Developed and Published by the
LEAN & SIX SIGMA WORLD ORGANIZATION

First Edition
2016-09-21

LSS 6002-DIS-1

Lean Six Sigma Green Belt Training
D R A F T
International Standard

ISBN: 978-0-9862150-6-3
Printed in U.S.A.
Reference Number: LSS 6002-DIS-1:2016

ISBN: 978-0-9862150-6-3
Printed in U.S.A.

American Quality Institute
Lean & Six Sigma World
Organization Copyright Office
E-mail: info@aqi.org
Web: www.lssworld.org

$80.00
ISBN 978-0-9862150-6-3
58000>
9 780986 215063

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Foreword

The proliferation of Lean, Six Sigma, and Lean Six Sigma continues to expand worldwide to every type of organization. Experienced practitioners and belts continue to be in high demand. Roles like Value Stream Manager, Kaizen Event Leader, Black Belt, Green Belt and others are now commonplace.

As one would expect, organizations want to tailor improvement and training to their needs. The resulting variation in terminology, training, certification, and applications has led to inconsistency in performance and success (both positive and negative) by both individuals and organizations. There is often confusion over terminology and definitions. Training time, depth, breadth, content, toolsets, and instructor/coach competencies vary widely. Even within organizations successful with Lean Six Sigma, standardization and consistent performance have become a problem.

The simple answer to this problem is to provide standardization and consistency. Experienced improvement practitioners know that to improve a situation, one needs to start with a baseline standard. Though one could focus on many different areas of standardization, the most reasonable starting point is that with the greatest need and a manageable scope – Lean Six Sigma Green Belt Training. The variation within Green Belt Training is indicative of the fragmentation of Lean Six Sigma as a whole, with content that varies widely from simple awareness training to advanced statistical methods. The combination of Lean and Six Sigma and Project Management tools only exacerbates this issue. Advertised training time can vary from hours to two weeks, and certification can even be achieved without any training or coaching. As "Green Belt" is not typically a full time role, effective training is critical due to the relative lack of "on-the-job" training and supervision dedicated to full time practitioners. A less-than-optimal Green Belt training program can significantly misrepresent the rigor and experience needed to drive change through Lean Six Sigma, and in turn diminish the impact of an entire deployment.

The main challenge in the creation of a Green Belt Training Standard is to balance two contradictory states: standards that reduce variation and meet minimum performance standards, but also provide the freedom and flexibility to adapt Lean & Six Sigma to specific situations and evolving practices. An organization was formed to tackle such challenges: The Lean & Six Sigma World Organization[SM] is a non-profit organization formed by practitioners interested in creating an independent, widely accessible, worldwide resource for establishing global consistency and communication in Lean & Six Sigma. Better and more consistent applications of Lean, Six Sigma, and other improvement principles will enhance organizational performance, individual competency, public good, and customer satisfaction.

The Lean & Six Sigma World Organization[SM] and the Lean Six Sigma Green Belt Standard Committee are composed of volunteers and practitioners. The organizations are actively seeking practitioners who are willing to deploy the standard and contribute to its continued success.

Introduction

Consider the overall perception and reputation of Lean and Six Sigma regarding the wide variety in success, deployment, training, and certification of Belts. Is it positive? Is it daunting when trying to compare the skills of one Green Belt to another?

From an employer's perspective, it can be confusing. Without guidance, the evaluation of multiple educational programs that deliver varying degrees of Green Belt training can be impossible. How can organizations feel confident in assessing the training and skills of the Lean Six Sigma Green Belt they want to hire?

A Lean Six Sigma Green Belt Candidate faces a similar dilemma. Choosing the right course to attend can be hit-or-miss. Once chosen, it would be devastating to spend time and money to go through a course, only to find that it is missing significant topics or lacks expected rigor. Lean Six Sigma Green Belt candidates must be able to recognize and select reputable training and training providers.

While various organizations have issued bodies of knowledge and training outlines, there has been no curriculum standard for Lean Six Sigma Green Belt training or operational definitions for the concepts and applications of the Lean Six Sigma principles and tools that a Green Belt should know – until now.

The *Lean Six Sigma Green Belt Training International Standard* provides a reference to which any Lean Six Sigma Green Belt training curricula can be compared and evaluated. Whether you are a training provider, employer, or a Lean Six Sigma Green Belt candidate the *Lean Six Sigma Green Belt Training Standard* is for you.

Please note. The scope of this *Lean Six Sigma Green Belt Training International Standard* does not include training standards for Master Black Belts, Black Belts, or Yellow Belts.

Lean Six Sigma Green Belt (GB) Training Requirements

1. Training Methods

Training methods implemented must entail equivalent duration and quality to in-class live training.

1) Classroom Training

- **Length of Training:** Minimum 40 hours
- **Classroom Size:** Recommend no more than 25 students per instructor
- **Curriculum:** Must include all elements of this LSS 6002 Standard
- **Principal Instructor:** Master Black Belt or a Black Belt with appropriate levels of subject matter knowledge, experience, competence and training abilities; subject matter experts can be used for portions of training as appropriate

2) Live Webinar Training

- **Length of Training:** Minimum 40 hours or equivalent depth of training, assessment, practice exercises and content to classroom training
- **Classroom Size:** Recommend limit to 35 to maximize ability of participants to clarify and ask questions
- **Curriculum:** Must include all elements of this LSS 6002 Standard
- **Principal Instructor:** Master Black Belt or a Black Belt with appropriate levels of subject matter knowledge, experience, competence and training abilities; subject matter experts can be used for portions of training as appropriate
- **Webinar Format:** Live Webinar Training must incorporate at least 10 minutes of Q&A period for each hour of training. Questions can be submitted via chat lines, emails, or in the discussion mode of the webinar platform. Without opportunity to ask questions, webinar training is considered e-learning training (see below).

3) Blended Training

(Combination of e-learning and live classroom or webinar formats)

- **Length of Training:** Total for classroom training and webinar training must be minimum 40 hours.
- **Classroom Size: Maximum of 35 for webinar and 25 for classroom, although** recommend limit to 25 participants to maximize opportunity for exercises, clarification and questions
- **Curriculum:** Must include all elements of this LSS 6002 Standard
- **Principal Instructor:** Master Black Belt or a Black Belt with appropriate levels of subject matter knowledge, experience, competence and training abilities; subject matter experts can be used for portions of training as appropriate

4) E-Learning

- **Length of Training:** minimum 40 or equivalent for the training, assessment, practice exercises and content for the E-learning.
- **Classroom Size:** No limit
- **Curriculum:** Must include all elements of this LSS 6002 Standard
- **Principal Instructor:** Developers of training content must be Master Black Belt or a Black Belt with appropriate levels of experience and competence; subject matter experts can be used for portions of training as appropriate; in addition to subject matter knowledge, all developers should have knowledge of effective E-learning development practices

Note: Training time above includes exams/assessments. Live training, particularly classroom training may include exercises, project presentations and teaching practice by participants. Classroom training provides best opportunity for clarification and asking questions and getting immediate response. Blended and webinar training offer reduced opportunity for clarification and questions. E-learning provides no opportunity for clarification and questions.

2. Testing & Final Exam

- It is recommended that testing and/or assessment be done multiple times during training to assess and monitor student understanding and progress
- At a minimum, participants must pass a cumulative final exam covering 90% of the material or retake exam to receive a certificate of training

3. Statistical Software Package (Optional)

- Green Belt students may learn to use an appropriate statistical software package as part of their training program. Curriculum and instruction may include teaching participants how to use the statistical software package to create graphs and statistical data analysis referred to in this standard.

4. Lean Six Sigma Green Belt (GB) Standard Training Curriculum

The following curriculum section outlines key concepts and topics that should be included in Green Belt training programs. Training content may be presented in a different order than it appears in this standard and may include additional tools. To avoid repeating wording in each section outlined, it is understood that all specific tool and method training that follows will cover the purpose (what), benefit (why), use during DMAIC (when), and approach (how to do). Training may include use of a statistical software package to run and analyze the statistical and graphical tools referenced in this standard.

The words "example," "examples," or "e.g." are provided for explanation and guidance in understanding a topic or requirement. In addition, the words "(optional)" or "(optional, but recommended)" gives an instructor the flexibility to include a topic in training based on the needs of participants and the knowledge of the instructor.

