extends TDD by writing test cases in a natural language that non-programmers can read.

Benchmarking – a standard used to compare performance against best-in-class companies. It then uses the information gathered to improve its own performance. Subjects that can be benchmarked include strategies, products, programs, services, operations, processes, and procedures.

Beta Risk- The probability of accepting the null hypothesis when the alternate hypothesis is true.

Blocking Variables- A homogenous set of conditions within which different conditions of the primary variables are compared. Used to ensure that background variables do not contaminate the evaluation of primary variable.

Bottleneck- A bottleneck is a sort of congestion in a system that occurs when workload arrives at a given point more quickly than that point can oversee it. It is metaphorically derived from the flowing of water through a narrow-mouthed bottle where the flow of water is constrained by the size of its neck.

Breakthrough Improvement-a rate of improvement at or near 70% over baseline performance of the as-is process characteristics.

Brownfield- A brownfield site is an existing facility that is usually managed in line with mass production methods.

Bugs- A software bug is a problem causing a program to crash or produce invalid output. It is caused by insufficient or erroneous logic and can be an error, mistake, defect, or fault.

Build to Order- A production environment where a product or service can be made and assembled after receipt of a customer’s order.

Burndown Chart- A burndown chart is a visual tool for measuring and displaying progress. Visually, a burndown chart is simply a line chart representing remaining overtime. Burndown charts are used to measure the progress of an agile project at both an iteration and project level.

Capability - measurement index that expresses the capability of the process by using a percentage.

Capital Linearity- A philosophy linked to capital expenditure on machinery such that a small amount of additional capacity can be added by using a number of smaller machines rather than one big and expensive machine.

Cause and Effect Diagram – also called a fishbone diagram. This is a graph that places the issue being discussed in the head of the fish. The bones of the fish are categories of problems that could be a problem. The smaller bones are the possible root causes **Casualty-** The principle that every change implies the operation of a cause.

Causative- Effective as a cause.

Cause- That which produces an effect or brings about change.

Cell- A cell is a group of people, machines, materials, and methods arranged so that processing steps are located adjacent to each other and in sequential order. This allows parts to be processed one at a time or, in some cases, in a constant small batch that is maintained through the process sequence. The purpose of a cell is to achieve and maintain an efficient, continuous flow of work.

Center Line- The line on a statistical process control chart which represents the characteristic's central tendency.

Central Tendency – data clustered around the middle. Mean, mode, and media are all examples of central tendency; numerical average, e.g., mean, median, and mode; center line on a statistical process.

Chaku-Chaku- One-piece flow ideal whereby machines automatically unload parts so that an operator can move apart from one machine to the next without stopping unloading parts.

Champion – a person who supports the successful completion of the project.

Characteristic - a process input or output which can be measured and monitored.

Chief Engineer- The Toyota term used to describe the person who is responsible for the successful development of a product line.

Classification- Differentiation of variables.

Client/Customers- The person or group that is the direct beneficiary of a project or service is the client / customer. These are the people for whom the project is being undertaken (indirect beneficiaries are stakeholders). In many organizations, internal beneficiaries are called "clients" and external beneficiaries are called "customers," but this is not a fixed rule.

Common Cause- SEE Random Cause.

Common Causes of Variation - sources of variability in a process which are truly random. These are inherent in the process itself and can be managed. This type of variation is usual, historical, quantifiable variation in a system.

Complexity -The level of difficulty to build, solve or understand something based on the number of inputs, interactions and uncertainty involved.

Confidence Level- The probability that a random variable x lies within a defined interval.

Confidence Limits- The two values that define the confidence level.

Confounding- Allowing two or more variables to vary together so that it is impossible to separate their unique effects.

Consumer Risk- Probability of accepting a lot when, in fact, the lot should have been rejected (see Beta Risk).

Continuous Data- A set of observations usually associated with physical measurement that can take on any mathematical value within specified parameters.

Continuous flow. Each process, whether in an office or plant setting, makes or completes only the one piece that the next process needs; the batch size is one. Single-piece flow, or one-piece flow, is the opposite of a batch-and-queue process.

Continuous Random Variable- A random variable which can assume any value continuously in some specified variable.

Constraints- Constraints are limitations that are outside the control of the project team and need to be managed around. They are not necessarily problems. However, the project manager should be aware of constraints because they represent limitations that the project must execute within. Date constraints, for instance, imply that certain events (the end of the project) must occur at certain dates. Resources are always a constraint since they are not available in an unlimited supply.

Control Chart - The most powerful tool of statistical process control. It consists of a run chart, together with statistically determined upper and lower control limits and a centerline.

Control Limits - Upper and lower bounds in a control chart that are determined by the process itself. They can be used to detect special or common causes of variation.

Control Specifications- Specifications called for by the product being manufactured.

Cost of Poor Quality (COPQ) - The costs associated with any activity that is not doing the right thing right the first time.

