

## *Lean Six Sigma Glossary*

**2 - Bin:** A type of pull system using two “bins” (a bin could be a card, or tote, or physical location, etc). The basic mechanics are as follows. Two bins of material are located at a station. When the first bin is emptied, the operator sends the empty bin to a location to be refilled, and begins working from the second bin. The first bin will be returned full prior to the emptying of the second bin.

**5-S:** A process and method for creating and maintaining an organized, clean and high performance workplace. The 5 – S’s are Sort, Set in Order, Shine, Standardize, and Sustain.

**ABC Analysis:** Used to rank order purchased parts and material according to the annual dollar value spent on each. More emphasis should be placed on the few parts that account for most of the cost.

**Acceptable Quality Level:** When a continuing series of lots is considered, a quality level that, for the purposes of sampling inspection, is the limit of a satisfactory process average.

**Acceptance Sampling Plan:** A specific plan that indicates the sampling sizes and the associated acceptance or non-acceptance criteria to be used. In attributes sampling, for example, there are single, double, multiple, sequential, chain, and skip-lot sampling plans. In variables sampling, there are single, double, and sequential sampling plans.

**Acceptance Sampling:** Inspection of a sample from a lot to decide whether to accept or not accept that lot. There are two types: attributes sampling and variables sampling. In attributes sampling, the presence or absence of a characteristic is noted in each of the units inspected. In variables sampling, the numerical magnitude of a characteristic is measured and recorded for each

**Accounts Payable:** The dollar amount of items a company has purchased but has not yet paid. Listed on the Balance Sheet under Current Liabilities.

**Accounts Receivable:** The dollar amount of products a company has sold but has yet to receive payment. Listed on the Balance Sheet under Current Assets.

**Adaptive Control:** A defect prevention method that detects errors or possible errors during processes before they can become defects.

**Aliasing:** When two factors or interaction terms are set at identical levels throughout the entire experiment (i.e., the two columns are 100% correlated).

**Alpha Risk:** See “Type I Error”.

**Alternative Hypothesis:** The hypothesis to be accepted if the null hypothesis is rejected. It is denoted by H1.

**Analysis Of Means (Anom):** A statistical procedure for troubleshooting industrial processes and analyzing the results of experimental designs with factors at fixed levels.

**Analysis Of Variance (ANOVA):** A basic statistical technique for analyzing experimental data. It subdivides the total variation of a data set into meaningful component parts associated with specific sources of variation in order to test a hypothesis on the parameters of the model or to estimate variance components. There are three models: fixed, random, and

mixed.

**Asynchronous Pull:** See 2-Bin

**Attribute Data:** Go/no-go information. The control charts based on attribute data include percent chart, number of affected units chart, count chart, count-per-unit chart, quality score chart, and demerit chart.

**Availability Level:** One of the 3 measures used to calculate overall equipment effectiveness. It represents the percent of time a machine is available to run parts.

**Average:** The average of a sample ( $\bar{x}$ ) is the sum of all the responses divided by the sample size.

**Balance Sheet:** Describes a company's assets, liabilities, and owner's equity.

**Balanced Design:** A 2-level experimental design is balanced if each factor is run the same number of times at the high and low levels.

**Batch:** A run of like products/parts through a process (number of product/parts run between product changeover).

**Bay Build:** All parts and material are assembled in one location. The assembly is not moved to progressive stations, but rather the material and operators are moved to the assembly. Typically used for large equipment that is difficult to transport during assembly.

**Benchmarking:** An improvement process in which a company measures its performance against that of best-in-class companies, determines how those companies achieved their performance levels, and uses the information to improve its own performance. The subjects that can be benchmarked include strategies, operations, processes, and procedures.

**Beta Risk:** See "Type II Error".

**Bias:** Systematic error which leads to a difference between the average result of a population of measurements and the true accepted value of the quantity being measured.

**Bill of Material: (BOM)** The listing of all components used to make up an assembly. The relationship between the end item assembly (bike) and all lower level items or assemblies (wheel, seat, etc).

**Bimodal Distribution:** A frequency distribution, which has two peaks. Usually an indication of samples from two processes incorrectly analyzed as a single process.

**Binomial Distribution:** Given that a trial can have only two possible outcomes (yes/no, pass/fail, heads/trails), of which one outcome has probability  $p$  and the other probability  $q = 1-p$ , the probability that the outcomes represented by  $p$  occurs  $x$  times in  $n$  trials is given by the binomial distribution.

**Blitz:** See Kaizen

**Block Diagram:** A diagram that shows the operation, interrelationships, and interdependencies of components in a system. Boxes, or blocks (hence the name), represent the components; connecting lines

**BOM Explosion:** MRP function that uses the start times, the lot sizes, and the BOM to

generate gross requirements of any required components at the next level(s).

**BOM:** See Bill of Material

**Bottleneck:** The slowest activity within a process.

**Box-Behnken Design:** A 3-level design used for quantitative factors and designed to estimate all linear, quadratic, and 2-way interaction effects.

**Brainstorming:** A technique that teams use to generate ideas on a particular subject. Each person in the team is asked to think creatively and write down as many ideas as possible. The ideas are not discussed or reviewed until after the brainstorming session.

**Buffer:** Typically used to describe the amount of inventory or queue in front of an operation.

**Business Value Add:** The time required to perform activities that are required to create/process a product but the customer should not pay for (example: OSHA reporting)

**C Chart:** Count chart.

**Calibration:** The comparison of a measurement instrument or system of unverified accuracy to a measurement instrument or system of a known accuracy to detect any variation from the required performance specification.

**Capability:** A measure of quality for a process usually expressed as sigma capability,  $C_{pk}$ , or defects per million opportunities (DPMO). It is obtained by comparing the actual process with the specification limits.

**Capacity:** The amount of production over a given time period.

**Cause-And-Effect Diagram:** A tool for analyzing process dispersion. It is also referred to as the Ishikawa diagram, because Kaoru Ishikawa developed it, and the fishbone diagram, because the complete diagram resembles a fish skeleton. The diagram illustrates the main causes and sub causes leading to an effect (symptom). The cause-and-effect diagram is one of the seven tools of quality.

**Central Composite Design:** A 3-level design that starts with a 2-level fractional factorial and some center points. If needed, axial points can be tested to complete quadratic terms. Used typically for quantitative factors and designed to estimate all linear effects plus desired quadratics and 2-way interactions.