5. Lean Six Sigma Introduction

5.1. Lean

5.1.1. Focus and strengths of Lean

5.1.2. History of Lean

5.2. Six Sigma

5.2.1. Focus and strengths of Six Sigma

5.2.2. History of Six Sigma

5.2.3. Sigma quality level and Six Sigma quality level

5.3. Lean Six Sigma

5.3.1. Benefits to integrating Lean and Six Sigma into Lean Six Sigma

5.3.2. Application to all processes and organizations

5.3.3. When to use Lean Six Sigma

5.3.4. Introduction to Lean Six Sigma problem solving and design approaches

5.3.4.1. DMAIC

5.3.4.2. Design for Lean Six Sigma methodologies (Conceptual Understanding e.g., DMADV, DMEDI, DMADOV, or others)

5.3.5. Difference between Lean Six Sigma and other projects (e.g., “go do it,” capital and other projects)

6. DMAIC and Purpose/Goal of Each Phase

6.1. Introduction to DMAIC and Purpose/Goal of each Phase

6.2. DMAIC Outputs

6.2.1. "Define" Example Outputs: Identified next, best, high impact project; selected project team, belt, process owner, and stakeholders; drafted project plan and charter; launched team; implemented project management tools as appropriate (examples: action plan, communication plan, risk management, stakeholder analysis, meeting minutes and other tools); conducted "Define Gate"

6.2.2. "Measure" Example Outputs: Developed understanding of current process using process map, value stream map, and/or work task analysis or time study; at minimum, baselined key project metric and secondary metrics; developed operational definitions for measures; developed data collection plan; validated measurement system indicating collected data can be trusted; baseline process capability determined; validated business opportunity; quick wins identified and implemented as appropriate; conducted "Measure Gate"

6.2.3. "Analyze" Example Outputs: Data collected, process analyzed and/or other tools used to identify, prioritize and select key X(s) (factors, root causes, or wastes) that will have biggest impact on project Y or key metric; quick wins identified and implemented as appropriate; conducted "Analyze Gate"

6.2.4. "Improve" Example Outputs: Evaluated and selected solution(s) to critical X(s) (key factors, root causes or wastes); process change efforts and risks understood and accepted; pilot planned and executed to validate and optimize solutions; tracking system in place to identify improvements over baseline; conducted "Improve Gate"

6.2.5. "Control" Example Outputs: Final solution(s) implemented; methods to sustain gains identified and implemented (example: SOPs, training plan, mistake proofing, and other process control systems); process is monitored and stabilized; transition improved process to Process Owner to sustain; business benefit(s) are calculated and monitored; future opportunities for improvement, including replications, have been identified and communicated; lessons learned documented and shared as appropriate; conducted "Control Gate"

6.3. Gate Reviews or Tollgates

6.3.1. Why use Gate Reviews/Tollgates?

6.3.2. When to: Completion at end of each phase of DMAIC and after project realization

6.3.2.1. Based on LSS maturity of organization, two gate reviews may be combined as appropriate

6.3.3. Typical Minimum Agenda Items

6.3.3.1. What did you do, what tool(s) did you use, what did you learn, what are your recommendations, progress against milestones, problems/barriers and risks

7. Lean Six Sigma Deployment Strategies

(Integrating best of both methods and DMAIC structure used as basis for kaizen event or project)

7.1. Key Success Factors for Deployment

7.1.1. Executive leadership driven with active engagement

7.1.2. Alignment to business strategy and key levers within the business

7.1.3. Measurement of results

7.1.3.1. Hard vs. soft savings

7.1.3.2. Estimated vs. realized savings

7.1.3.3. Key metrics: e.g., performance, operational, process and financial

7.1.4. Change management and adherence to change management principles

7.1.4.1. Organization alignment

7.1.4.2. Rewards and recognition

7.1.4.3. Other methods as appropriate

7.1.5. Appropriate resourcing of time, people and other resources

7.1.6. Project selection and prioritization (See Clause 5)

7.1.7. Type, quality, effectiveness and impact of improvement activities

7.1.8. People and skill development

7.1.8.1. Employee training at all levels of organization

7.1.8.2. Leadership development

7.1.8.3. Black Belt, Green Belt and other belt candidate selection, training and development

7.1.8.4. Coaching

7.1.9. Communication and awareness

7.1.9.1. Communication and action planning for setting the groundwork for LSS deployment

7.1.9.2. Building long-term sustainability for LSS deployment

8. Typical Lean Six Sigma Roles and Responsibilities

8.1. Business Leadership

8.1.1. Deployment Champion

8.1.2. Top Management

8.1.3. Executive Sponsor

8.1.4. Project Sponsor

8.1.5. Process Owner/Team Leader

8.1.6. Value Stream Manager

8.1.7. Finance

8.2. Technical Expertise (Core Team, Extended Team)

8.2.1. Yellow or other belt(s) (if applicable)

8.2.2. Future leaders of replication project(s) (if applicable)

8.2.3. Subject matter experts, including those who do the work

8.3. LSS Expertise

8.3.1. Characteristics of a successful LSS practitioner

8.3.2. Master Black Belt

8.3.3. Black Belt

8.3.4. Green Belt

8.3.5. Kaizen event leader

9. Project Identification and Selection

9.1. Project Identification: Sources of Projects

9.1.1. Voice of Customer

9.1.2. Business strategy, goals and objectives

9.1.3. Value Stream Mapping, SIPOC or other process maps

9.1.4. Financial or other business needs: e.g., safety, environmental, regulatory, legal, consumer, etc.

9.1.5. Multi-generational project planning and scoping

9.1.6. Identified organization risks

9.1.7. Replication projects

9.1.8. One improvement project surfaces other DMAIC projects

9.1.9. Problem or improvement opportunity identified by anyone in organization

9.2. Formal Project Selection for Identifying Highest Impact Projects

9.2.1. Project selection criteria and weightings appropriate to organization

9.2.1.1. Benefit / effort or similar criteria rating or ranking tool

9.2.1.1.1. Benefit criteria: e.g., customer, strategy or goal alignment, financial (cost reduction, revenue growth, capital reduction, cost avoidance, etc.), legal / regulatory, safety/environmental or other benefits or impacts or others

9.2.1.1.2. Effort criteria: e.g., personnel time, project duration, project risk, organization readiness, capital investment or others

10. Design for Lean Six Sigma Frameworks and Methodologies

10.1. Introduction and When to use Design for Lean Six Sigma (DFLSS) Instead of DMAIC

10.1.1. When a process, product, or service no longer meets customer, business or other requirements

10.1.2. When a process, product, or service does not exist and needs to be developed

11. Team and Project Management

11.1. Team Management

11.1.1. Team formation and team member selection

11.1.1.1. Team roles

11.1.1.2. Project and/or Executive Sponsor (or Champion)

11.1.1.3. Process owner

11.1.1.4. Core team members

11.1.1.5. Extended team members and/or subject matter experts

11.1.1.6. Others

11.1.1.7. Team member selection

11.1.2. Team launch

11.1.3. Team meetings / facilitation

11.1.4. Team performance evaluation and recognition

11.2. Project Management Communication Planning

11.2.1. Communication Planning

11.2.1.1. For project sponsors, team, affected employees, customers

11.2.1.2. Method chosen based on communication needs

11.2.1.3. One way vs. two way communication loops

11.2.2. Define, analyze, communicate with and manage project stakeholders (as appropriate)

11.2.2.1. Stakeholder analysis

11.2.2.2. Internal (e.g., VOB, value chain partners)

11.2.2.3. External (e.g., suppliers, regulatory, customer)

11.2.3. Action planning

12. Kaizen Events and Quick Wins

12.1. Difference between Kaizen Events and Quick Wins/Improvement Actions

12.2. Philosophies of Kaizen Events and Quick Wins/Improvements

12.2.1. Integration into LSS

12.2.1.1. Speed for small changes at any time during DMAIC to accelerate projects; or

12.2.1.2. Isolated kaizen event or quick win/improvement (separate from other LSS projects)

12.2.1.3. Low cost/low effort improvements or projects

12.2.2. Continuous cycles of improvement

12.2.3. Criteria (e.g., low cost, low effort, easily reversible, team has authority to make changes, and similar criteria.)