Critical Path- The series of consecutive activities that represent the longest time path through the process; The critical path is the sequence of activities that must be completed on schedule for the entire project to be completed on schedule. It is the longest duration path through the work plan. If an activity on the critical path is delayed by one day, the entire project will be delayed by one day (unless another activity on the critical path can be accelerated by one day).

Cycle Efficiency (CE)- CE is a measure of the relative efficiency in a production system. It represents the percentage of value-added time of a product through the critical path vs. the total cycle time (TCT).

Cycle Time Interval- The frequency that a particular item is made during a set period (usually days).

Critical to Quality (CTQ) – Any activity or thought related to the successful outcomes of the project.

Cross Dock- A facility that gathers and recombines a variety of inbound materials and parts from multiple suppliers to forward on to multiple customers.

Cutoff Point- The point which partitions the acceptance region from the rejection.

Cycle Efficiency (CE)- CE is a measure of the relative efficiency in a production system. It represents the percentage of value-added time of a product through the critical path vs. the total cycle time (TCT).

Cycle time. This is the time a person needs to complete an assigned task or activity before starting again.

Daily Standup/Scrum- A Daily Standup is a whole team meeting that happens at the same time every day that usually lasts 15 minutes or less. The meeting is designed to allow the entire team to synchronize with each other and to understand the flow and challenges of the development process. Each team member should provide the following information: what did I do yesterday, what am I planning to do today, and what impediments do I currently have?

Data- information used as a basis for reasoning, discussion, or calculation; often refers to quantitative information.

Discrete Random Variable- A random variable which can assume values only from a definite number of discrete.

Defect - An output of a process that does not meet a defined specification, requirement, or desire such as time, length, color, finish, quantity, temperature etc.

Defective - A unit of product or service that contains at least one defect.

Degrees OF Freedom- The number of independent measurements available for estimating a population parameter.

Deliverable- A deliverable is any tangible outcome that is produced by the project. All projects create deliverables. These can be documents, plans, computer systems, buildings, aircraft, etc. Internal deliverables are produced because of executing the project and are usually needed only by the project team. External deliverables are those that are created for clients and stakeholders. Your project may create one or many deliverables.

Demand- The usage of an item over a period. This also includes an understanding of the customer requirements regarding quality, lead-time, and price.

Density Function- The function which yields the probability that a particular random variable takes on any one of its values.

Dependent Variable- A response variable, e.g., y is the dependent or “Response” variable where $Y=f(X_1 \dots X_n)$ variable.

Design of Experiments (DOE) - an efficient, structured, and proven approach to interrogating a process or system for the purpose of maximizing the gain in process or system knowledge.

Design for Six Sigma (DFSS) - The use of six sigma thinking tools and methods applied to the design of products. Any Six Sigma model for managing a project, which is not DMAIC, is considered a DFSS.

Distributions- Tendency of large numbers of observations to group themselves around some central value with a certain amount of variation or “scatter” on either side.

Done- Also referred to as “Done-Done,” this term is used to describe all the various tasks that need to happen before a story is considered potentially releasable.

DMAIC. This acronym stands for "define, measure, analyze, improve, and control. It is the heart of the Six Sigma process and refers to a data-driven quality strategy for improving processes. It is an integral part of any company's Six Sigma quality initiatives.

DPMO - Defects per million opportunities - The total number of defects observed divided by the total number of opportunities, expressed in parts per million.

DPU - Defects per unit - The total number of defects detected in some number of units divided by the total number of those units.

Effect- That which was produced by a cause.

Engineer to Order- Products whose customer’s specifications are unique for each order therefore each product is engineered from scratch upon receipt of an order.

Epic- An exceptionally large user story that is eventually broken down into smaller stories.

Estimation- The process of agreeing on a size measurement for the stories, as well as the tasks required to implement those stories in a product backlog.

Exits- The amount of work completed over a given amount of time measured in £’s or Units.

Experiment- A test under defined conditions to determine an unknown effect; to illustrate or verify a known law; test or establish a hypothesis.

Experimental Error- Variation in observation made under identical test conditions. Also called residual error. The amount of variation which cannot be the variables included in the experiment.

Factors- Independent variables.

Failure Mode and Effects Analysis (FMEA) - A procedure used to identify, assess, and mitigate risks associated with potential products, system, or process failure modes.

Feature Creep- Feature creep occurs when software becomes complicated and difficult to use because of too many features.

FIFO- A strategically sized inventory that keeps the sequence of the production uniform throughout the value Stream maintaining flow.

Finish to Order- An environment such that products are built to as high a level as is possible and then configured to customers’ requirements upon receipt of order.

Fishbone Diagram - See cause and effect diagram.

Fixed Effects Model- Experimental treatments are specifically selected by the researcher. Conclusion only applies to the factor levels considered in the analysis. Inferences are restricted to experimental levels.

Fixed-Position Stop System- A problem addressing method on continuously moving production lines such that if a problem is identified and not resolved before a fixed point, the production line will stop.