**Central Limit Theorem:** If samples of size  $n$  are drawn from a population and the values of  $x$  are calculated for each sample, the shape of the distribution is found to approach a normal distribution for sufficiently large  $n$ . This theorem allows one to use the assumption of a normal distribution when dealing with  $x$ . "Sufficiently large" depends on the population's distribution and what range of  $x$  is being considered; for practical purposes, the easiest approach may be to take a number of samples of a desired size and see if their means are normally distributed. If not, the sample size should be increased. This theorem is one of the most important results in all of statistics and is the heart of inferential statistics.

**CEO:** Chief Executive Officer – Individual responsible for the overall performance of a company

**CFO:** Chief Financial Officer – Individual responsible for the overall management of a

company's financial assets.

**Change Notices:** MRP generated messages indicating modifications of existing jobs, such as changes in due dates or priorities.

**Check Sheet:** A simple data-recording device. The check sheet is custom-designed by the user, which. Flows him or her to readily interpret the results. The check sheet is one of the seven tools of quality. Check sheets are often confused with data sheets and checklists (see individual entries).

**Checklist:** A tool used to ensure that all important steps or actions in an operation have been taken. Checklists contain items that are important or relevant to an issue or situation. Checklists are often confused with check sheets and data sheets (see individual entries).

**Chi-Square Distribution:** The distribution of chi-square statistics.

**Chi-Square:** The test statistic used when testing the null hypothesis of independence in a contingency table or when testing the null hypothesis of a set of data following a prescribed distribution.

**Coefficient Of Determination:** ( $R^2$ ); the square of the sample correlation coefficient, a measure of the part of variable that can be explained by its linear relationship with a variable; it represents the strength of a model.  $(1 - R^2) * 100\%$  is the percentage of noise in the data not accounted for by the model.

**Coefficient Of Variation:** Defined as the standard deviation divided by the mean ( $s / \bar{X}$ ). It is the relative measure of the variability of a random variable. For example, a standard deviation of 10 microns would be extremely small in the production of bolts with a nominal length of 2 inches, but would be extremely high for the variation in line widths on a chip whose mean width is 5 microns.

**Commodity:** A category for like types of material used for grouping purposes (e.g., nuts, bolts, washers, vs. printed circuit boards, vs. capacitors).

**Common Causes:** Causes of variation that are inherent in a process over time. They affect every outcome of the process and everyone working in the process. (See also "special causes.")

**Company Culture:** A system of values, beliefs, and behaviors inherent in a company. To optimize business performance, top management must define and create the necessary culture.

**Confidence Interval:** Range within which a parameter of a population (e.g., mean, standard deviation, etc.) may be expected to fall, on the basis of a measurement, with some specified confidence level or confidence coefficient.

**Confidence Limits:** The end points of the interval about the sample statistic that is believed, with a specified confidence coefficient, to include the population parameter.

**Conformance:** An affirmative indication or judgment that a product or service has met the requirements of a relevant specification, contract, or regulation.

**Constraint:** A time trap that cannot meet customer demand

**Continuous Flow Manufacturing:** (CFM) Type of manufacturing philosophy that strives for

the speed and low cost of high-volume flow lines while retaining the flexibility and customization potential of low-volume job shops, all while continually improving quality.

**Continuous Improvement:** The ongoing improvement of products, services, or processes through incremental and breakthrough improvements.

**Control Chart:** A chart with upper and lower control limits on which values of some statistical measure for a series of samples or subgroups are plotted. The chart frequently shows a central line to help detect

**Control Limits:** Upper and lower bounds in a control chart that are determined by the process itself. They can be used to detect special causes of variation. They are usually set a  $\pm 3$  standard deviations from the centerline.

**Control:** A process is said to be in a state of statistical control if the process exhibits only random variation (as opposed to systematic variation and/or variation with known sources). When monitoring control with control charts, a state of control is exhibited when all points remain between set control limits without any abnormal (non-random) patterns.

**Corrective Action:** The implementation of solutions resulting in the reduction or elimination of an identified problem.

**Correlation Coefficient:** ( $r$ ) a number between -1 and 1 that indicates the degree of linear relationship between two sets of numbers.

**Cost of Capital:** The minimum acceptable rate of return required by shareholders for supplying capital. Also the discount rate used to determine the equity value of an asset. It is usually around 10-15%.

**Cost of Poor Quality:** The costs associated with providing poor-quality products or services. There are four categories of costs: internal failure costs (costs associated with defects found before the customer receives the product or service), external failure costs (costs associated with defects found after the customer receives the product or service), appraisal costs (costs incurred to determine the degree of conformance to quality requirements), and prevention costs (costs incurred to keep failure and appraisal costs to a minimum).

**Cost Of Quality:** A term coined by Philip Crosby referring to the cost of poor quality

**Count Chart:** A control chart for evaluating the stability of a process in terms of the count of events of a given classification occurring in a sample.

**Count-Per-Unit Chart:** A control chart for evaluating the stability of a process in terms of the average count of events of a given classification per unit occurring in a sample.

**$C_p$ :** During process capability studies,  $C_p$  is a capability index which shows the process capability potential but does not consider how centered the process is.  $C_p$  may range from 0 to infinity with a large value indicating greater potential capability. A value of 1.33 or greater is usually desired.

**$C_{pk}$ :** During process capability studies,  $C_{pk}$  is an index used to compare the natural tolerance of a process within the specification limits.  $C_{pk}$  has a value equal to  $C_p$  if the process is centered on the nominal; if  $C_{pk}$  is negative, the process mean is outside of the specification limits; if  $C_{pk}$  is between 0 and 1 then the natural tolerances of the process falls outside the spec limits. If  $C_{pk}$  is larger than 1, the natural tolerances fall completely within the spec

limits. A value of 1.33 or greater is usually desired.

**Craftsman:** Classification of employee with skilled labor capabilities to produce a product.

**Critical WIP:** The amount of WIP in a process BELOW which throughput is reduced and ABOVE which cycle time is increased.

**Cumulative Sum Control Chart (CuSum):** A control chart, which plots the cumulative deviation of each subgroup's average from the nominal value. If the process consistently produces parts near the nominal, the CuSum chart shows a line, which is essentially horizontal. If the process begins to shift, the line will show an upward or downward trend. The CuSum chart is sensitive to small shifts in process average.