12.3. Kaizen Events

12.3.1. DMAIC as structure for all kaizen events (why limit to DMAIC? Could use DFLSS or PDCA)

12.3.2. Kaizen events as single LSS project or incorporated into as a method to accelerate a project

12.3.3. Typical kaizen event length (e.g., 3-5 days) and approach

12.3.4. Typical kaizen event activities: (e.g., 5S, setup / changeover reduction, process flow improvement, work area redesign, and others)

13. Creating a Project Charter

13.1. Key Charter Elements

13.1.1. Problem Statement

13.1.2. Objectives/Deliverables

13.1.3. Specific and measurable project metric(s) and goals, both primary and secondary

13.1.4. In-scope and out-of-scope

13.1.5. Business impact

13.1.5.1. Financial

13.1.5.2. Non-financial (e.g., safety, quality, productivity, growth, reallocation of resources, cost avoidance, customer or employee satisfaction and other impacts)

13.1.6. Project team with clearly stated roles and responsibilities, including time commitment

(See 7.1.1.1 Team Roles)

13.1.7. Project plan or timeline

13.1.7.1. DMAIC gate review dates at a minimum and other milestones as appropriate

13.1.7.2. Gantt chart optional

13.1.8. Other Charter Elements Specific to Organizations or as Appropriate for Project (e.g., Operational definition, business impact assumptions, project risks)

14. Voice of Customer

14.1. Identify and Segment Internal, External, and Regulatory Customers

14.1.1. Internal, external, regulatory, and others

14.1.2. Economic, geographic, attitudinal, and/or other segmentations

14.2. Gather Voice of the Customer

14.2.1. Direct data collection (e.g., focus groups, interviews, surveys, solicited via social media)

14.2.2. Indirect data collection (e.g., market research, customer complaint analysis, unsolicited via social media)

14.3. Translate VOC data into Critical to Quality Requirements (CTQs) or Critical to Customer Requirements (CCRs)

14.3.1. Quantifiable requirements of a service or product to meet customer requirements

14.4. Voice of Customer (VOC) Analysis Tools

14.4.1. Kano Analysis

14.4.2. Affinity diagram

14.4.3. Others

15. Process Mapping

15.1. Process Maps and Their Use

15.1.1. Flow chart

15.1.2. SIPOC

15.1.3. Swim lane

15.1.4. Top-down

15.1.5. Input-output/X-Y map

15.1.6. Spaghetti diagram/Transport diagram

15.1.7. Others as appropriate

15.2. Value Stream Mapping

15.2.1. Levels of value stream mapping: e.g., single location (from supplier to customer), task or cell level, multiple locations (one or multiple companies)

15.2.2. Key value stream mapping activities (identify value streams, current state map, future state map, action plan)

15.2.2.1. If value streams are not obvious, use Product/Service Family Matrix

15.2.3. Components of value stream map

15.2.3.1. Process/material flow

15.2.3.2. Information/communication flow

15.2.3.3. Process data (wait time, task time, and other appropriate data)

15.2.3.4. Value add / Non value add identification

15.2.3.5. Timeline with value added time and lead time

15.2.4. Creation of current state map, future state map and future state action plan

16. Common Process Equations

16.1. Little's Law: Process Lead Time (PLT) or Process Cycle Time (PCT) = WIP/Exit Rate

16.2. Process Cycle Efficiency (PCE) =Total Value Added Time/Total Process Lead Time or Process Cycle Time

16.3. Rolled Throughput Yield (RTY) Calculation = Yield_1 x Yield_2 … x Yield_n

16.4. Takt Time = (Available Work Time/Customer Demand) or Takt Rate = (Customer Demand/Available Work Time)

17. Value Analysis and Waste Identification

17.1. Classifying Value Add/Non-Value Add

17.1.1. Customer Value Add

17.1.2. Business Non-value Add or similar term (e.g., business or essential value add, Type 1 Muda)

17.1.3. Non-value Add or waste or similar term (e.g., unnecessary non-value add, Type 2 Muda)

17.1.4. Eight wastes

17.1.4.1. Transportation

17.1.4.2. Inventory

17.1.4.3. Motion

17.1.4.4. Waiting

17.1.4.5. Over production

17.1.4.6. Over processing

17.1.4.7. Defects

17.1.4.8. Skills (under-utilized)

17.1.5. Safety (as impacted by all other wastes) (optional)

17.2. Waste Walk (Going to the Gemba)

18. Basic Statistics and Variation

18.1. Statistical Distributions

18.1.1. Continuous Distributions

18.1.1.1. Examples – Normal, Student t

18.1.1.2. Benefits of normal data and shape (e.g., use of more powerful statistics)

18.1.2. Discrete Distributions

18.1.2.1. Examples – Binomial, Poisson

18.1.3. Central Limit Theorem (Conceptual Understanding)

18.1.3.1. Sampling Distribution of subgroup means

19. Use of Software for Graphical and Statistical Analysis

19.1. Run and Interpret Graphs and Statistical Analysis Referred to in this Standard

19.2. Four Classes of Software Used to Support Lean Six Sigma (Optional)

19.2.1. Analysis tools, which are used to perform statistical, data or process analysis

19.2.2. Program management tools, used to manage and track a corporation's entire Six Sigma program

19.2.3. DMAIC and Lean online project collaboration tools for local and global teams

19.2.4. Data Collection tools that feed information directly into the analysis tools and significantly reduce the time spent gathering data

20. Measurement and Data Collection

20.1. Types of Measures

20.1.1. Quality, capacity, productivity, speed, and cost

20.1.1.1. Quality measures: sigma quality level, rolled throughput yield, % yield or % good, % defects or % errors, DPMO, DPU, ppm, and other similar measures

20.1.1.2. Speed measures: process lead time, WIP, process time and other similar measures

20.1.1.3. Capacity measures: cycle time, exit rate, and other similar measures

20.1.2. Measures/data by type:

20.1.2.1. Continuous or variable

20.1.2.2. Attribute or discrete or count data

20.1.2.2.1. Nominal, ordinal, binomial

20.1.3. Measures/data by location: leading, lagging, in-process

20.2. Data Collection-Planning Considerations and Terminology

20.2.1. Measure: what is being measured

20.2.2. Stratification factors: capturing and use of characteristics to sort data into different categories for further analysis; also known as "slicing the data"

20.2.3. Operational definitions: clear, precise description of factor being measured so each individual collects, measures and/or counts data the same way

20.2.4. Where data will be collected: data source

20.2.4.1. Historical or existing data with advantages and disadvantages

20.2.4.2. Location

20.2.5. How data will be collected

20.2.5.1. Procedure, form, checklist, pilot, and other

20.2.5.2. Types and impact of bias; methods that avoids bias

20.2.6. Who will collect the data (belt, team member(s), local workforce, others)

20.2.7. When, how often and how much data to collect

20.2.7.1. Time period or frequency of data collection

20.2.7.2. Population or sample

20.2.7.3. Amount of data in a sample data set (n), subgroup (n), or population (N)

20.2.7.4. Amount of data in a subgroup (n) and number of subgroups

20.2.8. Other planning elements as appropriate

20.3. Sampling

20.3.1. Population or process sampling

20.3.2. Sampling bias, such as self-selection, self-exclusion, ignoring non-conformances, judgment, convenience, etc.

20.3.3. Sample sizes

20.3.3.1. Continuous data

20.3.3.2. Discrete data

20.3.3.3. Finite population correction factor (when population is smaller than minimum calculated sample size)

20.3.4. Sampling strategies

20.3.4.1. Between (signal) and within (noise) variation

20.3.4.2. Methods (e.g., random, stratified random, systematic, consecutive/rational subgroup)

21. Measurement System Analysis (MSA)

21.1. MSA Terminology

21.1.1. Accuracy and precision

21.1.2. Repeatability and "within" variation (noise)

21.1.3. Reproducibility and "between" variation (signal)

21.1.4. Stability

21.1.5. Bias

21.1.6. Linearity

21.1.7. Calibration

21.1.8. Discrimination/resolution

21.1.9. Non-destructive (crossed) versus destructive (nested)

21.2. Gage R&R Study – Continuous Data (Conceptual Understanding)

21.2.1. Planning and conducting a Gage R&R Study

21.2.1.1. Determine number of items/parts, operators/inspectors/appraisers, number of repeat readings per item

21.2.1.2. Requirements: Randomization of measurements, adequate data, items/parts typical of range (both good and bad)

21.2.2. Gage R&R for non-destructive & destructive tests (crossed & nested)

21.2.2.1. Analysis of Variance (ANOVA) Method (preferred)

21.2.3. Graphical and statistical outputs

21.2.3.1. Guidelines for "acceptable," "may be," "unacceptable" values

21.2.3.2. % variance contribution, % study variation, % tolerance (or precision-to-tolerance ratio), % process

21.2.3.3. R chart

21.2.3.4. Xbar chart

21.2.3.5. Response by part

21.2.3.6. Operator part interaction

21.2.3.7. Number of distinct categories

22. Descriptive and Inferential Statistics

22.1. Descriptive Statistics

22.1.1. Measures of central tendency: mean, median, mode

22.1.2. Measures of variation: standard deviation, variance, range, quartiles, quantiles

22.1.3. Visual representation of normal distribution, standard deviation and % data

22.1.4. Proportion or %

22.1.5. Symbols of sample statistics and population parameters

22.1.5.1. Mean, median, variance, standard deviation, proportion, range, and sample size

22.1.6. Graphs

22.1.6.1. Pareto chart

22.1.6.2. Bar chart

22.1.6.3. Probability plots (e.g. normal probability plot, quantile-quantile plot)

22.1.6.4. Time series or run chart

22.1.6.5. Scatter plot or matrix plot

22.1.6.6. Box plot

22.1.6.7. Histogram

22.2. Sample Size

22.2.1. Determine sample size

22.2.2. Relationship between sample size and confidence intervals, confidence levels, power, precision (difference trying to detect), variation, and alpha/beta risk