Flowchart - A graphic model of the flow of activities, material, and/or information that occurs during a process.

Fluctuations- Variances in data are caused by a large number of minute variations or differences.

Frequency Distribution- The pattern or shape formed by the group of measurements in a distribution.

Functional Manager- The functional manager is the person you report to within your functional organization. Typically, this is the person who does your performance review. The project manager may also be a functional manager, but he or she does not have to be. If your project manager is different from your functional manager, your organization is utilizing matrix management.

Gage R&R – is used in Measurement Systems Analysis (MSA) Quantitative assessment of how much variation (repeatability and reproducibility) is in a measurement system compared to the total variation of the process or system.

Gemba- Japanese term used to describe the “actual place” where value is added or the shop floor.

Greenfield- A new production facility not restricted by practices of the past therefore having a culture of adapting change without resistance.

Gantt Chart- A Gantt chart is a bar chart that depicts activities as blocks over time. The beginning and end of the block correspond to the beginning and end-date of the activity.

Heijunka- Leveling production by product and/or quantity over a fixed time.

High-Level Stream Map- A visual representation of the aggregated material and information flows within a company or business unit.

Histogram - A bar chart that depicts the frequencies (by the height of the plotted bars) of numerical or measurement categories.

Homogeneity of Variance- The variances of the groups being contrasted are equal (as defined by statistical test of significant differences).

Hoshin- the Japanese work for planning and used throughout operational, financial, strategic, and project-based scenarios.

Independent Variable- A controlled variable; a variable whose value is independent of the value of another variable.

Input - A resource consumed, utilized, or added to a process or system. Synonymous with X, characteristic, and input variable.

Inspection- Mass production would use inspectors outside of a process. Lean producers assign the responsibility of quality to the areas where the processes are performed. Inspections are performed within the areas that own the assembly process.

Issue- An issue is a major problem that will impede the progress of the project and that cannot be resolved by the project manager and project team without outside help. Project managers should proactively deal with issues through a defined issues management process.

Instability- Unnaturally large fluctuations in a pattern.

Interaction- The combined effect of two factors observed over and above the singular effect of each factor against the level the other factor. A significant interaction indicates that the effect of each factor on the response changes depending on the value of the other factor.

Interval- Numeric categories with equal units of measure but no absolute zero point, i.e., quality scale or index.

Inventory Turns- A measure to quantify the pace at which inventory rotates throughout a company.

$$\text{Inventory turns} = \text{annual cost of goods sold} / \text{average value of inventory during year}.$$

Jidoka- Quality built into processes such that if a process is not capable of creating the required output, then it will not operate until it can.

Jishuken- a Japanese word used to describe a “hands-on learning workshop.”

Just in Time (JIT)- stands for "just in time." This means producing or conveying only the items that are needed by the next process when they are needed and, in the quantity, needed. This process can even be used between facilities or companies.

Kaikaku- Radical improvement designed to quickly eliminate and/ or add value to a value stream. Also described as Breakthrough Kaizen.

Kaizen Event – A rapid improvement event; part of a continuous improvement program. A focused, dedicated, and well-defined event that is used to get quick hit value by implementing “do-now” solutions leading to waste elimination.

Kaizen- Incremental change for the better. The organized use of common sense to improve cost, quality, delivery, safety, and responsiveness to customer needs.

Kanban- Kanban, pronounced /'kan'ban/, is a method for developing products with an emphasis on just-in-time delivery and the optimization of flow of work on the team. It emphasizes that developers pull work from a queue, and the process, from definition of a task to its delivery to the customer, is displayed for participants to see.

Kanban post-A storage container for Kanban cards pulling deliveries.

Labor Linearity- A staffing philosophy such that as demand increases or reduces workforce is added one at a time as such labor requirements are linear to production volume.

Lead-Time- The total time from the beginning of the supply chain to the time something needs to ship. The sum of the VA/NVA time for a product to move through the entire value stream.

Lean – Lean software development is a translation of Lean manufacturing and Lean IT principles and practices to the software development domain. Adapted from the Toyota Production System and is a set of

techniques and principles for delivering more value with the same or less resources by eliminating waste across organizations and business processes.

Lean Transactional- The application of lean-to business processes such as paperwork flow through an office in accounts or marketing.

Level Selling- The elimination of sales spikes generated by end of month sales targets at dealers and so forth. This allows for improved flow of demand from the customers and improvements in anticipated demand.

Lifecycle- Lifecycle refers to the process used to build the deliverables produced by the project. There are many models for a project lifecycle. For software development, the entire lifecycle might consist of planning, analysis, design, construction/test, implementation, and support. This is an example of a "waterfall" lifecycle. Other lifecycles include iterative development, package implementation, and research and development. Each of these lifecycle models represents an approach to building the deliverables on your project.

Line Charts- Charts used to track performance without relationship to process capability of control limits.

Linear regression- Analyzes the relationship between two variables, X and Y.

Long-term Variation - The observed variation of an input or output characteristic which has had the opportunity to be observed over time.