**Customer Value Add:** Time required to perform an activity that changes the form, fit, or function of a product to meet the needs of the customer (ex., chip cutting)

**Customers:** Someone for whom work or a service is performed. The end user of a product is a customer of the employees within a company that manufactures the product. There are also internal customers in a company. When an employee does work or performs a service for someone else in the company, the person who receives this work is a customer of this employee.

**Cycle Stock:** Represents the amount of inventory associated with the cycle time interval.

**Cycle Time Interval:** The elapsed time from when a product is run across a given workstation until it is run again. Describes how often a work order will be released to the floor. It is a function of the batch size and is calculated by multiplying the batch by the yield and dividing by the demand.

**Daily Going Rate:** The daily demand for product based on firm customer orders. Can also be defined as the established production schedule versus available production time.

**Dashboards:** Term for a series of key measures (e.g., the various gages on a car dashboard that must be monitored while driving).

**Days Sales Outstanding (DSO):** A comparative measurement for Accounts Receivable. It is defined as the total dollars of Accounts Receivable divided by an average day's worth of revenue.

**Decision Matrix:** A matrix used by teams to evaluate problems or possible solutions. After a matrix is drawn to evaluate possible solutions, for example, the team lists them in the far-left vertical column. Next, the team selects criteria to rate the possible solutions, writing them across the top row. Third, each possible solution is rated on a scale of 1 to 5 for each criterion and the rating recorded in the corresponding grid. Finally, the ratings of all the criteria for each possible solution are added to determine its total score. The total score is then added to help decide which solution deserves the most attention.

**Defect Prevention:** Any attempt at eliminating the root cause of defects prior to their occurrence. See Mistake-Proof.

**Defect:** A nonconformity or departure of a quality characteristic from its intended level or state.

**Degrees Of Freedom:** A parameter in the t, F, and  $\chi^2$  distributions. It is a measure of the amount of information available for estimating the population variance;  $s^2$ . It is the number of

independent observations minus the number of parameters estimated.

**Dependant Demand:** Demand for components that make up independent demand products. For example, if the independent demand for a bicycle is 4, then the dependant demand for pedals is 8.

**Design Engineering:** Organization responsible for the design of a company's product or service.

**Design For Manufacture:** Steps taken in the design of a company's product to ensure that current manufacturing processes are used, and that the design of the product minimizes costs during production.

**Design Of Experiments (DOE):** A branch of applied statistics dealing with planning, conducting, analyzing, and interpreting controlled tests to evaluate the factors that control the value of a parameter or group of parameters:

**Die:** Tooling used to form or cut material in a defined shape.

**Direct Labor:** Classification of employees whose primary job function is machine or work station operation – performs value-added activities (touch labor) – see value-add. In a project environment, direct labor is defined as anyone who can charge time directly to the support of a specific project (versus indirect labor whose time cannot be split and must be allocated across all projects (e.g., accounting)).

**Direct Material:** The material that is specified on the Bill of Material (BOM) in exact measurement.

**Discrete Manufacturing:** Manufacturing environment where a workstation processes a single unit and then switches over to the next product to be produced.

**Distribution Center:** An area or warehouse where goods and services are consolidated stored or repackaged prior to transfer to a final customer.

**Distribution Department:** An organization whose function is the delivery of goods and services after they are manufactured.

**Distributions:** See "Probability Distribution".

**Downtime:** Non-productive time generally due to equipment stoppage, lack of materials, or lack of operator – generally refers to machine breakdown.

**Economic Value Add:** A measure of the value created by a business in a single period of time. It is the return a business makes above its cost of capital.  $\text{Economic Value Add} = \text{Earnings} - (\text{Cost of Capital} \times \text{Capital Invested})$

**Efficiency:** The ratio of the actual product produced to a standard. Calculated by dividing the standard parts per hour by the actual parts per hour.

**Electronic Data Interchange (EDI):** Term used to describe the electronic transfer of information. Often used in purchasing to electronically send requirements to a supplier.

**Exception Notices:** MRP generated report to notify the users that there are discrepancies between the expected output and what MRP has planned. These might indicate job count

differences, inventory discrepancies, late jobs, etc.

**Exit Rate (Exits):** Amount of product or service that completes a process in a given period of time.

**Expediter:** Individual whose primary function is ensuring suppliers deliver products on time or the company's customers receive their orders on time (by-passes typical process).

**Experimental Design:** A formal plan that details the specifics for conducting an experiment, such as which responses, factors, levels, blocks, treatments, and tools are to be used

**Exponential Distribution:** A probability distribution mathematically described by an exponential function. Used to describe the probability that a product survives a length of time  $t$  in service under the assumption that the probability of a product failing in any small time interval is independent of time.

**External Setup:** Setup that can be done while a machine or process is in operation. Does not delay production.

**F Distribution:** Distribution of F-statistics.

**F Statistic:** A test statistic used to compare the variance from two normal populations.

**Facility Engineer:** Individual who maintains commercial facilities to include: plant, equipment, and grounds.

**Factor:** An assignable cause which may affect the responses (test results) and of which different versions (levels) are included in the experiment.

**Factorial Experiments:** Experiments in which all possible treatment combinations formed from two or more factors, each being studied at two or more versions (levels), are examined so that interactions (differential effects) as well as main effects can be estimated.

**Failure Mode Effect Analysis (FMEA):** A procedure in which each potential failure mode in every sub- item of an item is analyzed to determine its effect on other sub-items and on the required function of the item.

**Finished Goods:** Completed product ready for shipment to the customer.

**Fire Fighting:** An expression used to describe the process of performing emergency fixes to problems.

**Firm Planned Orders:** A planned order in MRP that is held fixed; it will be released regardless of changes in the system, and changes will not be made to this order by the system. Can be used to produce a stable production plan and decrease system nervousness.

**First Pass Yield:** The number of units that will be produced through the entire process. This is the product of the yield at each individual step. For example a three step process that has a yield of 95% for each step, has a First Pass Yield of  $0.95 \times 0.95 \times 0.95 = 85.7\%$

**Fishbone Diagram:** See "cause-and-effect diagram"

**Flowcharting:** Graphical representation of the steps in a process. Flowcharts are drawn to better understand processes. The flowchart is one of the seven tools of quality.