22.3. Inferential Statistics

22.3.1. Inferential statistics summary of pertinent parameters (format depends on software or method used to calculate)

22.3.2. Confidence intervals for sample statistics and relationship to population parameters

22.3.3. Hypothesis testing (reference Chapter 21: Hypothesis Testing)

23. Control Charts – Continuous and Discrete

23.1. Control Chart Selection

23.2. In Control/Out of Control

23.2.1. Identify out of control points

23.2.1.1. Western Electric Rules

23.2.2. Responding to common cause (random cause) versus special cause (assignable variation)

23.2.2.1. Who can respond or take action

23.2.2.1.1. Special cause: local workforce

23.2.2.1.2. Common cause: systemic issues often require management involvement

23.2.2.2. Appropriate improvement actions

23.2.2.2.1. Special cause: investigate and eliminate root cause; remove identified special cause from limit calculation

23.2.2.2.2. "Good" special cause: investigate and incorporate "good" special cause into process

23.2.2.2.3. Common cause: investigate and improve the process or system

23.3. Continuous Data Control Charts

23.3.1. Xbar-R (signal / noise) with definition of rational subgroups

23.3.2. Xbar-S (signal / noise) with definition of rational subgroups

23.3.3. I-MR (or X-MR)

23.4. Discrete Data Control Charts

23.4.1. P, NP, C, U with assumptions

23.4.1.1. Defects (Poisson Distribution) versus defective units (Binomial)

23.4.1.2. Fixed versus variable sample size or opportunity

23.5. Pitfalls and Dangers in Control Charting

23.5.1. Tampering, perceiving everything as special cause, ignoring special cause, artificially creating or failing to properly define rational subgroups, gaps in time between data points, stability/in-control does not imply capability, and others

23.6. When to Fix or Recalculate Control Limits

23.6.1. When to recalculate limits for ongoing control (e.g., after removing identified special cause and recommended minimum sample size reached)

23.6.2. When to recalculate limits after control has been established (e.g., system or process changes)

23.7. Split or Staged Control Charts

24. Process Capability – Continuous and Discrete

24.1. Process Must Be Stable (in Control) in Order to Predict Future Capability

24.2. Assessing Continuous Capability Statistically

24.2.1. Continuous, normal data when upper and/or lower specification limit available

24.2.1.1. Cp/Pp – assumes centering within specs; takes into account spread of data; within, short term variation (Cp) versus overall/between, longer term variation (Pp)

24.2.1.2. Cpk/Ppk –takes into account spread and actual location of data; within, short term variation (Cpk) versus overall/between, longer term variation (Ppk)

25. Hypothesis Tests

25.1. Null and Alternate Hypotheses

25.1.1. Reject null or unable to reject null

25.1.2. P value and relation to alpha risk

25.2. Sampling Error

25.2.1. Type 1 – alpha – producer risk (discovered something that isn't really there, for example, rejecting good product when you shouldn't have)

25.2.1.1. Confidence level and typical confidence levels

25.2.1.2. Relationship: Confidence Level = 1 - alpha

25.2.2. Type 2 – beta –consumer risk (missed a significant event, for example, shipping bad product when you shouldn't have)

25.2.2.1. Power and desired power levels

25.2.2.2. Relationship: Power = 1- beta

25.2.2.3. Relationship to sample size: increasing sample size increases power and decreases beta risk

25.3. Difference or Comparative Hypothesis Tests – Used to Determine Differences between Xs with Respect to Y

25.3.1. Difference between parametric (assumed distribution, usually normal) and non-parametric (no assumed distribution)

25.3.2. Impacted by sample size, estimated variation of the population, confidence level and precision

25.3.3. Used for both continuous and discrete data

25.3.4. Confidence intervals and relationship to hypothesis tests

25.3.5. Continuous y, discrete x hypothesis tests

25.3.5.1. Differences in means for normal data

25.3.5.1.1. Two sample t with and without equal variance

25.3.5.1.2. One sample t

25.3.5.1.3. ANOVA (One way)

25.3.5.2. Differences in Variances

25.3.5.2.1. 1 variance

25.3.5.2.2. 2 variance

25.3.5.2.3. Test for equal variance (test(s) may depend on software used

26. Correlation and Regression

26.1. Correlation

26.1.1. Used to identify key X(s), factors or causes (even if they don't end up in the regression model)

26.1.2. Correlation versus causation

26.1.3. Graphical: scatterplot

26.1.4. Analytical:

26.1.4.1. R or r (Pearson correlation coefficient)

26.1.4.2. P value

26.2. Regression – Adding the Ability to Predict a Continuous Y Using a Model

26.2.1. Simple linear – one continuous X and one continuous Y (R-Sq, p value)

26.2.1.1. Null hypotheses concerning intercept and slope

26.2.1.2. Outliers or unusual observations: residuals, Cooks D, leverage

26.2.1.2.1. Requirement for normal and independent residuals

26.2.1.2.2. Remedies for handling outliers or problem residuals that affect model

26.2.2. Abuses of regression (e.g., causation, extrapolation, generalization)

27. Tools to Identify and Select Root Causes

27.1. Brainstorming

27.2. Affinity Diagram

27.3. Fishbone, Ishikawa or Cause-and-Effect Diagram

27.4. Five Why's (as a stand-alone tool or in conjunction with Fishbone Analysis)

27.5. Cause-and-Effect Matrix

27.6. Various Process Maps (e.g. X-Y/Input-Output Map, Process Flow Chart)

27.7. Failure Mode(s) and Effects Analysis (FMEA)

27.8. Force Field Analysis

27.9. Multi-Voting

27.10. Is/Is Not Analysis (Stratification Analysis)

27.11. Other Tools as Appropriate

28. Risk Assessment and Response Tools

28.1. Project Risk Analysis

28.1.1. Formal project risk assessment (optional)

28.1.2. Addressing risks in project charter

28.1.3. Addressing risks in gate reviews

28.1.4. Addressing risk to improvements

28.1.5. Root cause analysis

28.2. Tools

28.2.1. Failure modes and effects analysis (FMEA)

28.2.2. Force field analysis

28.2.3. Brainstorming (what has or could go wrong)

29. Design of Experiments (DOE)

29.1. Benefits of DOE

29.1.1. Versus other experimental methods such as one-factor-at-a-time (OFAT), trial-and-error) hypothesis testing, others

29.1.2. Benefits for transactional applications

29.2. Sequential Experimentation: Screening, Refining, and Optimizing

29.3. Full and Fractional Designs – Assumes Linear Relationship between Levels (Conceptual Understanding)

29.3.1. Terminology and concepts

29.3.1.1. Factors and levels

29.3.1.2. Run, DOE notation and minimum number of runs calculations

29.3.1.3. Power

29.3.1.4. Resolution

29.3.1.5. Confounding/aliasing

29.3.1.6. Scarcity of Effects Principle

29.3.1.7. Standard design matrix

29.3.1.8. Run order versus Yates Standard Run Order

29.3.1.9. Effects

29.3.1.9.1. Main effects

29.3.1.9.2. Interactions

29.3.1.10. Replicates and repeats

29.3.1.11. Center points

29.3.1.12. Blocking

29.3.1.13. Randomization

30. Lean Layout and Flow Improvement Tools and Methods

30.1. One Piece or One Work Flow

30.1.1. One Piece Flow definition

30.1.2. Relationship to batch size reduction and balanced work

30.1.3. Balancing work to flow the work

30.2. Balancing Work to Takt

30.3. Batch Size Reduction (Conceptual Understanding)

30.3.1. Justification for batch size reduction (e.g., WIP/process lead time reduction)

30.3.2. Factors that affect batch size (e.g., changeover time, quality, downtime)

30.4. Constraint/Bottleneck/Pacemaker Identification and Management

30.4.1. Have bottleneck or constraint if work is not balanced

30.4.2. Relationship to dictating and improving capacity of entire process

30.4.3. Difference between constraint and bottleneck

30.4.4. Identification of bottleneck, constraint

30.4.5. Concept of sub-optimization

30.4.6. Subordinate non-bottleneck steps to pace of constraint

30.4.7. Avoiding sub-optimization

30.4.8. Methods for improving bottleneck, constraint, pacemaker

30.5. 5S

30.5.1. Sort

30.5.2. Set in order

30.5.3. Shine

30.5.4. Standardize

30.5.5. Sustain

30.6. Diagrams

30.6.1. Area layout diagram

30.6.2. Spaghetti diagram (movement of people)

30.6.3. Transport diagram (movement of work)

31. Rapid Changeover/Setup Reduction

31.1. Definition of Quick Changeover and / or Setup Reduction

31.1.1. How to measure setup time

31.1.2. How to apply principles of setup to transactional processes (e.g., month-end close, call centers)

31.2. Benefits of Setup Reduction / Quick Changeover

31.2.1. Batch size reduction, increased flexibility, increased capacity, and others

31.3. Setup Reduction / Quick Changeover Steps

31.3.1. Integration with DMAIC

31.3.2. Five key steps

31.3.2.1. Document steps of setup

31.3.2.2. Convert internal to external events and/or serial to parallel events

31.3.2.2.1. Definitions of internal vs. external and serial vs. parallel

31.3.2.3. Streamline internal events

31.3.2.4. Eliminate adjustments

31.3.2.5. Document, implement and sustain improvements

31.3.3. Methods and tools integrated into four key steps as appropriate

31.3.3.1. Spaghetti diagram, shadow board, 5S, work instructions, checklists, point-of-use storage, quick connections, and other methods and tools