Lower Control Limit (LCL) - Used in control charts to show the lower limit. Typically, three standard deviations below the central tendency.

Machine Cycle Time- The amount of time the unit spends in the operational cycle of a machine.

Mean- The statistical measure on a sample that is used as an estimate of the meaning of the population from which the sample was drawn. Numerically it equals the sum of scores divided by the number of samples.

Measurement Accuracy - For a repeated measurement, it is a comparison of the average of the measurements compared to some known standard.

Measurement Precision - For a repeated measurement, it is the amount of variation that exists in the measured values.

Median - The middle value of a data set when the values are arranged in either ascending or descending order.

Metric - A measure that is a key indicator of performance. It should be linked to goals or objectives and carefully monitored.

Milestone- A milestone is a scheduling event that signifies the completion of a major deliverable or a set of related deliverables. A milestone, by definition, has duration of zero and no effort. There is no work associated with a milestone. It is a flag in the work plan to signify that some other work has completed. Usually, a milestone is used as a project checkpoint to validate how the project is progressing. In many cases there is a decision, such as validating that the project is ready to proceed further, that needs to be made at a milestone.

Milk Run- Reducing transport costs and batch sizes by performing multiple pick up and drops at multiple suppliers using one truck.

Mixed Effects Model- Contain elements of both the fixed and random effects models.

Muda- the Japanese word for waste or Non-Value-Added activity.

Mura- the Japanese word used to describe variation or fluctuation.

Muri- the Japanese word used to describe overburdening or strain/stress.

Nemawashi- a Japanese expression used to describe the practice of obtaining support and buy-in for change by firstly the idea and then the plan with upper management and stakeholders. Directly translated means “preparing” the ground for planting.

Nominal- Unordered categories which indicate membership or non-membership with no implication of quantity, i.e., assembly area number one, part numbers, etc.

Nonconforming Unit- A unit which does not conform to one more specification, standards, and/or requirements.

Nonconformity- A condition within a unit which does not conform to some specific specification, standard, and/or requirement; often referred to as a defect; any given nonconforming unit can have the potential for more than one nonconformity.

Non-Value Added (NVA) - Any activity performed in producing a product or delivering a service that does not add value.

Normal Distribution - The distribution characterized by the smooth, bell-shaped curve.

Null Hypothesis- A tentative explanation which indicated that a chance distribution is operating, a contrast to the null hypothesis.

Obeya- Translated as “Big Room” this is the expression used by the Japanese to describe the powerful project room concept also known as a “war room.”

Objective- An objective is a concrete statement that describes what the project is trying to achieve. The objective should be written at a low level, so that it can be evaluated at the conclusion of a project to see whether it was achieved. Project success is determined based on whether the project objectives were achieved. A technique for writing an objective is to make sure it is **Specific, Measurable, Attainable/Achievable, Realistic, and Time bound (SMART)**.

One Piece Flow- Making and moving only one piece or part at a time. See Continuous Flow.

One-sided Alternative- The value of a parameter which has an upper bound and a lower bound, but not both.

Operator Cycle Time- The time it takes an operator to go through all his or her work elements before repeating them.

Order Interval- Represents the frequency (days) that a part is ordered.

Ordinal- Ordered categories (ranking) with no information about distance between each category, i.e., rank ordering of several measurements of an output parameter.

Ordinate- The vertical axis of a graph.

Overall Equipment Effectiveness (OEE)- A total productive maintenance (TPM) measures of how effectively equipment is being used. $OEE = \text{availability rate} \times \text{performance rate} \times \text{quality rate}$.

Overproduction – The process of producing more, sooner, or faster than is required by the next process or customer.

P Charts- Charts used to plot percent defectives in a sample.

Pacemaker- The only point in the production process is scheduled and therefore dictates the pace of production for a whole system of processes.

Pacesetter- The point in the process that limits the output of the total process.

Pair Programming- is an agile software development technique in which two programmers work together at one workstation. One types in code while the other reviews each line of code as it is typed in. The person types are called the driver. The person reviewing the code is called the observer (or navigator). The two programmers switch roles frequently.

Parameter- A constant defining a particular property of the density function of a variable.

Pareto Diagram- A chart which ranks, or places in order, common occurrences.

Perturbation- A nonrandom disturbance.

Pitch- The amount of time required by a production area to make one container of products. $\text{Takt time} \times \text{pack-out qty} = \text{pitch}$.

Plan for Every Part (PFEP)- A comprehensive plan for each part consumed within a production process. This would take the form of a spreadsheet or simple table and contain such data as pack-out quantity, location of use and storage, order frequency and so on. This provides one accurate source of information relating to parts.

Plan, Do, Check, Act (PDCA)- An improvement cycle introduction to the Japanese in the fifty's by W. Edwards Deming. Based upon proposing then implementing an improvement, then measuring the results and acting accordingly.

Planning Poker- Also called Scrum poker, is a consensus-based technique for estimating, mostly used to estimate effort or relative size of tasks in software development.