**Force Field Analysis:** A technique for analyzing the forces that will aid or hinder an organization in reaching an objective. An arrow pointing to an objective is drawn down the middle of a piece of paper. The factors that will aid the objective's achievement (called the driving forces) are listed on the left side of the arrow; the factors that will hinder its achievement (called the restraining forces) are listed on the right side of the arrow.

**Forecast:** The prediction of demand over a given time period based on input from Sales and Marketing, and historical trends.

**Frequency Distribution:** A set of all the various values that individual observations may have and the frequency of their occurrence in the sample or population.

**Full Factorial:** All possible combinations of the factors and levels. Given  $k$  factors, all with two levels, there will be  $2^k$  runs. If all factors have 3 levels, there will be  $3^k$  runs.

**Gage R & R:** See "Gauge Repeatability and Reproducibility".

**Gating:** The process by which items are not released into a process until there is available capacity. Often used in engineering to limit the amount of projects the department is working on so that they may get the current open projects completed.

**Gauge Repeatability And Reproducibility:** The evaluation of a gauging instrument's accuracy by determining whether the measurements taken with it are repeatable (i.e., there is close agreement among a number of consecutive measurements of the output for the same value of the input under the same operating conditions) and reproducible (i.e., there is close agreement among repeated measurements of the output for the same value of input made under the same operating conditions over a period of time)

**Gauge:** Any device used to obtain measurements. The term is frequently used to refer specifically to shop floor devices, including go/no-go devices.

**Generic Pull:** The establishment of a WIP cap on the amount of inventory within a predefined physical work area. Tool used to control and predict cycle time.

**Go/No Go:** A technique where a unit is measured against specific quantitative criteria and either passes or fails.

**Goodness-Of-Fit:** Any measure of how well a set of data matches a proposed distribution. Chi-square is the most common measure for frequency distributions. Simple visual inspection of a histogram is less quantitative, but equally valid, way to determine goodness-of-fit.

**Gross Requirements:** Term used within the master production schedule (MPS) to describe the total demand needed. .

**Group Problem Solving:** A problem solving methodology by which a group of individuals will define the result requirement, identify the gap from present state and brainstorm ideas to close the gap. The end result is a project definition or action items that the team must work through to get the desired results.

**Group Technology:** See work cells

**Growth:** Percent increase in revenue.

**Histogram:** A graphic summary of variation in a set of data. The pictorial nature of the histogram lets people see patterns that are difficult to see in a simple table of numbers. The

histogram is one of the seven tools of quality.

**Hypothesis Tests, Alternative:** The hypothesis that is accepted if the null hypothesis is disproved. The choice of alternative, hypothesis will determine whether "one-tail" or "two-tail" tests are appropriate.

**Hypothesis Tests, Null:** The hypothesis tested in tests of significance is that there is no difference (null) between the population of the sample and specified population (or between the populations associated with each sample). The null hypothesis can never be proved true. It can, however, be shown, with specified risks of error, to be untrue; that is, a difference can be shown to exist between the populations. If it is not disproved, one may surmise that it is true. (It may be that there is insufficient power to prove the existence of a difference rather than that there is no difference; that is, the sample size may be too small. By specifying the minimum difference that one wants to detect and P, the risk of failing to detect a difference of this size, the actual sample size required, however, can be determined.)

**Hypothesis Tests:** A procedure whereby one of two mutually exclusive and exhaustive statements about a population parameter is concluded. Information from a sample is used to infer something about a population from which the sample was drawn.

**Income Statement:** Standard financial statement that reflects a company's revenues and expenses. The result is a reflection of the amount of profit a company has made.

**In-Control Process:** A process in which the statistical measure being evaluated is in a state of statistical control (i.e., the variations among the observed sampling results can be attributed to a constant system of chance causes). (See also "out-of-control process.")

**Independent Demand:** Any demand that comes from outside the system. This includes all demand for final products as well as some demand for components (e.g., when they are sold as replacement parts).

**Indirect Labor:** Classification of employees who do not perform any process tasks on a product – performs non-value added activities. In a project environment, indirect labor is defined as anyone whose time cannot be charged directly to a single project and must be allocated across all projects (e.g., accounting).

**Inner Array:** A Taguchi term used in parameter design to identify the combinations of controllable factors to be studied in a designed experiment. Also called "design array" or "design matrix".

**Inspection:** Measuring, examining, testing, or gauging one or more characteristics of a product or service and comparing the results with specified requirements to determine whether conformity is achieved for each characteristic

**Interaction Plot:** A graphical display showing how two factors (input variables) interact if one factor's effect on the response is dependent upon the level of the other factor.

**Internal Setup:** Setup that must be performed while the machine or process is not operating. Production cannot take place during this time.

**Inventory Turns:** Represents an efficiency measure of inventory, and can be measured as gross annual sales divided by average on-hand inventory.

**Capital Employed:** The investment a company makes in working capital, plant, property and

equipment (PP&E)

**Just-In-Time (JIT):** A manufacturing practice pioneered by the Toyota Motor Company where each workstation acquires the required materials from upstream workstations precisely as needed. JIT requires a systems approach to transforming the manufacturing environment and is focused on continuous improvement.

**Kaikaku:** Radical change

**Kaizen:** A continuous improvement vehicle for driving quick hit value by implementing “do-now” solutions through waste elimination. A key component of the Toyota Production System.

**Kaizen:** A Japanese term that means gradual unending improvement by doing little things better and setting and achieving increasingly higher standards. Masaaki Imai made the term famous in his book Kaizen: The Key to Japan's Competitive Success.

**Kanban:** Japanese word for signal. It is used in a pull system to signal when production is to start, and can take a number of forms (e.g., cards, boards, lights, bins, etc).

**Kurtosis:** A measure of the shape of a distribution. A positive value indicates that the distribution has longer tails than the normal distribution (platykurtosis); while a negative value indicates that the distribution has shorter tails (leptokurtosis). For the normal distribution, the kurtosis is 0.

**LCL:** Lower control limit. For control charts, the limit above which the process subgroup statistics must remain when the process is in control. LCL is typically three standard deviations below the centerline.