32. Pull Systems

32.1. Benefits of Pull (Kanban) Systems versus Push Systems

32.2. Generic Pull vs. Replenishment Pull vs Kanban

32.2.1. Generic pull systems (optional, but recommended)

32.2.1.1. When and where to use

32.2.1.2. WIP cap

32.2.1.3. Little's Law

32.2.1.4. Calculating PLT, PCE, WIP cap

32.2.2. Replenishment pull systems (including discussion of supermarket and Kanban) (optional, but recommended)

32.2.2.1. When and where to use replenishment pull

32.2.2.2. Purchase pull vs. manufacturing pull

32.2.2.3. Replenishment pull calculations

32.2.2.4. Multi-site pull systems

32.2.3. Two-bin (optional, but recommended)

32.2.3.1. When and where to use

32.2.3.2. Serial vs parallel

33. Solution Selection

33.1. Multi-Voting

33.2. Rating Matrices (criteria based)

33.2.1. Pugh matrix

33.2.2. Other rating matrices

33.3. Ranking Matrices (criteria based)

34. Piloting Solutions – Key Steps

34.1. Plan Pilot (including duration and location of pilot, other considerations)

34.2. Create Measurement Plan with Success Metrics

34.3. Develop Standard Operating Procedures

34.4. Train Process Participants

34.5. Assess Risk (e.g., FMEA, Force Field Analysis, ask “what can go wrong”)

34.6. Conduct Pilot, Collect Data and Analyze Results

34.7. Check for Unintended Consequences or “Ripple Effects” for Others

34.8. If Pilot Successful, Ask for Permission to Go to Full-Scale Implementation

35. Validating/Verifying Improvements

35.1. When to Validate/Verify Improvements (e.g., after pilot and after full-scale implementation)

35.2. Statistical Methods

35.2.1. Hypothesis test of before and after metric(s) (preferred approach)

35.2.1.1. Means, medians, variances, or proportions (% yield, DPMO, ppm, others)

35.2.2. "After" data plotted on control chart with control limits calculated from "baseline" data

35.2.2.1. "After" data shows "good" special cause: e.g., run of multiple points below the mean (see next bullet)

35.2.3. Run of six or more consecutive data points on one side of a mean or median (weaker statistical method)

35.2.3.1. Use when takes long time or is difficult to collect "after" data

35.2.4. Measurement system analysis (preferred approach for MSA improvement project)

35.2.4.1. Gage R&R (continuous measure)

35.2.4.2. Kappa or Kendall's attribute agreement analysis

35.3. Non-Statistical and/or Graphical Methods

35.3.1. Split control chart on "baseline" and "after" data showing changes in limits

35.3.1.1. Weak approach since difficult to know what constitutes a statistical difference in limits if there is considerable overlap

35.3.2. Improved Cp, Cpk, Pp, Ppk, sigma quality level

35.3.2.1. Weak approach since difficult to know what constitutes a statistically significant change in Cp, Cpk, Pp, Ppk, sigma quality level

35.3.2.2. Better to use a two proportion hypothesis test using % yield, DPMO or ppm

35.3.3. Change is large enough that difference is obvious

35.3.3.1. Method typically used when it is difficult or takes a long time to generate a data point ("baseline" or "after" data is limited)

35.3.3.2. Lean often relies on this method because changes are large, although even with Lean you are better off validating results statistically

35.3.4. Creation of a new, working process, product or service (e.g., using DFLSS)

36. Documenting Lessons Learned

36.1. Project Summary

36.1.1. e.g., Story Board, Library Card, Four Blockers or other methods

36.2. Survey Project Participants

36.3. Identify and Collect Lessons Learned During Project, Not Just At End

37. Sustaining the Gains

37.1. Control Plan

37.2. Standard Operating Procedures/Standard Work

37.3. Work Instructions

37.3.1. Tips: developed by and/or for user, make visual, keep short (e.g., 1-2 pages), and others

37.4. Poka Yoke (also known as mistake or error proofing)

37.5. FMEA

37.6. Visual Controls

37.7. Metrics and/or Dashboard to Monitor Process Performance

37.7.1. What is being measured

37.7.1.1. e.g., quality (% yield, Ppk, ppm, other)

37.7.2. How the measurement will be tracked or displayed

37.7.2.1. Control chart, run chart (time series chart), table, or other appropriate method?

37.7.3. Who is responsible for the measure

37.7.4. To whom are the results reported

37.7.5. Acceptability threshold and the action plan if exceeded

37.7.6. Control charts (or less desirable time series charts) (as appropriate)

37.7.7. Capability: e.g., Sigma Quality Level, Ppk, % Yield

37.7.8. Others as appropriate

37.8. Training for All Process Participants; Incorporate Into New Hire Training

37.9. Project Closure

37.10. Transfer Ownership of the New Process to the Process Owner

37.11. Follow-Up Audits

37.12. Validate and/or Sustain Gate Reviews

37.13. Other Methods to Sustain Gains

38. Replication Opportunities

38.1. Identify and Plan Replication

38.1.1. E.g., Replication Matrix (Comparing processes and solutions in matrix to identify replication opportunities)

38.1.2. E.g., Multi-Generation Project Plan (MGPP)

38.2. Adapt, Adopt, Forget

38.2.1. Adapt (replication): e.g., if problem exists in another process and the root causes are the same, you can replicate the improvements; if root causes different but processes are similar might replicate approach used to determine root cause(s)

38.2.2. Adopt (reproduction): e.g., improvements in one process reproduced in another with local changes

38.2.3. Forget if the root causes are not the same

List of Acronyms and Symbols

Symbols and acronyms reflect common uses in Lean Six Sigma, and are provided to explain their use in this standard.

BNVA	Business Non-Value Add
CCR	Critical Customer Requirement
CT	Cycle Time
CTQ	Critical to Quality
CVA	Customer Value Added
DFLSS	Design for Lean Six Sigma
DMADOV	Define/Measure/Analyze/Design/Optimize/Validate
DMADV	Define/Measure/Analyze/Design/Validate
DMAIC	Define/Measure/Analyze/Improve/Control
DMEDI	Define/Measure/Explore/Develop/Implement
DOE	Design of Experiments
DPMO	Defects per Million Opportunities
DPU	Defects per Unit
ER	Exit Rate
EXITS	Exit Rate (units/time)
FMEA	Failure Mode and Effects Analysis
Gage R&R	Gage Repeatability and Reproducibility
IT	Information Technology
LSS	Lean Six Sigma
LT	Lead Time
MGPP	Multi-Generation Project Planning
MSA	Measurement System Analysis

N or n	Amount of data in a Population (N), Sample (n), or Subgroup (n)
NVA	Non-Value Added
PCE	Process Cycle Efficiency
PCT	Process Cycle Time
PDCA	Plan/Do/Check/Act
PDSA	Plan/Do/Study/Act
PLT	Process Lead Time
POU	Point-of-Use Storage
PPM	Parts-per-Million
RTY	Rolled Throughput Yield
S or s	Standard deviation of a population (S) or sample (s)
SOP	Standard Operating Procedure
SPC	Statistical Process Control
SQL	Sigma Quality Level
TIMWOODS	Acronym for the 8 wastes
VA	Value Add
VOB	Voice of Business
VOC	Voice of Customer
VSM	Value Stream Map
WIP	Work in Process
Xbar	Sample Mean
α	Alpha
β	Beta
μ	Population Mean
σ	Population Standard Deviation

Glossary

The Glossary is provided to help understand the terminology and requirements in this standard, not to provide definitive and comprehensive definitions.