Poka Yoke - Mistake-proof device or procedure designed to prevent a defect from occurring throughout the system or process. Error-proofing is a manufacturing technique for preventing errors by designing the manufacturing process, equipment, and tools so that an operation cannot be performed incorrectly. Poka Yoke is the Japanese phrase for do it right the first time.

Population- A group of similar items from which a sample is drawn. Often referred to as the universe.

Power of an Experiment- The probability of rejecting the null hypothesis when it is false and accepting the alternative hypothesis when it is true.

Prevention- The practice of eliminating unwanted variations of priori (before the fact), e.g., predicting a future condition from a control chart and applying corrective action before the predicted event transpires.

Primary Control Variables- The major independent variables in the experiment.

Probability of an Event- The number of successful events divided by the total numbers of trials.

Probability- The chance of something happening in percent or number of occurrences over a large number of trials.

Problem- A deviation from a specified standard.

Problem-Solving- A process of solving problems; the isolation and control of those conditions which generate or facilitate the creation of undesirable symptoms.

Process- A particular method of doing something, involving a number of steps or operations.

Process Average- The central tendency of a given process characteristics across a given amount of time or a specific point in time.

Process control Chart- Any of a number of various types of graphs upon which data are plotted against specific control limits.

Process Control- SEE statistical process control.

Process Owner - Have responsibility for process performance and resources. They provide support, resources, and functional expertise to six sigma projects. They are accountable for implementing six developed sigma solutions into their process.

Process Spread- The range of values in which a given process characteristic displays; this term most often applies to the range but may also encompass the variance. The spread may be based on a set of data collected at a specific point in time or may reflect the variability across a given amount of time.

Producers Risk- Probability of rejecting a lot when, in fact, the lot should have been accepted (see Alpha Risk).

Product Backlog- Acts as a repository for requirements targeted for release at some point. These are typically high-level requirements with high level estimates provided by the product stakeholders. The requirements are listed on the backlog in priority order and maintained by the product owner.

Product Owner- The product owner represents the voice of the customer and is accountable for ensuring that the team delivers value to the business. The Product Owner writes customer-centric items (typically user stories), prioritizes them, and adds them to the product backlog. Scrum teams should have one Product Owner.

Production Kanban- A signal that specifies the type and quantity of product that an upstream process must produce.

Program- A program is an umbrella structure established to manage a series of related projects. The program does not produce any project deliverables. The project teams produce them all. The purpose of the program is to provide overall direction and guidance, to make sure the related projects are communicating effectively, to provide a central point of contact and focus for the client and the project teams, and to determine how individual projects should be defined to ensure that all the work gets completed successfully.

Program Manager- A program manager is the person with the authority to manage a program. (Note that this is a role. The program manager may also be responsible for one or more of the projects within the program.) The program manager leads the overall planning and management of the program. All project managers within the program report to the program manager.

Project- A project is a temporary structure to organize and manage work and to build a specific defined deliverable or set of deliverables. All projects are unique, which is one reason it is difficult to compare different projects to one another.

Project Definition (charter)- Before you start a project, it is important to know the overall objectives of the project, as well as the scope, deliverables, risks, assumptions, project organization chart, etc. The project definition (or charter) is the document that holds this relevant information. The project manager is responsible for creating the project definition. The sponsor should approve the document to signify that the project manager and the sponsor agree on these important aspects of the project.

Project Manager- The project manager is the person with the authority to manage a project. The project manager is 100 percent responsible for the processes used to manage the project. He or she also has people management responsibilities for team members, although this is shared with the team member's functional manager. The processes used to manage the project include defining the work, building the work plan and budget, managing the work plan and budget, scope management, issues management, risk management, etc.

Project Phase- A phase is a major logical grouping of work on a project. It also represents the completion of a major delivery or set of related deliverables. On an IT development project, logical phases might be planning, analysis, design, construct (including testing), and implementation.

Project Team- The project team consists of the full-time and part-time resources assigned to work on the deliveries of the project. They are responsible for understanding the work to be completed; completing assigned work within the budget, timeline, and quality expectations; informing the project manager of issues, scope changes, and risk and quality concerns; and proactively communicating status and managing expectations.

Pull- Material flow triggered by actual customer need rather than a scheduled production forecast. Downstream process signal to upstream processes exactly what is required and in what quantity.

Push- The production of goods regardless of demands or downstream needs, usually in large batches to ensure “efficiency.”

Quality Function Deployment (QFD) - A systematic process used to integrate customer requirements into every aspect of the design and delivery of products and services. Output graphics are often the House of Quality.

R Charts- Plot of the difference between the highest and lowest in a sample Range Control Chart.

Random- Selecting a sample so each item in the population has an equal chance of being selected, lack of predictability.

Random Cause- A source of variation which is random; a change in the source (“trivial many”), e.g., a correlation does not exist; any individual source of variation results in a small amount of variation in the response; cannot be economically eliminated from a process; an inherent natural source of variations.