**Lean Production:** A manufacturing strategy that uses less of everything compared to traditional manufacturing. The focus is on eliminating waste or non-value add activities within a process.

**Little's Law:** The fundamental relationship between WIP, cycle time, and throughput and is defined as:

**Logistics:** All activities involved in the movement and storage of goods from source to final consumer: Sourcing/Purchasing to Materials Management to Physical Distribution.

**Loss Function:** A technique for quantifying loss due to production deviations from target values.

**Lot Sampling:** Inspection process by which a sample of parts is inspected and based on the outcome the entire lot may be accepted or rejects.

**Lot Sizing:** MRP function that divides the netted demand into appropriate lot sizes to form jobs. Lot sizes group all demand requirements over a given period defined in MRP.

**Main Effects Plot:** A graphic display showing the influence a single factor has on the response when it is changed from one level to another. Often used to represent the “linear effect” associated with a factor.

**Manufacturing Cycle Efficiency:** A measurement of the percent of value-add time through a process. Calculated by dividing the value-add time by the total cycle time.

**Manufacturing Cycle Time:** See Process Cycle Time.

**Manufacturing Resources Planning (MRP II):** Builds on MRP by including demand management, forecasting, capacity planning, master production scheduling, rough-cut capacity planning, capacity requirements planning, dispatching, and input/output control.

**Marketing Department:** Business unit within the organization whose function is to determine target markets in terms of desired customer price, delivery, and quality.

**Master Production Schedule:** MPS is the source of demand for the MRP system. It gives the quantity and due dates for all parts that have independent demand. The MPS contains gross requirements, on-hand inventory balance, and scheduled receipts.

**Master Schedule:** See Master Production Schedule

**Material Handler:** Individual whose job function is the transport of raw materials, in-process materials, or finished goods.

**Material Requirements Planning (MRP):** Is a "Push" system since work is scheduled to start based on demand versus a "Pull" system that authorizes production as inventory is consumed. The basic function of MRP is as follows. MRP uses the Bill of Material, the On-Hand inventory balance, and Scheduled Receipts then performs Netting, Lot Sizing, Time Phasing, and BOM Explosion on each level in the bill of material, to create Planned Order Releases, Change Notices, and Exception Notices.

**Material Resource Planning:** Enhance MRP system that contains the functionality to perform jobs costing, capacity planning and shop floor control. Often referred to as MRPII

**Materials Department:** Business unit within the organization with the function of determining raw materials requirements based on customer orders, ordering the materials from suppliers, and ensuring deliveries of finished products are made to the customer.

**Max Loop (Kanban):** Represents the maximum amount of inventory a replenishment pull system will ever encounter. Calculated by summing the amount of WIP, cycle stock and safety stock within a pull system loop.

**Mean Time Between Failure (MTBF):** The average time that is expected between failures for a product or machine for a defined unit of measure (e.g., operating hours, cycles, miles).

**Mean:** The average of a set of values. We usually use  $\bar{x}$  to denote a sample mean, whereby we use the Greek letter  $\mu$  to denote a population mean.

**Median:** For a sample the number that is in the middle when all observations are ranked in magnitude.

**Method Sheets:** Revision controlled documents that describe in words and pictures how a unit is to be built or assembled.

**Middle Management:** Managers within an organization with the status above first line supervision and below top management, such as departmental heads.

**Min Loop (Kanban):** Represents the minimum amount of inventory a replenishment pull system should ever encounter and still be able to meet the customer demand. Calculated by summing the WIP and safety stock within a pull system loop.

**Mistake Proof:** Process to ensure that defects cannot be created (e.g., square pegs and round holes).

**Mode:** The number in a set that occurs the most frequently.

**Muda:** Waste

**Multi-Vari Chart:** See "Multivariate Control Chart".

**Multivariate Control Chart:** A control chart for evaluating the stability of a process in terms of the levels of two or more variables or characteristics n: sample size (the number of units in a sample).

**Mura:** Abnormality

**Muri:** Stress or strain

**Net Operating Time:** Scheduled production time

**Net Requirements:** Term used within MRP to describe the net inventory needed to satisfy demand. Calculated by subtracting the on-hand inventory and scheduled receipts from the gross requirements.

**Netting:** MRP process used to calculate net requirements. Netting provides two important functions: (1) it adjusts scheduled receipts by expediting those that are currently scheduled to arrive late and deferring those currently scheduled to arrive early, and (2) it computes net demand.

**Noise:** Unexplained variability in the response. Typically, due to variables which are not controlled.

**Nominal Group Technique (NGT):** A technique, similar to brainstorming, used by teams to generate ideas on a particular subject. Team members are asked to silently come up with as many ideas as possible, writing them down. Each member is then asked to share one idea, which is recorded. After all the ideas are recorded, they are discussed and prioritized by the group.

**Nominal:** For a product whose size is of concern; the desired mean value for the particular dimension, the target value.

**Non-Value Add:** Any activity that does not add form, feature or function to the product. Non-value add activities include transportation, storage, inventory/buffers, handling, queues, machine repairs, etc.

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

**np Chart:** Is for attribute data and is a control chart of the number of defective units in a subgroup. Assumes a constant subgroup size. Based on the binomial distribution.

**One- Factor-At-a-Time Approach:** A popular, but inefficient way to conduct a designed experiment.

**On-Hand Inventory:** Term used within the master production schedule (MPS) for the current amount of inventory within the system.

**Operating Level:** One of the 3 measures used to calculate overall equipment effectiveness. It represents the percent of available time a machine is operating at the desired speed.

**Operation:** A single workstation where one task is performed on the product.

**Order Frequency:** Similar to cycle time interval but is a term used to represent purchased items (see Order Interval).

**Order Interval:** The elapsed time from when a product is ordered until it is ordered again. Describes how often a purchase order will be released to a supplier.

**Order:** A set of instructions to a supplier to produce a specified quantity of product by a defined due date.

**OSHA:** Occupational Safety and Health Administration – the governmental organization that administrates work place safety and health standards.

**Outer Array:** A Taguchi term used in parameter design to identify the combinations of noise factors to be studied in a robust designed experiment.

**Out-Of-Control:** A process is said to be out-of-control if it exhibits variations larger than its control limits or shows a systematic pattern of variation.

**Overall Equipment Effectiveness:** Term used in total productive maintenance to describe the percent of time a piece of equipment is producing quality product at the desired rate. Calculated by multiplying the availability level, operating level and quality level.