% Yield	A ratio of desired outcomes divided by total opportunities.
5S	A systematic foundational process for creating and maintaining an organized, clean, and high performance workplace enabling the identification of normal and abnormal conditions at a glance. The five S's are frequently translated from the original Japanese words as sort, set in order, shine, standardize and sustain.
Affinity Diagram	A technique for organizing ideas from a brainstorming session by grouping similar ideas into themes or groupings. These themes can then serve as input into a Cause and Effect Diagram
ANOVA	Analysis of Variance is used to test for statistical difference in population means between three or more categorical groups.
Attribute Data	Data that is counted as whole numbers. Attribute data can be counted in categories which are binomial (e.g., good/bad, yes/no, male/female), ordinal (ordered categories in which preference or ranking is important such as 1-5 ranking on a customer survey) or nominal (named categories where order does not matter such as error classifications). Also called Discrete, Count, or Categorical Data. Identifying data is attribute is important in sample size and determining graphical or statistical tools used.
Bar Chart	A graphical comparison between different characteristics where the height of the bars show relative frequency or magnitude of occurrence.
Binomial Distribution	Distribution used to describe data where each event or trial has only two outcomes. (e.g., referring to success or failure where P is used to represent the probability of x successes (failures) out of n trials)

Box Plot	A graphical technique that displays information about continuous data in the form of a box and whiskers representing the center, spread, shape, quartiles and outliers of the data.
Categorical Data	See Attribute Data
Cause-And-Effect Diagram	A visual tool used to organize possible causes for a specific problem or effect by graphically displaying them in increasing detail. It is used to identify root causes. It is also referred to as an Ishikawa or Fishbone diagram.
Cause-and-Effect Matrix	Shows the correlation between process steps and inputs and key customer ranked outputs to better understand where to focus in the process for optimal satisfaction of customer needs.
Continuous Data	Numerical data that theoretically can be infinitely divided based on the capability of the measurement system. Examples are time, money, weights, etc. Numerical, continuous data can have decimals or fractions, unlike attribute data which counts whole numbers. Continuous Data is preferred over attribute data since Continuous Data uses more powerful statistics and provides more information with generally fewer samples.
Control Charts	A process-monitoring tool designed to allow for the distinction between common cause and special cause variation.
Count Data	See Attribute Data.
Correlation	An indication of a relationship between paired continuous data.

Cp	Measurement of potential process capability that uses the ratio of the width of a tolerance or specification divided by the natural width of the process calculated as six standard deviations. It assumes that the process is centered within the tolerance or spec range. This only holds true if you are dealing with a two-sided specification. The formula is s $Cp = (USL\text{-}LSL)/6\sigma$. Cp takes into account the spread of the data. Cp is often referred to as short term capability.
Cpk	A measure of actual process capability that uses the ratio of the specification closest to the mean of the process divided by one half the natural width of the process calculated as three standard deviations. Unlike Cp this calculation is used when the process is not centered within the tolerance or specification range. The formula is [Min (USL – Average)/3σ or (LSL – Average)/3σ]. Cpk takes into account the location of the center of data and data spread, unlike Cp which only takes into account the spread of the data. Cpk is often referred to as short term capability.
Critical Customer Requirements (CCRs)	Specifically defined expectations of what is important to the customer.
Critical to Quality (CTQ)	Critical to Quality are the internal critical quality parameters that relate to the wants and needs of the customer. CTQs are what are important to the quality of the process or service to ensure the things that are important to the customer are being met.
Defects per Million Opportunities (DPMO)	Measure of quality calculated by dividing the number of defects by the total opportunities for defects multiplied by 1,000,000.
Descriptive and Inferential Statistics	Descriptive statistics are used to describe the center, variation, and shape of a set of data whether discrete or continuous. Inferential statistics are used to make statements about population parameters based on sample statistics.

Design of Experiments (DOE)	A statistical technique that utilizes the manipulation of controllable factors (independent variables/X) at different levels to see their effect on some response (dependent variable/Y). Based on the outcome of the experiment we can determine which of the Xs has a causal relationship with the Y, how strong is that relationship, any interactions between the Xs and at what level we should set the Xs to optimize the Y.
Design for Lean Six Sigma (DFLSS)	Design for Lean Six Sigma is a technique for designing a new product or process based on customer needs. It is used when there is no existing product/process, the product/process is so defective it needs to be redesigned from scratch or when the process/product is functional but incapable of meeting customer needs.
Discrete Data	See Attribute Data.
Discrete Distributions	The statistical or probabilistic properties of observable (either finite or infinite but countable) data. A discrete distribution is characterized by a limited number of possible observations. Common discrete distributions used in Lean Six Sigma are binomial and Poisson.
DMADOV	An approach for doing Design for Lean Six Sigma. See DFLSS above. (Define/Measure/Analyze/Design/Optimize/Validate)
DMADV	An approach for doing Design for Lean Six Sigma. See DFLSS above. Define/Measure/Analyze/Design/Validate
DMAIC	Design/Measure/Analyze/Improve/Control is the core, rigorous, structured method used by Lean Six Sigma for process improvement and problem solving.
DMEDI	An approach for doing Design for Lean Six Sigma. See DFLSS above. (Design/Measure/Explore/Develop/Implement)

Exit Rate (ER)	Rate at which an item or unit leaves or exits the process over a period of time. It is expressed in terms of units per time. For example, 3 units per 6 hours.
Executive Sponsor	The senior leader who has overall accountability for the success of the project. This person is often the natural leader of the process being improved and often has authority over all stakeholders of project.
Failure Mode and Effects Analysis (FMEA)	A tool used for risk mitigation. It looks at the steps of the proposed improved process and evaluates what kinds of things could go wrong, what is the effect if it does occur, what is the severity of that effect from the customer's perspective, what is the cause of the things that can go wrong, how often it might occur, what controls are in place to prevent the failure from happening, the cumulative risk priority number (severity x occurrence x detection) and the action steps needed to reduce the risk.
Fishbone	See Cause and Effect Diagram.
Force Field Analysis	Identifies all the forces and factors, both restraining/blocking and driving/supporting, which can affect the solution of an issue or problem so that the positive drivers can be reinforced and/or negatives reduced or eliminated.
Gage R&R	Gage Repeatability and Reproducibility is a statistical tool for analyzing the variation in observed measurements critical in determining whether you can have faith in what the measurement system is telling you.
Gantt Chart	A simple bar chart used for project scheduling. It displays information about the work breakdown, total duration of each task and % completion for a project.

Gate Review	A formal event that occurs after each phase of DMAIC where the learnings, recommendations and accomplishments of each step in DMAIC are reviewed with project stakeholders to assess whether the project is on track and can move forward to the next phase. If everything is still on track, permission is granted to move onto the next stage. Gate Review is a best practice approach for updating stakeholders and ensuring buy-in throughout the project. Also known as a Tollgate.
Gemba	Japanese term meaning the place where the work takes place. "Going to Gemba" is a phrase used during Kaizen, Kaizen Events and problem solving which means going out to observe where the work is being done.
Generic Pull	Designed to place a limit, or cap**,** on the maximum number of things or work in process (WIP_{cap}), so that the lead time is known and stable. The underlying principle is that Starts (putting things into the process) equals Exits (things leaving the process) so that a consistent WIP exists in the process. Also referred to as Work Control System or CONWIP (CONstant Work In Process)
Histogram	A bar graph in which the widths of the bars are proportional to the classes or groups into which the variable has been divided and the heights of the bars are proportional to the class frequencies or how often a value occurs within that class. It illustrates the shape, centering, and spread of the data distribution and indicates whether there are any outliers.
Hypothesis Test	A statistical test that determines whether to reject or fail to reject a hypothesis based on data and desired confidence level.

I-MR	The Individual and Moving Range control chart is used to monitor continuous data over time that is collected one value at a time. The "I" chart measures the individual value and the "MR" chart measures the range between consecutive values, typically two adjacent values. It is used to distinguish between common and special cause variation.
Input-Output or X-Y Map	Type of process map useful for root cause identification related to variation reduction, quality improvement, and/or problem solving. For each process step you identify the inputs (Xs) and outputs (Ys). This is used at a micro process level.
Ishikawa Diagram	See Cause and Effect Diagram.
Kaizen	Japanese term that means continuous improvement, taken from the words '*Kai*', which means continuous and '*zen*', which means improvement.
Kanban	Kanban is Japanese for "visual signal" or "card." It is frequently used as the signaling mechanism in a pull system to supply components or signal work often through the use of a card displaying a sequence of specifications and instructions.
Kappa	A statistical measure for measurement system analysis indicating the degree of agreement of the binomial, nominal, or ordinal assessments made by multiple appraisers when evaluating the same samples. It is an output of doing an Attribute Agreement Analysis for discrete data as opposed to a Gage R&R for continuous data.