Random Effects Model- Experimental treatments are a random sample from a larger population of treatments. The conclusion can be extended to the population. Interferences are not restricted to the experimental levels.

Random Sample- One or more samples randomly selected from the universe (population).

Random Variable- A variable that can assume any value of a set of values.

Random Variations- Variations in data that result from causes that cannot be pinpointed or controlled.

Randomness- A condition in which any individual event in a set of events has the same mathematical probability of occurrences as all other events within the specified set, i.e., individual events are not predictable even though they may collectively belong to definable distribution.

Range- The difference between the highest and lowest in a set of values or “subgroup.”

Ranks- Values assigned to items in a sample to determine their relative occurrence in a population.

Ratio- Numeric scale which has an absolute zero point and equal units of measure through, i.e., measurements of an output parameter, i.e., amps.

Regression Analysis - includes any techniques for modeling and analyzing several variables. Linear regression was the first type of **regression analysis** to be studied rigorously, and to be used extensively in practical applications.

Reject Region- The region of values of which the alternate hypothesis is accepted.

Repeatability (of a Measurement) - the extent to which repeated measurements of a particular object with a particular instrument produce the same value.

Replication- Observations made under identical test conditions.

Representative Sample- A sample which accurately reflects a specific condition or set of conditions within the universe.

Reproducibility (of a Measurement) - The extent to which repeated measurements of a particular object with a particular individual produce the same value.

Requirements- Requirements are descriptions of how a product or service should act, appear, or perform. Requirements refer to the features and functions of the deliverables you are building on your project. Requirements are a part of project scope. High-level scope is defined in your project definition (charter). The requirements form the detailed scope. After your requirements are approved, they can be changed through the scope change management process.

Research- Critical and exhaustive investigation or experimentation having for its aim the revision of accepted conclusion in the light of newly discovered facts.

Residual Error- See Experimental Error.

Response Time- The Time that an order needs to be satisfied.

Retrospective- A team meeting that happens at the end of every development iteration to review lessons learned and to discuss how the team can be more efficient in the future. It is based on the principles of applying the learning from the previous sprint to the upcoming sprint.

Rework - Activity required to correct defects produced by a process.

Risk- There may be potential external events that will have a negative impact on your project if they occur. Risk refers to the combination of the probability the event will occur and the impact on the project if the event occurs. If the combination of the probability of the occurrence and the impact to the project is too high, you should identify the potential event as a risk and put a proactive plan in place to manage the risk.

Robust- The conditions or state in which a response parameter exhibits hermetic to external cause of a nonrandom nature, i.e., impervious to perturbing influence.

Safety Stock- Inventory held to compensate for variation in demand, quality, and downtime.

Sample- One or more observations drawn from a larger collection of observations or universe (population).

Scatter Diagrams- Charts which allow the study of correlation, e.g., the relationship between two variables.

Scope- Scope is the way you describe the boundaries of the project. It defines what the project will deliver and what it will not deliver. High-level scope is set in your project definition (charter) and includes all your deliverables and the boundaries of your project. The detailed scope is identified through your business requirements. Any changes to your project deliverables, boundaries, or requirements would require approval through scope change management.

Scope Change Management- The purpose of scope change management is to manage change that occurs to previously approved scope statements and requirements. Scope is defined and approved in the scope section of the project definition (charter) and the more detailed business requirements. If the scope or the business requirements change during the project (and usually this means that the client wants additional items), the estimates for cost, effort, and duration may no longer be valid. If the sponsor agrees to include the new work in the project scope, the project manager has the right to expect that the current budget and deadline will be modified (usually increased) to reflect this additional work. This new estimated cost, effort, and duration now become the approved target. Sometimes the project manager thinks that scope management means having to tell the client "No." That makes the project manager nervous and uncomfortable. However, the good news is that managing scope is all about getting the *sponsor* to make the decisions that will result in changes to project scope.

Scrum- Scrum is a framework within which people can address complex adaptive problems, while productively and creatively delivering products of the highest possible value. It is based on the adaptive and iterative methodology of software development.

Scrumban- Scrumban is a mix between Scrum and Kanban, which contains the best features of both methods.

Scrum Master- Scrum is accountable for removing impediments to the ability of the team to deliver the sprint goal/deliverables. The ScrumMaster is not the team leader but acts as a buffer between the team and any distracting influences. The ScrumMaster ensures that the Scrum process is used as intended. The ScrumMaster is the enforcer of rules. A key part of the Scrum expert's role is to protect the team and keep them focused on the tasks at hand. The role has also been referred to as servant-leader to reinforce these dual perspectives.

Sensei- Japanese word for “teacher” and denotes proficiency within their field of knowledge. A Sensei should be a wise and easily understood mentor that guides thinking with his subjects rather than dictating the point to promote learning.

Set-up Time- The amount of time required to changeover a process after producing the last part of one product to the first good part of the next product.