**p Chart:** Is for attribute data and is a control chart of the proportion of defective units (or fraction defective) in a subgroup. Based on the binomial distribution.

**p Value:** Is the probability of making a Type I error. This value comes from the data itself. It also provides the exact level of significance of a hypothesis test.

**Pareto Chart:** A graphical technique used to quantify problems so that effort can be expended in fixing the “vital few” causes, as opposed to the “trivial many.” The Pareto, suggests that most effects come from relatively few causes; that is, 80% of the effects come from 20% of the causes. The Pareto chart is one of the seven tools of quality.

**Pareto Principle:** 80% of the trouble comes from 20% of the problems (i.e., the vital few problems).

**Pegging:** Allows the planner to see the source of demand that results in a given planned order release. Used to determine which customer demand will not be covered if shortages exist.

**Personnel Department:** Business unit within an organization whose function is the determination, recommendation, and administration of personnel policies, workforce hiring and termination procedures.

**Planned Order Releases:** Eventually become the jobs that are processed in the plant. An MRP generated Planned Order Release contains at least three pieces of information: (1) the part number, (2) the quantity required, (3) the due date.

**Point of Use Storage:** Term for the storing of material only at the place that it will be

consumed. Eliminates warehousing and extra non-value add handling.

**Poisson Distribution:** A probability distribution for the number of occurrences per unit interval (time or space), where  $\lambda$  = average number of occurrences per interval is the only parameter. The Poisson distribution is a good approximation of the binomial distribution for the case where  $n$  is large and  $p$  is small.  $\lambda = (np)$ .

**Poke-Yoke:** Japanese term for mistake proofing. An engineered method which makes it very difficult or impossible to produce a defective part. Does not require human assistance.

**Population:** A set or collection of objects or individuals. It can also be the corresponding set of values, which measure a certain characteristic of a set of objects or individuals.

**Pre-Control Charts:** A method of controlling a process based on the specification limits. It is used to prevent the manufacture of defective units, but does not work toward minimizing variation in the process. The area between the specifications are split into zones (green, yellow, and red) and adjustments made when a specified number of points fall in the yellow or red zones.

**Probability Distribution:** The assignment of probabilities to all of the possible outcomes from an experiment. This assignment is usually portrayed by way of a table, graph, or a formula.

**Probability:** A measure of the likelihood of a given event occurring. It is a measure that takes on values between 0 and 1 inclusive with 1 being the certain event and 0 meaning that there is relatively no chance at all of the event occurring. How probabilities are assigned is another matter. The relative frequency approach to assigning probabilities is one of the most common.

**Problem Solving:** The process of determining the cause from a symptom and then choosing an action to improve a process or product.

**Process Cycle Efficiency:** A measurement of the percent of value-add time through a process. Calculated by dividing the value-add time by the cycle time.

**Process Capability Index:** The value of the tolerance specified for the characteristic divided by the process capability. There are several types of process capability indexes, including the widely used  $C_{pk}$  and  $C_p$ .

**Process Capability/Performance:** See " $C_p$ ", " $C_{pk}$ ".

**Process Capability:** A statistical measure of the inherent process variability for a given characteristic. The most widely accepted formula for process capability is  $6\sigma$ .

**Process Cycle Efficiency:** See Cycle Efficiency

**Process Flow Diagram (Chart):** Path of steps of work used to produce a product or perform a function.

**Process Manufacturing:** A manufacturing environment where the product is continuous in nature. Examples include food processing, petroleum, personal care (e.g. toothpaste), etc.

**Process Lead Time:** The time to complete a process. Measured by dividing the amount of WIP by the amount of exits or throughput in a process.

**Process Lead Time:** See Lead Time

**Process Mapping:** See "Flowcharting".

**Process:** Any activity and/or task performed in order to achieve a desired result.

**Processing Time:** Time required performing a process on an individual part.

**Production Control Department:** Business unit within the organization with the function of determining production build schedules based on customer requirements, marketing forecasts and product build time.

**Productivity:** Measurement used to represent the percent of time an operation is performing to a standard. Calculated by dividing the standard hours earned by the actual operating time. Can also be calculated by multiplying the utilization by the efficiency.

**Progressive Build:** The assembly is moved from one station to the next, where further value-add operations are performed.

**Projects-In-Process:** The amount of WIP in a project environment.

**Pull System:** Process that authorizes production as inventory is consumed. A pull system directly responds to plant changes, but must be forced to accommodate customer due dates. The Toyota Production System is an example of a classic pull system.

**Purchased Price Variance:** Common term used in procurement to describe the amount of dollars spent on purchased parts over or under a preset standard. Typically a poor metric unless the standards are frozen for a period of time.

**Purchasing Department:** Business unit within an organization responsible for finding appropriate suppliers and procuring goods.

**Push System:** Process that schedules production based on demand. A push system directly accommodates customer due dates, but must be forced to respond to plant changes. MRP is an example of a classic push system.

**Quality Control Department:** Business unit within an organization responsible for determining product quality standards and conveying them throughout the organization. This includes monitoring performance against the standards.

**Quality Function Deployment (QFD):** A structured method in which customer requirements are translated into appropriate technical requirements for each stage of product development and production. The QFD process is often referred to as listening to the voice of the customer.

**Quality Level:** One of the 3 measures used to calculate overall equipment effectiveness. It represents the percent of time a machine is operating at the desired speed with zero defects.

**Quality Loss Function:** A parabolic approximation of the quality loss that occurs when a quality characteristic deviates from its target value. The quality loss function is expressed in monetary units: the cost of deviating from the target increases quadratically the farther the quality characteristic moves from the target. The formula used to compute the quality loss function depends on the type of quality characteristic being used. Genichi Taguchi first introduced the quality loss function in this form.

**Queue Management:** The process for controlling wait time; waiting to be processed, waiting to move, waiting for parts and material, etc.

**Queue Time:** Time delay associated with waiting on an activity or task to be performed (typically refers to a buffer of parts/product).

**Queue:** Term for waiting in line.

**Random Sampling:** A commonly used sampling technique in which sample units are selected in such a manner that 0 combinations of n units under consideration have an equal chance of being selected as the sample.