Kendall's for Ordinal Data	*Kendall's Coefficient of Concordance* indicates the degree of association of ordinal assessments made by multiple appraisers when evaluating the same samples. Kendall's coefficient is commonly used in attribute agreement analysis (attribute gage R&R). *Kendall's correlation coefficient* is done if a known rating for each sample is provided. The correlation coefficients are given for each appraiser to indicate the agreement of each appraiser with the known standard; and an overall coefficient to represent all appraisers with the standards. The correlation coefficient helps you determine whether an appraiser is consistent but inaccurate.
Key Stakeholders	All the people impacted by a project who have a stake in the outcome. These people should be communicated with at the appropriate level to keep them linked to the project and its successful outcomes.
Lead Time	The amount of time required for work to pass from the start to finish of a process. The start and finish of the process needs to be defined. There are different types of lead times including process, production, customer and other lead times. See Little's Law for additional information. Also known as Process Lead Time or Process Cycle Time.
Lean	A business practice designed to remove waste from a process.
Little's Law	PLT= WIP/ER defines a fundamental relationship between common Lean measurements. Also one of the simplest equations in Queueing Theory. Process Lead Time (PLT; the time it takes from when an item or work first enters a process until the time it leaves it) is equal to the number of items already in the process (WIP; work in process) divided by the Exit Rate (ER; the number of units exiting the process per a unit of time). See Process Lead Time, Work in Process and Exit Rate for additional information.

Lean Six Sigma (LSS)	Lean Six Sigma is a business process methodology designed to reduce waste and variation and continuously improve all processes to meet and exceed customer expectations. Lean Six Sigma combines the strengths and minimizes the weaknesses of two popular improvement approaches in use today – Lean and Six Sigma.
Matrix Plot	A graphical output used in conjunction with Correlation and Multiple Regression. Matrix Plot is a series of scatter plots which graphically show the correlation or relationship between Xs and between Xs and a Y. See scatter plot for additional information.
Mean	Also known as the average. It is the mathematical center of the data and is calculated by adding up all the values in your data set and then dividing by the number of values. The mean may be misleading because it can be skewed by an outlier. Mean is not a good representation of the center of the data for non-normal distributions.
Median	The physical center of a set of data. After sorting the data from high to low or low to high, it is the data point that has half the values above and half the values below. In the event of an even number of values, it will be the average of the two in the center. Used in conjunction with or as an alternative to the mean since it will not be skewed by outliers. Median is a better representation of the center of the data for non-normal distributions.
Multi-Generation Project Plan (MGPP)	Multi Generation Project Plan is used to extend a project over time because of some constraint. Projects with a wide scope or where technology hasn't caught up with the proposed improvements will benefit from a MGPP. MGPP is a useful tool in managing project scope and scope creep to keep the project length reasonable.
Normal Data	Data that exhibits a "normal" or Gaussian distribution (commonly known as the "bell curve").

Non-Normal Data	Data that does not follow a normal distribution. Since the normal distribution is often an assumption in a number of powerful statistical applications, it is important to know whether the data is normally distributed. In the event that the data is not normal then alternative statistical analysis will need to be done.
Non-Parametric	A set of statistical tools or distributions in which there is no assumption of an underlying distribution.
Non-Value Added Work	Work that cannot be classified as Value Added (see definition). Non-Value Added Work is often split into two categories: Business Non-Value Added or Non-Value Added. In a process that has never done Lean, non-value added work typically represents 90-95% of the work. See Value Added Work and Waste for more information.
Outliers	Output is the products or service that result from the execution of a process. An outlier is a data point that is statistically far from the rest of the data. Different approaches may be used to identify outliers. All outliers should be investigated.
P Value	In hypothesis testing it is the actual risk of being wrong if you reject the null hypothesis when you shouldn't have. It is often compared to the Alpha (α) value, which is the risk you are willing to assume in incorrectly rejecting the null hypothesis. They are reported in terms of percentages or probability.
Pareto Chart	A bar chart that shows items in descending order of magnitude or frequency. Based on the 80/20 Principle it strives to separate the vital few from the trivial many to help focus improvement opportunities.
PCE	Process Cycle Efficiency is a key Lean metric which calculates the percentage of Customer Value Added time as a ratio to Process Lead Time (PCE = CVA/PLT)

PDCA / PDSA	Plan/Do/Check/Act (PDCA) or Plan/Do/Study/Act (PDSA) is an alternate problem solving methodology, often used for simple problem solving and implementing known solutions. Many variations of PDCA and PDSA have been created over time, with some approaches including key steps in the DMAIC process.
PLT	See Lead Time for definition and see Little's Law for additional information.
Point-of-use storage (POUS)	POUS refers to the situation where raw materials or other items are stored near to where they will be used rather than at a more distant central location.
Poisson Distribution	The Poisson Distribution is a discrete distribution which takes on the values X = 0, 1, 2, 3, etc. It is often used as a model for the number of events (such as the number of trucks arriving at a customer) in a specific time period. The Poisson distribution is determined by one parameter, lambda.
Poka Yoke	Japanese term which means mistake or error proofing.
Population Parameter	Statistical descriptors of a population. These descriptors are usually represented as Greek letters: e.g., μ (mean), η (median), σ (standard deviation).
Pp/Ppk	Process capability metrics similar to Cp and Cpk defined above. The difference is that the standard deviation used in the calculations is between rather than within. Between uses the standard formula of SQRT [Σ (μ–xbar)^2 / (n-1)] while within uses the estimate of Rbar/d_2. These are referred to as measures of long term capability. Pp and Ppk are often referred to as "longer term capability" or "long-term capability" (only if data taken over the long-term exhibiting 80% or more of full process variation).
Primary Metric	The primary metric is the improvement project's most important measure of success. Primary metrics should be tied to the problem statement.

Probability Density Function (PDF)	A statistical function that describes the relative likelihood for a random continuous variable to take on a given value.
Probability Plots	A graph used to evaluate whether a set of data fits a specific distribution
Process Cycle Efficiency (PCE)	Ratio calculated by dividing total value added time by total process lead time. Typically expressed as a percentage. The ratio gives an indication of the waste and opportunity in the process (% that is not value added). May be known as Process Efficiency or other similar terms.
Process Cycle Time (PCT)	See Lead Time for definition and see Little's Law for additional information.
Process Lead Time (PLT)	See Lead Time for definition and see Little's Law for additional information.
Process Owner	Manager who will "own" the process and be responsible for sustaining the gains when an improvement project is completed. The Belt will formally transfer responsibility for sustainment of project gains to Process Owner upon completion of project.
Product Cell	Also known as work cells or pods in which people and equipment are arranged and organized to produce a complete product or family of products or services.
Project Sponsor	The Sponsor is the ultimate owner of a project. He or she supports project leaders and team members to work on the project. The sponsor will review and approve projects and recommendations that are within his/her authority. A sponsor will also facilitate project progress by providing guidance, resources and removing obstacles.
Project Team	A cross functional group of people selected to work on an improvement project.

Proportion	Often used in LSS to define a ratio between counts and/or measures (e.g., total defectives/total items giving us a proportion defective). Proportions are often expressed as percentages (%) by multiplying a proportion by 100.
Pugh Matrix	This matrix utilizes comparisons and scoring of several different concepts against a base concept. The best ideas are then synthesized thus creating stronger concepts and eliminating weaker ones until an optimal concept finally is reached. It is often used in the Design for Lean Six Sigma methodology.
Pull	Refers to a process where items are released into a process or produced based on customer demand rather than being pushed into the process based on a schedule or anticipated demand. Once something is consumed, it will be replaced. Work is started or items are transferred based on a signal or trigger by customer or customer step, not at the convenience of the supplier or supplying step. See Generic Pull and Replenishment Pull for additional information.
Push	Work is sent faster, earlier or in greater quantity than can be handled by the next step or customer, so the work often sits. Symptoms of push include excessive
Quick Win	A quick win is an improvement that is visible, has immediate benefit, and can be delivered quickly after the project begins.
R Chart	Range Chart is a control chart which plots the range of a subgroup (subgroup could have a sample size of one). The Range Control chart measures the within sample variation, precision or noise of a time based set of sample data. If the R chart is not in statistical control then it means there is sufficient noise in the data collection or process to warrant investigation and either elimination or incorporation of the special causes. Average of the subgroup ranges is used to calculate control chart limits for the R chart and other continuous control charts.