Short Term Variation - The amount of variation observed in a characteristic which has not had the opportunity to experience all the sources of variation from the inputs acting on it.

Signal Kanban- A signal that triggers an upstream process to produce when a minimum quantity is reached at the downstream process.

Single Minute Exchange of Die (SMED)- A technique to reduce setup or changeover times to eliminate the need to build in batches.

Spaghetti Chart- A visual chart showing the path taken by a product or person during a process to highlight excessive motion.

Special Cause- SEE Assignable cause.

Special Cause Variation - non-random causes of variation. Sometimes outside the project manager's control.

Specification Limits – the boundaries of acceptable performance.

Spike- A short, time-boxed piece of research, usually technical, on a single story that is intended to provide just enough information that the team can estimate the size of the story.

Sponsor (executive sponsor and project sponsor)- The sponsor is the person who has ultimate authority over the project. The executive sponsor provides project funding, resolves issues and scope changes, approves major deliverables, and provides high-level direction. He or she also champions the project within the organization. Depending on the project and the organizational level of the executive sponsor, he or she may delegate day-to-day tactical management to a project sponsor. If assigned, the project sponsor represents the executive sponsor on a day-to-day basis and makes most of the decisions requiring sponsor approval. If the decision is large enough, the project sponsor will take it to the executive sponsor.

Sprint/ Iteration- A fixed duration period where user stories are chosen to work on. The term Sprint comes from the Scrum methodology and is analogous to the term Iteration. A sprint is defined as a 2-4-week increment of software development activities that delivers working software and the end of the increment. External influences are not allowed to change the requirements of the stories being worked on.

Sprint Backlog- At the beginning of each sprint, the team has sprint planning with a result being a backlog of work that the team anticipates completing at the end of the sprint. These are the items that the team will deliver against throughout the duration of the sprint.

Sprint Planning- Is a pre-sprint planning meeting attended by the core agile team. During the meeting, the Product Owner describes the highest priority features to the team as described in the product backlog. The team then agrees on the number of features they can accomplish in the sprint and plans out the tasks required to achieve delivery of those features. The planning group works on the features of User Stories and assigns Acceptance criteria to each story.

Sprint Review- Each Sprint is followed by a Sprint review. During this review, the software developed in the previous Sprint is reviewed and if necessary new backlog items are added.

Story Points- Unit of estimation measuring complexity and size.

Stable Process- A process, which is free of assignable causes, e.g., in statistical control.

Standard Deviation - One of the most common measures of variability in a data set or in a population. It is the square root of the variance.

Standardized Work- A defined work method that describes the proper workstation and tools, work required, quality, standard inventory knacks and sequence of operations.

Stakeholders- Specific people or groups who have a stake in the outcome of the project are stakeholders. Normally stakeholders are from within the company and may include internal clients, management, employees, administrators, etc. A project can also have external stakeholders, including suppliers, investors, community groups, and government organizations.

Statistical Control- A quantitative condition which describes a process that is free of assignable/special causes of variation, e.g., variation in the central tendency and variance. Such a condition is most often evidence on a control chart, i.e., a control chart which displays an absence of nonrandom variation.

Statistical Process Control (SPC) - use of basic graphical and statistical methods for measuring, analyzing, and controlling the variation of a process for the purpose of continuously improving the process.

Steering Committee- A steering committee is usually a group of high-level stakeholders who are responsible for providing guidance on overall strategic direction. They do not take the place of a sponsor but help spread the strategic input and buy-in to a larger portion of the organization. The steering committee is especially valuable if your project has an impact on multiple organizations because it allows input from those organizations into decisions that affect them.

Subgroup- A logical grouping of objects or events which displays only random event-to event variations, e.g., the objects or events are grouped to create homogenous groups free of assignable or special causes. By virtue of the minimum within group variability, any change in the central tendency or variance of the universe will be reflected in the “subgroup-to subgroup” variability.

Supermarket- A strategically controlled store of parts used by downstream processes.

Supplier – vendor or entity responsible for providing an input to a process in the form of resources or information.

Symptom- That which serves as evidence of something not seen.

System- That which is connected according to a scheme.

Systematic Variables- A pattern which displays predictable tendencies.

Takt time – Rate of demand from customer. It is the available operating time for the requirement.

Task- A user story can be broken down into one or more tasks. Tasks are estimated daily in hours (or story points) remaining by the developer working on them.

Task board/ Storyboard- A wall chart with cards and sticky notes that represent all the work for in each sprint. The notes are moved across the board to show progress.

Team- The Team is responsible for delivering the product. A Team is typically made up of 5– 9 people with cross-functional skills who do the actual work (analyze, design, develop, test, technical communication, document, etc.). It is recommended that the Team be self-organizing and self-led, but often work with some form of project or team management.

Test Driven Development- Test-driven development (TDD) is a software development process that relies on the repetition of a noticeably short development cycle: first the developer writes a failing automated test case that defines a desired improvement or new function, then produces code to pass that test and finally refactors the new code to acceptable standards.