**Random:** Varying with no discernable pattern.

**Range Chart:** A control chart in which the subgroup range, R, is used to evaluate the stability of the variability within a process

**Raw Material:** Material that has not been altered from the state in which it was received from the supplier.

**Raw Materials:** A classification of materials that have yet to encounter any value-add activity during the manufacturing process.

**Red Tagging:** Term used to identify material that needs to be expedited in order to meet customer due dates.

**Regression:** A statistical technique for determining the best mathematical expression describing the functional relationship between one response and one or more independent variables.

**Reliability:** The probability of a product performing its intended function under stated conditions without failure for a given period of time

**Repeatability:** The extent to which repeated measurements of a particular object with a particular instrument produce the same value.

**Repetitive Manufacturing:** Manufacturing which characteristically has few part numbers, predictable or regular volume, large batch sizes, and a straightforward product flow.

**Replenishment Pull System:** A pull system whereby the supplying process is de-coupled from the consuming process via buffer inventory. Part replenishment is based on consumption from the buffer inventory.

**Replication:** The repetition of the set of all the treatment combinations to be compared in an experiment. Each of the repetitions is called a replicate.

**Reproducibility:** The variation between individual people taking the same measurement and using the same gauging.

**Residual:** The difference between an observed value and a predicted value.

**Return on Capital (ROC):** The yearly return a shareholder receives on his investment. Calculated by dividing the profit after tax by the invested capital.

**Rework:** Non-value add work performed to correct a defect that has occurred.

**Robustness:** The condition of a product or process design that remains relatively stable with a minimum of variation even though factors that influence operations or usage, such as environment and wear, are constantly changing

**Rolled Throughput Yield:** The product of the yield for successive operations in a process

**Routing:** A defined path a product takes as it is moved from operation to operation throughout a process to achieve a final product (also defines the criteria at each step).

**Run Chart:** A basic graphical tool that charts a process over time recording either individual readings or averages over time.

**S Chart:** Sample standard deviation chart

**Safety Stock:** The amount of inventory needed to compensate for variation (i.e. demand, quality, and supplier delivery).

**Safety Time:** The additional time added to the leadtime or setback time of a product within an MRP system. Used to compensate for variation in cycle time and vendor lead time.

**Sales & Operations Planning (S&OP):** The process that takes as input sales and marketing forecasts, customer orders, and plant capacity to produce a master schedule that generates all material requirements necessary to fulfill these requirements.

**Sample Size:** The number of elements or units in a sample.

**Sample Standard Deviation Chart:** A control chart in which the subgroup standard deviation,  $s$ , is used to evaluate the stability of the variability within a process.

**Sample:** A group of units, portion of material, or observations taken from a larger collection of units, quantity of material, or observations that serves to provide information that may be used as a basis for making a decision concerning the larger quantity.

**Scatter Diagram:** A graphical technique to analyze the relationship between two variables. Two sets of data are plotted on a graph, with the y-axis being used for the variable to be predicted and the x-axis being

**Scheduled Receipts:** Term used within the master production schedule (MPS) for outstanding orders (both purchased and manufacturing).

**Scrap:** Material that contains non-conforming defects that cannot be properly repaired.

**Seiketsu:** Japanese term used in 5S program to describe constant adherence to the first 3 steps and safety. Often referred to as "standardize".

**Seiri:** Japanese term used in 5S program to describe segregate and eliminate. Often referred to "sort".

**Seiso:** Japanese term used in 5S program to describe the daily cleaning process. Often referred to as "shine".

**Seiton:** Japanese term used in 5S program to describe arrange and identify. Often referred to

as "set in place" or "set in order".

**Self Checks:** Inspection process that is done by the same person that performed the work.

**Setup Time:** The length of time from the last good product of a production run to the first good product(s) of the next production run.

**Setup:** The process of changing from producing one product type to a different type. Contains both internal and external elements.

**Seven Tools Of Quality:** Tools that help organizations understand their processes in order to improve them. The tools are the cause-and-effect diagrams, check sheet, control chart, flowchart, histogram, Pareto chart, and scatter diagram.

**Shitsuki:** Japanese term used in 5S program to describe the motivation to achieve habitual compliance. Often referred to as "sustain".

**Sigma Quality Level:** A commonly used measure of process capability that represents the number of standard deviations between the center of a process and the closest specification limit.

**Sigma:** The Greek letter ( $\sigma$ ) that is often used to describe the standard deviation of data.

**Six Sigma:** See the section "Six Sigma Quality".

**Six Sigma:** A term coined by Motorola that emphasizes the improvement of processes for the purpose of reducing variability and making general improvements. Generally refers to a quality level of 3.4 defects per million opportunities.

**Six-Sigma Quality:** A term used to generally indicate that a process is well within specifications, i.e., that the specification range is  $\pm 6$  standard deviations. The term is usually associated with Motorola, which named one of its key operational initiatives "Six Sigma Quality."

**Skewness:** A measure of the symmetry of a distribution. A positive value indicates that the distribution has a greater tendency to tail to the right (positively skewed or skewed to the right), and a negative value indicates a greater tendency of the distribution to tail to the left (negatively skewed or skewed to the left). Skewness is 0 for a normal distribution.

**SKU:** Stock Keeping Unit (part number).

**Source Inspection:** The process of inspecting the quality of material at the location of the supplier prior to the receipt of the material.

**Special Causes:** Causes of variation that arise because of special circumstances. They are not an inherent part of a process. Special causes are also referred to as assignable causes. (See also "common causes.")

**Specification Limits:** The bounds of acceptable values for a given product or process. They should be customer driven.

**Specification:** A document that states the requirements to which a given product or service must conform.

**Standard Deviation ( $\sigma$ ,  $s$ ):** A mathematical quantity that describes the variability of a

response. It equals the square root of variance. The standard deviation of a sample(s) is used to estimate the standard deviation of a population (s).

**Standardized Normal Distribution:** A normal distribution or a random variable having a mean and standard deviation of 0 and 1 respectively. It is denoted by the symbol Z and is also called the Z distribution.

**Starving:** a condition where the actual WIP in the process is less than the Critical WIP

**Statistic:** A quantity calculated from a sample of observations, most often to form an estimate of some population parameter.