Range	The highest value minus the lowest value in a set of data. The smallest the range can be is zero. It cannot be a negative value.
Rational/ Consecutive Subgrouping	Sampling technique that collects data taken under same or similar process conditions, often consecutively, and groups the data into a group for analysis. The grouping of these items is intended to minimize the within sample variation and should be a natural and rational grouping where process variables are consistent during the time of data collection. Rational subgroups are a foundation for Xbar-R and Xbar-S controls charts and certain capability analysis.
Regression	A statistical technique for examining the relationship between one or more independent variables (X) and a dependent variable (Y) and determining a prediction equation that allows for an estimate of the Y based on the values of the X(s).
Repeatability	Used in Gage R&R, it is the variation associated with a single person measuring the same thing, the same way, using the same equipment and getting the same answer.
Replenishment Pull	This is a system that relies on a demand to trigger the replenishment of inventory, work or service either manufactured or purchased. Among other benefits, Replenishment Pull is used to prevent overproduction and to reduce customer lead times. Typical system comprised of a “supermarket” and “Kanban.” Replenishment pull is also known as Supermarket, Kanban, or Pull System.
Reproducibility	Used in Gage R&R, it is the variation associated with multiple people measuring the same thing, the same way, using the same equipment and getting the same answer.

Rolled Throughput Yield (RTY)	Rolled Throughput Yield is the probability of a unit getting through the process without reworking or scrapping it, and is a measure of the pure capability of the process. It is calculated by multiplying the yield or quality level of each step in the process. RTY is also known as First Pass Yield (amount of work that makes it through a process right the first time).
Run Chart	A graphical plot of time sequenced continuous data with the horizontal axis being time and the vertical axis being the scale of measurement for the variable. It allows you to see patterns and change over time. But, unlike the control chart, it does not allow you to distinguish between common and special cause variation.
Sample Size	The calculated size of a desired sample that is often used for inferential statistics. The sample size will depend upon the level of desired confidence and precision along with an estimate of the population variation. Cost often must be considered as well.
Sample Statistics	Statistical descriptors of a sample. These sample descriptors are represented by Roman letters while Population Parameters are statistical descriptors of a population and are represented by Greek letters.
Scatterplot	A graphical representation of the relationship between an X and a Y variable with the horizontal axis being the scale for the X variable and the vertical axis being the scale for the Y variable. The intersection of the paired X and Y values is plotted as a dot. The scatter plot is interpreted using four dimensions; positive or negative (as X goes up Y either goes up or down), shape (can we envision either a line or curve running through the center of the data), spread of the data and finally, any outliers. Scatter Plots are often used in conjunction with correlation and regression.

Secondary Metric	The secondary metric is the "counterbalancing" metric that you do not want to sacrifice on behalf of the primary metric. It is a check that keeps an unintended consequence from occurring while focusing on improving the primary metric. For example, if the primary metric is inventory reduction, the secondary metric might be out-of-stocks for customer orders.
Sequential Experimentation: Screening, Refining, Optimizing	Sequential Experimentation is the most efficient and cost-effective approach to running DOE, particularly when starting with many potential factors. Sequential Experimentation is a series of Designed Experiments starting with the screening of multiple factors (usually use Fractional Factorials or Plackett-Burman designs) followed by the refining and deeper insight into the causal relationship (usually use Full Factorials) and finally optimizing the relationship (usually use Response Surface Modeling). Additionally, Mixture and Taguchi designs can be used.
SIPOC	A process map which defines the Suppliers, Input, Process, Output, and Customers in a way that allows a high level look at the process which has been selected for improvement.
Six Sigma	Six Sigma has grown to have many meanings. It can describe a structured method for improving all processes utilizing the DMAIC methodology. It also refers to an overarching approach to implementing organization-wide process improvement. In statistics, Six Sigma can represent six standard deviations for a population, and can also be used to describe the capability of a process where the closest specification is six standard deviations away from the process mean so that it is very unlikely that defects will occur. Six Sigma Quality Level equates to 3.4 defects per million opportunities.
Standard Operating Procedure (SOP)	Standard Operating Procedures are established or prescribed methods to be followed routinely for the performance of designated operations or in designated situations.

Spaghetti Diagram	A graphical technique used to illustrate the physical movement of an item or person through the steps and tasks of the selected process. It shows the path that the item takes as a line overlaid on the workplace floor plan and records all the movements and distances that the item takes.
Standard Deviation	A statistical measure of the variation of a set of data. It is the average distance that all the points are away from the mean. Standard Deviation is a good measure of variability for a normal distribution.
Sub-Optimization	By focusing on a limited set of elements of a process and improving them, the overall process, because of the interactions between all the elements, will result in a less than optimal outcome for the entire process.
TAKT Time/Rate	The allowable time allocated to the completion of a product or service necessary to meet customer demand. Takt Time is the ratio of available time to do the work divided by the customer demand in units. Takt Rate is the inverse of Takt Time.
Theory of Constraints	A methodology that identifies and seeks to improve a process by focusing on the constraint or bottleneck in the process.
Time Series Chart	A graph that displays numerical data in a time sequence with the X axis being a measure of time and the Y axis the units of measure of the variable being charted. It is used to visually see trends and patterns in the data.
Tollgate	See Gate Review.

Type 1 – Alpha – Producer Risk	Type 1 – Alpha – Producer Risk - The risk of being wrong if you reject the Null Hypothesis and claim that something significant has happened when it has not. It is the risk of discovering something that is not there. For example, thinking that the product is bad and scrapping it when in fact, the product is good. Thinking that your marketing promotion was successful when in fact, it was not. Useful analogies include "the boy who cried wolf" and "convicting an innocent defendant."
Type 2 – Beta – Consumer Risk	Type 2 – Beta –Consumer Risk – The risk of being wrong if you fail to reject the Null Hypothesis and claim that nothing significant has happened when in fact it has. For example, thinking that the product is good and shipping it when in fact, it is bad. Thinking that your marketing program was a failure, when in fact, it was successful. Useful analogies include "the boy doesn't see the wolf." and "acquitting a guilty defendant." This risk depends on the difference between the actual and hypothetical situation. As an example, a very bad production lot is more likely to be rejected (lower Type 2 risk) than a moderately bad one (higher Type 2 risk)
U-Shape Cell	A work area or process that is organized in the shape of a 'U' rather than a straight line, eliminating the waste of walking back from the end of the line or process to the start. Frequently used in manufacturing to allow an operator to finish their work in virtually the same location that they started and to work on both sides of the area to make it easier to balance work with other employees.
Value Added Work	Classification of work based on the point of view of the customer. Often described as work an external customer would be willing to pay for or give you time to do if they knew you were doing it. Value Added Work often adds form, fit or function to a product or service. In a process that has never done Lean, value added work may only 5-10% of the work. See Non-Value Added Work and Waste for more information.

Variance	The square of the standard deviation. It is used to add and subtract variability and get mathematically correct totals, which is not possible adding and subtracting standard deviations.
Waste	Non-value added work as defined by the customer. Lean has defined seven wastes to help in identifying non-value added work. See Waste Walk for additional information. The seven are Transportation, Inventory, Motion, Waiting, Overproduction, Over-processing and Defects. Additionally you may see "People" (waste of their knowledge) or "Safety" (which is not a waste but can be impacted on by Waste).
Waste Walk	A formal and structured walk of the Gemba, or work area, specifically identifying the sources of waste
Work in Process (WIP)	The number of items in the system or process, being worked on or waiting to be worked on. Also known as "Things in Process" or other similar terms.
WIP cap	The maximum WIP in a process as it relates to a Generic Pull System. See Generic Pull for additional information.
Work Cell	See Product Cell.
X	Process input(s), root cause(s), or factor(s). In LSS, a "key X" refers to one or more critical root cause(s), waste(s) or other factor(s) identified that most impact the key metric (Y) for an improvement project.
Xbar Chart	A control chart that monitors the mean of a sequenced set of "rationally" determined subgroups/samples of continuous data. It measures the between subgroup variation and is used to distinguish between common and special cause variation.

Xbar-R or Xbar and R	A combination of two control charts used for continuous data that can be rationally sub grouped. Used when the rational subgroup size is between 2 and 10. The Xbar chart (as described above) is used in combination with a Range Control Chart (which plots the subgroup ranges). The Range is calculated by taking the difference between the highest and lowest values in the subgroup/sample. It is used to measure the within sample/subgroup variation and is used to distinguish between common and special causes of variation.
Xbar-S or Xbar and S	A control chart for continuous data similar to the Xbar/R except that the standard deviation of the sample/subgroup is used instead of the range. Used when the rational subgroup is greater than 8-10.
Y	Process output, key result trying to achieve or primary metric on a project. Y = f(X) describes a fundamental relationship in statistics and problem solving – to identify the Xs (inputs, factors, root causes or wastes) that most impact the Y (output, key metric or result trying to achieve).

Feedback

- Please visit the Lean & Six Sigma World Organization website, www.lssworld.org, to get updates on the LSS 6002 Standard.
- If you would like to provide feedback, please visit: http://lssworld.org/LSS_Standards