Test of Significance- A procedure to determine whether a quantity subjected to random variation differs from postulated value by an amount greater than that due to random variation alone.

Theory- A plausible or scientifically acceptable general principle offered to explain phenomena.

Theory of constraints - theory describes the methods used to maximize operating income when an organization is faced with bottleneck operations. This theory also deals with how to manage the unknown.

Time Boxing- Time boxing is a planning technique common in planning projects (typically for software development), where the schedule is divided into a number of separate time periods (time boxes, normally two to six weeks long), with each part having its own deliverables, deadline, and budget.

Total Cycle Time (TCT)- The time taken from work order release into value stream until completion / movement of product into shipping / finished goods.

Total Productive Maintenance- A means of maximizing production system efficiency by analyzing and eliminating down-time through up-front maintenance of equipment.

Toyota Production System- The production system developed and used by the Toyota Motor Company which focuses on the elimination of waste throughout the value stream.

Trend - A gradual, systematic change over time or some other variable.

Two-Sided Alternative- The value of a parameter which designates an upper and lower bound.

Type I Error- See Alpha Risk.

Type II Error-See Beta Risk.

Any pattern in which a significant number of measurements do not group themselves around a center line; when the pattern is unnatural it means that outside disturbances are present and are affecting the process.

User Persona- Personas are a description of the typical users of a given software. A persona description should include skills, background, and goals.

User Story- A user story is a very high-level definition of a requirement, containing just enough information so that the developers can produce a reasonable estimate of the effort to implement it. A user story is one or more sentences in the everyday capture of what the users want to achieve. A user story is also a placeholder for conversation between the users and the team. The user stories should be written by or for the customers for a software project and are their main instrument to influence the development of the software. Developers could also write User Stories to express non-functional requirements (security, performance, quality, etc.)

Upper Control Limit- A horizontal line on a control chart (usually dotted) which represents the upper limits of process capability.

Value Added Activity- Any activity that changes the product in terms of fitness, form, or function towards something that a customer is willing to pay for.

Value Added Time- The time expended in value added activity to produce a unit. Time for those work elements that transform the product in a way for which the customer is willing to pay for.

Value stream - all activities, both values added, and non-value added, that are required to bring a product, group, or service from the point of order to the hands of a customer and a design from concept to launch to production to delivery.

Value Stream Map- A visual representation of a process showing flow of information and material through all steps from the supplier to the customer.

Value. This term refers to a product or service capability that is provided to a customer at the right time and at an appropriate price.

Variable- A characteristic that may take on different values.

Variables Data- Numerical measurement made at the interval or ratio level; quantitative data e.g., ohms, voltage, diameter, subdivision of the measure scale are conceptually meaningful, e.g., 1.6478 volts.

Variation- Any quantifiable difference between individual measurements such differences can be classified as being due to common causes (random) or special causes (assignable).

Variation Research- Procedures techniques and methods used to isolate one type of variation from another (for example, separating product variation from test variation).

Velocity- It is a relative number which describes how much work the team can get done over a period.

Visualization- The design of a workplace such that problems and issues can be identified without timely and in-depth investigation. Truly visual workplaces should be capable of assessment in less than 3 seconds.

VOB - The voice of the business is derived from financial information and data. Voice of the business - Represents the needs of the business and the key stakeholders of the business. It is usually items such as profitability, revenue, growth, market share, etc.

VOC - Voice of the customer - Represents the expressed and non-expressed needs, wants and desires of the recipient of a process output, a product, or a service. It is usually expressed as specifications, requirements, or expectations.

VOE – Voice of the employee. Represents the expressed and non-expressed needs, wants and desires of what the employee needs to be successful.

VOP - Voice of the process - represents the performance and capability of a process to achieve both business and customer needs.

Waste (Muda) - includes anything that does not add value to a final product or service; an activity that consumes valuable resources without creating customer value.

WIP (Work in process)- These are items- material or information- between machines, processes, or activities waiting to be processed, any inventory between raw materials and finished goods.

Withdrawal Kanban- A sign that specifies the type and quantity of product that the downstream process may withdraw.

Work Cells- An arrangement of people, machines, materials, and methods such as processing steps are adjacent and in sequential order thus, parts can be processed one at a time.

Work Plan (schedule)- The project work plan tells you how you will complete the project. It describes the activities required, the sequence of the work, who is assigned to the work, an estimate of how much effort is required, when the work is due, and other information of interest to the project manager. The work plan allows the project manager to identify the work required to complete the project. Also, it allows the project manager to monitor the work to determine whether the project is on schedule.

X – Input

X&R Charts- A control chart representing process capability over time; displays variability in the process average and range across time.

XP- A software development methodology intended to improve software quality and responsiveness to changing requirements. As a type of agile software development, it advocates frequent “releases” in short development cycles (timeboxing), intended to improve productivity and introduce checkpoints where new customer requirements can be adopted.

Y – Output



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