**Statistical Inference:** The process of drawing conclusions about a population on the basis of statistics.

**Statistical Process Control (SPC):** The application of statistical techniques in the control of processes. SPC is often considered a subset of SQC, where the emphasis in SPC is on the tools associated with the process but not product acceptance techniques. Often the term "statistical quality control" is used interchangeably with "statistical process control."

**Statistical Sampling:** Statistical process for determining the characteristics of a population from the characteristics of a sample.

**Stocking Strategy:** Policy for determining inventory buffer locations when customer required lead times are shorter than actual lead times.

**Strategic Procurement:** Organization typically responsible for negotiating prices and contract terms with suppliers.

**Successive Checks:** Inspection process where an operator inspects the work of a previous operator prior to performing more value-add work.

**Supplier Certification:** Process by which suppliers are rated and certified based on their ability to deliver a quality product, on time at the right price. Based on their level of certification they may receive first right of refusal for newly sourced items or they may get to bid but they may not be our supplier of choice.

**Supplier Lead Time:** Quoted time from when an order is placed with a supplier until the product is delivered to the customer.

**Supplier Managed Inventory:** Inventory that is owned and controlled by the supplier until the time that it is consumed. The supplier is responsible for all reordering, stocking, and handling of the inventory.

**Supplier Rating:** See supplier certification

**Suppliers:** Companies who provide products to another company for use in the course of producing a product or service.

**Synchronous Pull:** Process by which products or subassemblies are triggered once an item reaches a certain level of completeness. Often referred to as a trigger pull system

**T Distribution:** A symmetric, bell-shaped distribution that resembles the standardized normal (or Z) distribution, but it typically has more area in its tails than does the Z

distribution. That is, it has greater variability than the Z distribution.

**T Test:** A hypothesis test of population means when small samples are involved.

**Tactical Purchasing:** Organization typically responsible for placing and managing orders with suppliers.

**Takt Boards:** Visual tool used to communicate required production rates, and track progress to that requirement.

**Tampering:** Action taken to compensate for variation within the control limits of a stable system. Tampering increases rather than decreases variation, as evidenced in the funnel experiment.

**Test Statistic:** A single value, which combines the evidence obtained from sample data. The P-value in a hypothesis test is directly related to this value.

**Throughput:** The output of a process (see also Exit Rate)

**TIM WOOD:** Acronym used to remember the seven wastes (Transportation, Inventory, Movement, Waiting, Overprocessing, Overproduction, Defects). Also TIM P WOOD where P is untapped People.

**Time Phasing:** MRP function to offset the due dates of planned jobs with lead times to determine start times.

**Time Trap:** See Bottleneck

**Tolerance:** The permissible range of variation in a particular dimension of a product. Tolerances are often set by engineering requirements to ensure components will function together properly. In DOE, tolerance is a measure (from 0 to 1) of the independence among independent variables.

**Tooling Department:** A business unit within an organization whose function is the maintenance and/or creation of tooling used in the manufacture of products.

**Total Cycle Time:** See Cycle Time

**Total Preventive Maintenance:** A proactive approach to equipment maintenance involving maintenance personnel and operators focusing on maintaining reliable equipment, eliminating breakdowns, and eliminating equipment related defects.

**Toyota Production System:** A manufacturing system or philosophy founded by Kiichiro Toyota that focuses on the link between cycle time, WIP, batch size and cycle time. Provides for the elimination of waste in ways that companies employ human resources, equipment and material.

**Transfer Quantity:** The amount of material that is moved on to the next operation. This quantity is less than the batch size.

**Trend Control Chart:** A control chart in which the deviation of the subgroup average, X-bar, from an expected trend in the process level is used to evaluate the stability of a process

**Trigger Point:** Location where signal to perform work is initiated.

**Trigger Pull System:** See synchronous pull.

**Trigger:** Signal to perform work.

**Tukey Test:** A statistical test to measure the difference between several means and tell the user which ones are statistically different from the rest.

**Type I Error:** An incorrect decision to reject something (such as a statistical hypothesis or a lot of products) when it is acceptable

**Type II Error:** An incorrect decision to accept something when it is unacceptable

**u Chart:** Count per unit chart; a control chart of the average number of defects per part in a subgroup.

**UCL:** Upper control limit. For control charts, the upper limit below which a process statistic must remain to be in control. Typically, UCL is three standard deviations above the centerline.

**Uptime:** Net operating time less downtime, setup time, etc.

**Utilization:** The ratio of the actual operating time to the total available operating time. Calculated by dividing the actual operating time by the total available time.

**Variability:** The quality of non-uniformity. It is closely associated with randomness. The cause and effects of variability can be measured using probability and statistics.

**Variables Data:** Measurement information. Control charts based on variables data include average ( $\bar{X}$ ) chart, range (R) chart, and sample standard deviation (s) chart.

**Variance:** A measure of variability in a data set or population. It is the square of the standard deviation.

**Variation:** A change in data, a characteristic, or a function that is caused by one of four factors: special causes, common causes, tampering, or structural variation (see individual entries)

**Vendor Lead Time:** See supplier lead time

**Vendor Managed Inventory:** See Supplier Managed Inventory

**Vendors:** See suppliers.

**WIP Cap:** The maximum amount of WIP that should be released into a process in order to maintain a constant and predictable cycle time.

**WIP Stock:** The amount of inventory associated with the manufacturing cycle time of a process. For example if the cycle time is 10 days and the demand is 10 units per day then the WIP stock would be 100 units.

**Workcell:** A group of manufacturing workstations arranged in order of product sequence of operations (or a family of products)

**Workcenter:** A group of workstations.

**Work-In-Process (WIP):** Materials that have been released into production for processing but have not been completed as finished goods.

**Workorder Synchronization:** The process by which workorders are released so that they meet up at the correct time during the assembly process. Used in conjunction with a trigger or synchronous pull system.

**Workstation:** A single workstation where a task is performed on a product.

**X-bar And R Charts:** Applies to variable data and is used to create control charts for the average and range of subgroups of data.

**X-bar And S Charts:** For variable data; control charts for the average and standard deviation ( $\sigma$ ) of subgroups of data.

**X-bar Chart:** Average chart

**Yield:** The amount of material that is processed by an operation less the scrap.

**Z Distribution:** See "Standardized Normal Distribution".

**Z Value:** A standardized value formed by subtracting the mean and then dividing this difference by the standard deviation.